Jane's

UNDERWATER WARFARE SYSTEMS

Edited by Anthony J Watts

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Contents

How to use *Jane's Underwater Warfare Systems* [4]

Glossary of acronyms and abbreviations [5]

Alphabetical list of advertisers [10]

NATO designations of Russian equipment [13]

Executive overview [15]

Users' Charter [24]

SUBMARINES
The submarine 3
Submarine forces 15
Aspects of submarine design 23
Submarine and submersible designs 27
Submarine escape and rescue systems 75
Machinery and platform control systems 83

ANTI-SUBMARINE WARFARE
Submarine and surface ship ASW combat management 101

Sonar systems 127
Surface ship sonar systems 129
Submarine sonar systems 163
Airborne dipping sonars 189
Sonobuoys 197
Airborne acoustic processing and receiving systems 207
Static detection systems 217

Countermeasures 225
Acoustic decoys 227
Electronic warfare 239

Underwater communications 251
Submarine communications systems 253
Underwater telephones 263
Communications buoys 267

Electro-optical sensors 271

Magnetic anomaly detection systems 285

UNDERWATER WEAPONS
Strategic and cruise missiles 289

Guided ASW/ASUW weapons 301

Torpedoes 307

Mines 339

ASW rockets and depth charges 365

MINE WARFARE VESSELS
Mine warfare forces 375

Mine warfare vessel designs 384

MINE WARFARE
Mine warfare 419

Mine warfare combat management 421

Minehunting sonar systems 433

Mine warfare laser systems 455

Underwater vehicles 459

Underwater vehicle ancillary equipment 493

Mine clearance systems 501

Divers' equipment 515

ASSOCIATED UNDERWATER WARFARE SYSTEMS
Signature management 549
Acoustic ranges 553
Magnetic ranges 557
Multi-influence ranges 563
Degaussing systems 569
Acoustic control 573

Environmental measuring systems 577

Prediction systems 585

Oceanographic and hydrographic survey equipment 591

Training and simulation systems 605
Command team trainers 605
Mine warfare trainers 613
Submarine equipment trainers 617
Aircraft ASW equipment trainers 621
Sonar equipment trainers 623
Targets 633

General navigation equipment 641

Submarine radar 649

Consoles and displays 653

Transducers, hydrophones and pingers 657

Miscellaneous equipment 667

Research and development 675

Contractors 683

Manufacturers' index 697

Alphabetical index 705

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How to use *Jane's Underwater Warfare Systems*

The book is divided into six main sections covering Submarines, Anti-submarine warfare, Underwater weapons, Mine countermeasures forces, Mine warfare and Associated underwater warfare systems.

These main divisions are further divided into subsections covering various related systems associated with that specific aspect of underwater warfare, for example, combat management systems, sonar systems, torpedoes, mines and so on. The section on submarines covers submarine forces, aspects of submarine design and design descriptions of a number of submarines and submarine machinery systems. The section on mine countermeasures forces covers mine-countermeasures forces and tables of construction and mine countermeasures vessel designs. The section on mine warfare covers the various equipments associated with mine-countermeasures such as sonars, minesweeping systems, ROVs and so on. The section on Associated underwater warfare systems covers various disciplines which, although not directly related to the other main sections, nevertheless have an important bearing on the conduct of underwater warfare. These primarily concern equipments used in the measuring of environmental conditions which determine the quality of sound propagation through water. Other subsections cover such important areas as training systems, associated navigation equipments, such as echo-sounders, radars and so on. Two sections under development and expansion are research and development organisations and submarine escape and rescue systems (which is listed under the Submarines section). Equipment and systems are listed alphabetically under the country of origin, which is also entered alphabetically. Each entry gives details of the type of equipment, a technical description, its operational status and, in many cases, a history of the development of the equipment and its specifications, as well as a final note listing the main contractor.

Type As a quick ready-reference this specifies, within each subsection, the type and role of that particular equipment.

Development Where applicable this heading covers the history of the development of a specified item of equipment up to the point where it entered service and, in some instances, details of any major development after entry into service.

Description Under this heading a detailed technical description is given of each system, in so far as military and commercial confidentiality allows. Where equipments integrate with other equipment or systems, this is noted.

Specifications Under this heading the main technical parameters of systems are listed, including dimensions and weight (water displacement in the case of ship specifications) operating parameters (where available) and, in the case of weapons, destructive charge and so on.

Operational status This lists the current status of the system – that is, under development, on order, undergoing trials and so on and where known, a note of the users of the equipment. This is further amplified in certain sections by a table listing the operational platforms carrying the equipment.

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Glossary of acronyms and abbreviations

AA	Active Adjunct (sonar)
ACINT	Acoustic Intelligence
ACTD	American Coastal Tactical Defense (Magic Lantern system) (USA)
ADCAP	Advanced Capabilities (USA)
ADP	Automatic Data Processing
AF	Audio Frequency
AFC	Automatic Frequency Control
AGC	Automatic Gain Control
AI	Artificial Intelligence
AIO	Action Information Organisation
AIP	Air Independent Propulsion
ALCS	Airborne Launch Control System
ALFS	Airborne Low-Frequency Sonar
ALISS	Advanced Lightweight Influence Sweep System (USA)
AMCM	Advanced Mine Countermeasures (USA)
ARPA	Automatic Radar Plotting Aid
ASROC	Anti-Submarine Rocket (USA)
AsuW	Anti-Surface Warfare
ASV	Anti-Surface Vessel
ASW	Anti-Submarine Warfare
ATE	Automatic Test Equipment
ATM	Asynchronous Transfer Mode
AUV	Autonomous Underwater Vehicle
BIBS	Built-In Breathing Set
BITE	Built-In Test Equipment
CAC	Computer Aided Classification
CAD	Computer Aided Detection
CASS	Command Active Sonobuoy System
CCD	Charge-Coupled Device
CCIS	Command and Control Information System
CCTV	Closed-Circuit Television System
CFAR	Constant False Alarm Rate
CFS	Command function select
CIC	Combat Information Centre
CIU	Control Interface Unit
COTS	Commercial Off The Shelf
cp	controllable pitch (propeller)
CPA	Closest Point of Approach
CPU	Central Processing Unit
CRM	Corrosion Related Magnetic
CRT	Cathode Ray Tube
CSDT	Control for Submarine Discharge Torpedo
CSLT	Control for Surface-Launched Torpedoes
CSU	Control Selection Unit
CZ	Convergence Zone (sonar)
DARPA	Defence Advanced Research Projects Agency (USA)
DCN	Direction des Constructions Navales (France)
DDS	Dry Deck Shelter (for submarines)
DED	Docking and Essential Defects
DERA	Defence Establishment Research Agency (UK)
DGPS	Digital Global Positioning System
DHS	Data Handling System
DICASS	Directional Command Activated Sonobuoy System
DIFAR	Directional low Frequency Analysis and Recording
DMT	Deep Mobile Target
DoD	Department of Defense (USA)
DPM	Digital Plotter Map
DRA	Defence Research Agency (UK)
DRTS	Detecting, Ranging and Tracking System
DSP	Digital Speech Processor
ECAN	Etablissement des Constructions et Armes Navales (France)
ECCM	Electronic Counter-Countermeasures
ECDIS	Electronic Chart Display System
ECG	Electrocardiogram
ECM	Electronic Countermeasures
ECR	Embedded Computer Resources
EDM	Engineering Development Model
EEG	Electroencaphalogram
EEZ	Economic Exclusion Zone
EFS	Electronic Function Select
ELINT	Electronic Intelligence
EMI	Electromagnetic Interference
EMS	Electromagnetic Signature
EOD	Explosive Ordnance Disposal
EPROM	Erasable Programmable Read-Only Memory
ERAPS	Expendable Reliable Acoustic Path Sonobuoy
ESM	Electronic Support Measures
EW	Electronic Warfare
FCS	Fire-Control System
FLIR	Forward-Looking Infra-Red
FMS	Foreign Military Sales
FOM	Figure-Of-Merit
fp	fixed pitch (propeller)
FRAS	Free-Rocket Anti-Submarine (Russia)
FRP	Fibre Reinforced Plastic
FSD	Full-Scale Development
GMDSS	Global Maritime Distress System for Ships
GMSK	Gaussian Minimum Shift Key
GPS	Global Positioning System (formerly NAVSTAR)
GRP	Glass Reinforced Plastic
GT	Gas Turbine
GUI	Graphic User Interface
ICBM	Intercontinental Ballistic Missile
IFCS	Integrated Fire-Control System
IFF	Identification, Friend or Foe
IHO	International Hydrographic Organisation
II	Image Intensifier
IMO	International Maritime Organisation
INS	Inertial Navigation System
IR	Infra-Red
IRBM	Intermediate Range Ballistic Missile
ISR	Intelligence, Surveillance, Reconnaissance
ITT	Invitation To Tender
IUSS	Integrated Undersea Surveillance System (USA)
LAMPS	Light Airborne Multipurpose System (USA)
LAN	Local Area Network
LANTIRN	Low-Altitude Navigation and Targeting Infra-Red Night System (USA)
LAPADS	Lightweight Acoustic Processing And Display System (UK)
LBL	Long Baseline
LCD	Liquid Crystal Display
LED	Light Emitting Diode/Display
LFA	Low Frequency Active
LLTV	Low-Light Television
LLLTV	Low-Light Level Television
LOFAR	Low-Frequency Analysis and Recording
LOS	Line Of Sight
LRU	Line Replacement Unit
LSM	Littoral Sea Mine
MAD	Magnetic Anomaly Detector
MCAC	Multi-Mission Craft, Air Cushion (USA)
MCDV	Maritime Coastal Defence Vessel
MCM	Mine Countermeasures
MCMV	Mine Countermeasures Vessel
MFC	Multifunction Console
MIRV	Multiple Independently targetable Re-entry Vehicle
MLU	Mid life upgrade
MNS	Mine Neutralisation System
MoD	Ministry of Defence (UK)
MoU	Memorandum of Understanding
MPA	Maritime Patrol Aircraft
MRV	Multiple Re-entry Vehicle
MSBS	submarine launched ballistic missile (Mer-Sol Balistique Stratégique) (France)
MSC	coastal minesweeper
MSO	ocean-going minesweeper
MTBF	Mean Time Between Failures
MTI	Moving Target Indication
NAVSTAR	Navigation Satellite Timing And Ranging
NOAA	National Oceanic and Atmospheric Administration (USA)
NSF	National Science Foundation (USA)
NSR	Naval Staff Requirement (UK)
NSWG	Naval Surface Warfare Group (USA)
OBT	On Board Trainer/ing
ONI	Office of Naval Intelligence
ONR	Office of Naval Research (USA)
ORBAT	Order Of Battle
OTPI	On Top Position Indicator
OTT	Out To Tender
PCB	Printed Circuit Board
PCU	Power Control Unit
PD	Project Definition
PL	Propagation Loss
PoD	Probability of Detection
PPI	Plan Position Indicator
PROM	Programmable Read Only Memory
PSP	Programmable Signal Processor
RAM	Radar Absorbent Material
RAM	Random Access Memory
RAP	Reliable Acoustic Path
RCC	Recompression Chamber
RCS	Radar Cross-section
RDSS	Rapid Deployable Surveillance System (USA)
RDT&E	Research, Development, Test And Evaluation

RfP	Request for Proposal
RFS	Radio Frequency Surveillance
RLG	Ring Laser Gyro
ROV	Remotely Operated Vehicle
RPV	Remotely Piloted Vehicle
RRDT	Random Rotating Directional Transmission
RWR	Radar Warning Receiver
Rx	Receive
SACU	Stand-Alone digital Communications Units
SAR	Search And Rescue
SAS	Synthetic aperture sonar
SATCOM	Satellite Communications
SAV	Surface Auxiliary Vessel
SAW	Surface Acoustic Wave
SCS	Submarine Control System
SDV	Swimmer Delivery Vehicle
SE	Static Electric
SEPADS	Sonar Environmental Prediction And Display System (UK)
SEWACO	Sensor Weapon Control And Command (Netherlands)
SINS	Ship's Inertial Navigation System
SLBM	Submarine-Launched Ballistic Missile
SLCM	Submarine-Launched Cruise Missile
SLMM	Sea-Launched Mobile Mine (USA)
SNLE	nuclear-powered ballistic missile submarine (Sous-marin Nucléaire Lanceur d'Engins balistique) (France)
SOSUS	Sound Surveillance System (USA)
SPAT	Self-Propelled Acoustic Target (UK)
SSB	conventional powered ballistic missile submarine
SSB	Single Sideband
SSBN	nuclear-powered ballistic missile submarine
SSE	Submerged Signal Ejector
SSK	submarine (non-nuclear)
SSKP	Single Shot Kill Probability
SSN	nuclear-powered attack submarine
STC	Sequential Turbocharging
SURTASS	Surveillance Towed Array Sensor System (USA)
SUT	Surface and Underwater Target (UK)
SVGA	Super Video Graphics Array
SYNAPS	Synthetic Aperture Sonar processing
TACTAS	Tactical Towed Array Sonar
TAS	Towed Array Sonar
TDD	Target Detection Device
TMA	Target Motion Analysis
TWS	Track-While-Scan (radar)
TWT	Travelling-Wave Tube
Tx	Transmit
UAV	Unmanned Aerial Vehicle
UCSS	Undersea Coastal Surveillance System (USA)
UEP	Underwater Electric Potential
USB	Upper Sideband or Ultra Short Baseline
USBL	Ultra Short Baseline
UUV	Unmanned Underwater Vehicle
VCS	Versatile Console System
VDS	Variable Depth Sonar
VGA	Video Graphics Array
VHSIC	Very High-Speed Integrated Circuit
VLA	Vertical Launch ASROC
VLAD	Vertical Line Array Difar
VLSI	Very Large-Scale Integration (electronic circuits)
XBT	Expendable Bathythermograph
XSV	Expendable Sound Velocity system

Mathematical and scientific symbols

AC	Alternating Current
Ah	Ampere hour
AM	Amplitude Modulated
bhp	brake horse power
CEP	Circular Error of Probability
CSO	Constant shallow omni
CW	Continuous Wave
dB	decibels
DC	Direct Current
Demon	Demodulated Noise (sonar processing)
DF	Direction-Finding
EHF	Extremely High-Frequency
ELF	Extremely Low-Frequency
ELFE	Extremely Low Frequency Electromagnetic
flops	floating point operations per second
FM	Frequency Modulated
FFT	Fast Fourier Transform
FSK	Frequency Shift Keying
g	grams
HBO	hyperbaric oxygen therapy
HE	High Explosive
HF	High-Frequency
HFM	Hyperbolic Frequency Modulated
hp	horse power
HP	High Pressure
HTP	High Test Peroxide
Hz	Hertz
IF	Intermediate Frequency
IFM	Instantaneous Frequency Measurement
KBPI	Kilobytes Per Inch
kWb	Kilowatt Brake
kWh	Kilowatt Hour
l	litres
LFM	Linear Frequency Modulated
LOX	Liquid Oxygen
LPM	Linear Period Modulation
mA	Milli Amps
Mbar	Millibar
Megaflops	Million floating point operations per second
MF	Medium Frequency
Mips	Million instructions per second
Ml	Millilitre
mmho	Milli ohms (conductivity)
MSK	Minimum Shift Keying
msw	Metres sea water
mV	milli Volts
NBFSK	Narrow Band Frequency Shift Keying
nm	nanometre
ns	nanoseconds
oa	overall
PBX	Plastic Bonded Explosive
PRF	Pulse Repetition Frequency
psi	pounds per square inch
PVDF	Polyvinyl Difluoride
PW	Pulse width
RF	Radio Frequency
rpm	revolutions per minute
rpm	rounds per minute
SFOC	Specific Fuel Oil Consumption
SFSK	Space Frequency Shift Keying
SHF	Super High Frequency
shp	shaft horse power
S/m	Siemens per metre
SRDT	Single Rotating Directional Transmission
t/m³	tonnes per cubic metre
TRDT	Triple Rotating Directional Transmission
TUP	Transfer Under Pressure
UHF	Ultra High-Frequency
Pa	micro Pascal
s	micro seconds
UV	Ultraviolet
VHF	Very High Frequency
VLF	Very Low Frequency
Wh	Watt hours
WRDT	Wide Rotating Directional Transmission
YIG	Yttrium Indium Garnet

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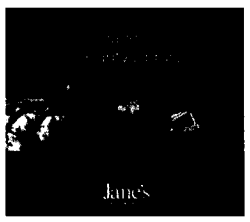


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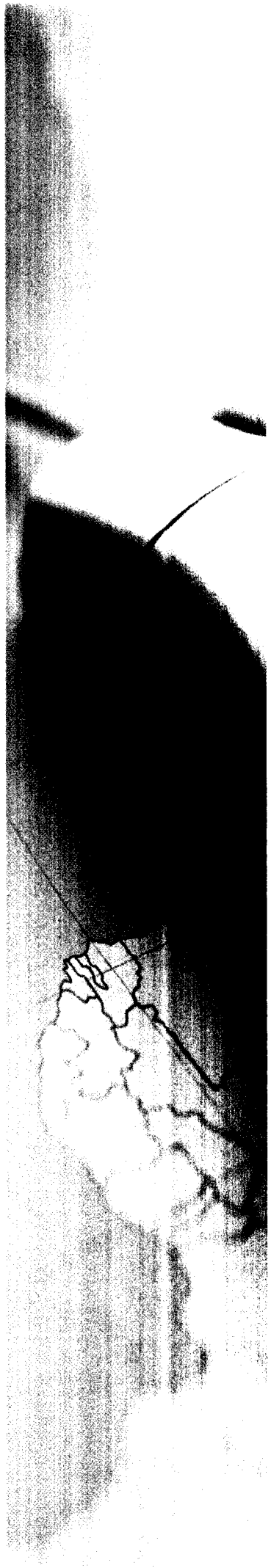
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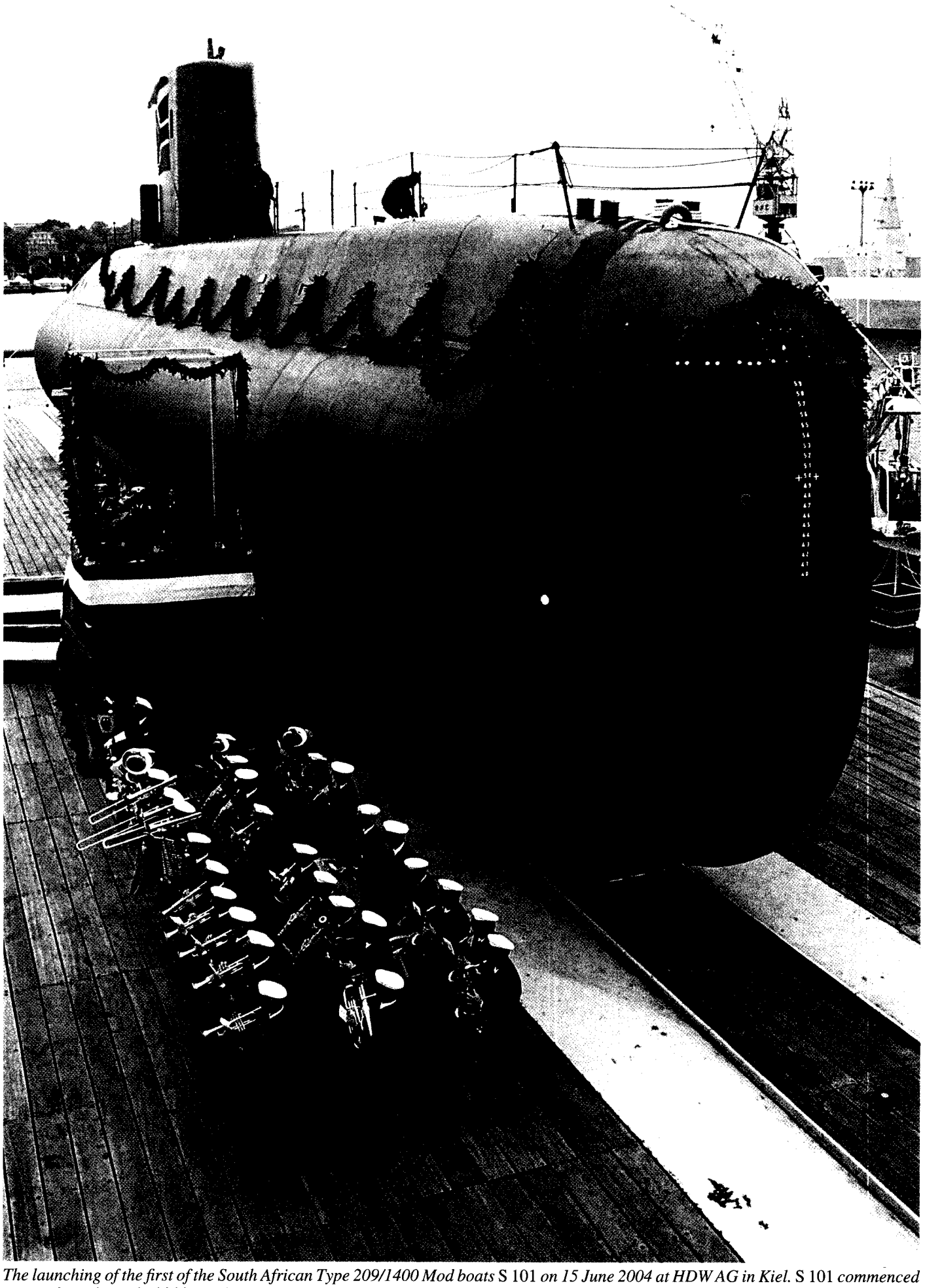
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NATO DESIGNATIONS OF RUSSIAN EQUIPMENT

NATO designations of current Russian underwater warfare systems and equipment

Designation	Description
Bald Head	Submarine ESM system
Ball End	Minehunter surveillance radar
Brick Group	Submarine ECM system incorporating Brick Pulp and Brick Spit
Brick Pulp	Submarine EW antenna
Brick Spit	Submarine EW antenna
Bull Horn	Active/passive surface ship MF sonar
Bull Nose/MGK 336	Surface ship HF/MF active bow sonar
Cluster Bay	Rising sea mine
Cluster Guard	Anti-sonar hull coating for submarines
Cluster Gulf	Rising sea mine for deep water
Cod Eye A/B	Submarine radiometric sextant
Drum Tilt	Mine warfare vessel fire-control radar
Elk Tail	Active HF VDS
Feniks	Passive MF submarine sonar
Fin Curve	Mine warfare vessel navigation radar
Foal Tail	Active HF VDS
Golf Ball	Submarine mast sensor
Herkules/MG 322	Submarine and surface ship HF passive scanning sonar
Horse Jaw/MG 322	Active MF surface ship sonar
Horse Tail	Active MF VDS
Lamb Tail	Helicopter-type HF VDS
Low Trough	Mine warfare vessel surveillance radar
Mare Tail	Active MF VDS
Mouse Roar/MG 519	Active HF submarine sonar
Mouse Tail	Active HF VDS
Ox Tail	Variable depth sonar
Ox Yoke	Active MF surface ship sonar
Park Lamp	Submarine mast direction-finding loop antenna
Pike Jaw	Active/passive MF searchlight attack sonar
Punch Bowl	Submarine mast radome

Designation	Description
Quad Loop	Submarine direction-finding system
Rat Tail	Active HF VDS/helicopter dipping sonar
Rim Hat	Submarine ESM system
Sampson	SS-N-21 intermediate-range SLBM
Shark Fin	Submarine medium-frequency sonar
Shark Gill	Passive/active LF/MF submarine sonar
Shark Hide	Passive LF submarine flank array
Shark Rib	Passive LF submarine flank array
Shark Teeth/MGK 400	Passive/active LF/MF submarine bow sonar
Shipwreck	SS-N-19 Cruise missile
Silex	SS-N-14 ASW missile
Siren	SS-N-9 submarine-launched anti-ship missile
Skiff	SS-N-23 SLBM
Skin Head	Mine warfare vessel navigation radar
Snoop Plate	Submarine surveillance radar
Snoop Slab	Submarine surface search radar
Snoop Tray	Submarine surveillance radar
Spin Trough	Mine warfare vessel navigation radar
Square Head	Mine warfare vessel IFF
Squid Head	Submarine ESM system
Stag Ear	Minehunting HF searchlight sonar
Stag Horn	Active HF sonar
Stallion	SS-N-16 ASW missile
Starfish	SS-N-15 ASW missile
Steer Hide	Active LF/MF surface ship sonar
Stingray	SS-N-18 SLBM
Stop Light	Submarine ESM system
Sturgeon	SS-N-20 SLBM
Tamir	Active HF submarine/surface ship sonar
Trout Cheek	Passive MF submarine bow sonar
Whale Tongue	Active MF surface ship sonar
Wolf Paw	Active MF surface ship sonar



The launching of the first of the South African Type 209/1400 Mod boats S 101 *on 15 June 2004 at HDW AG in Kiel.* S 101 *commenced sea trials at the end of 2004 and will be delivered to the SAN in 2005.* (Michael Nitz) *NEW*/0589883

Executive Overview

The current world situation and implications for underwater warfare

One year on from my last comments on the world situation and coalition forces remain in Iraq trying to maintain security to allow ordinary peace loving citizens to go about their daily business. The work of rebuilding the country and its infrastructure slowly progresses against an increasingly hostile and belligerent relatively small faction determined whatever the cost to undermine any attempt at creating a stable, autonomous Iraqi government and society. Terrorist activities are rife in the country and major terrorist groups appear to have developed a two-pronged attack strategy. Firstly, they seem to have combined forces and switched from attacking coalition forces to hounding and harassing the fledgling Iraqi security forces (police and army) usually with devastating and horrifying effect; and secondly through the taking of foreign hostages and demanding the release of 'political' prisoners in exchange for the hostages lives. As if these incidents were not enough, criminal gangs are also taking hostages with a view to demanding large sums of money in return for the hostages' freedom. So what is the purpose of these actions? To destabilise the country completely and create such an atmosphere of fear that when the elections were held in January 2005 very few people would turn out to vote. This, the terrorist groups hope, so it seems, will allow them to take over control of this war-torn country and impose their own rule of law, probably akin to that of the Taliban in Afghanistan.

Talking of which, with all the international debate and furore over Iraq, publicity on Afghanistan and its future has dimmed, not completely into insignificance, but it has certainly disappeared from the limelight. Afghanistan is another country where coalition forces went to war to rid a nation of what was seen by the West as a tyrannous regime – the Taliban. A major coalition effort continues to be mounted to stabilise the country, provide an atmosphere in which free elections can take place and in which the warring war lords can be brought together to work in harmony, an almost impossible task given the historical background of Afghanistan and the many varied fractious disputes over control of territory and religious beliefs. But progress is being made, albeit at a very slow pace.

Meanwhile, the hunt for Osama bin Laden goes on, but against an extremely high security backdrop.

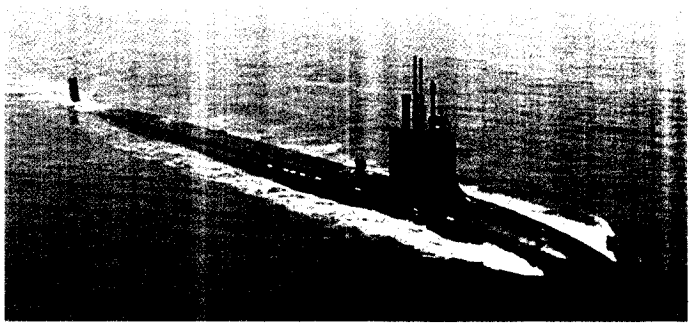
Then there are the terrorist activities directed against Russian occupation of Chechnya. This was given gruesome publicity when over 335 hostage children and adults were murdered in the town of Beslan in Russia on 3 September 2004.

There seems, in fact, to be hardly any country in the world that is free from the threat of terrorist activities.

But what do all these events, which have focused the mind of the world on counter-terrorism, have to do with underwater warfare? The commanders of the world's navies agree almost to a man that the major threat facing the world in the future is that of terrorism followed closely by asymmetric threats. Many also agree and accept that no single country on its own can counter the threat of terrorism, and that a concerted, integrated and co-operative effort by both civil and military powers must form the cornerstone of an international offensive to face the threat. If this fact is accepted, then there will have to be a paradigm change in which naval forces are used and deployed.

Naval operations must be directed towards denying terrorists the use of the sea for their nefarious activities. This will not be an easy task as terrorists operate in very small groups – frequently alone – and to apprehend a potential terrorist before he or she can cause serious destruction of life and damage to infrastructure is extremely difficult, as had already been seen in operations in Israel, Iraq, Chechnya, Afghanistan and other places.

Naval forces trained in ASW and MCM which requires detection, localisation, classification and destruction of a very high order against very small targets often operating alone and very well hidden/ camouflaged, would seem to be in a position to offer some very important lessons in strategy, tactics, and modes of operation as well as command and operating procedures for forces engaged in counter terrorism activities. The fight against terrorism can only be prosecuted on the basis of accurate and reliable intelligence. Here, it is the special operations forces that are highly trained in covert operations and able to carry out surveillance, reconnaissance and intelligence gathering that are needed to form the spearhead against any suspected terrorist group.



The modern submarine, whether SSN or SSK, poses a formidable threat. To carry out a search to detect, localise, classify and destroy a hostile submarine requires a force of some considerable size composed of a variety of assets including other submarines, surface and aerial platforms deploying a wide range of sensors and anti-submarine weapons. The task of detecting and locating a submarine in the brown water littoral is further compounded by the hostile environmental conditions and the potential for the presence of hostile forces. In the future it will become even more difficult to prosecute ASW as more advanced technology enters service aboard submarines. The picture shows the latest and most technologically advanced, nuclear powered submarine in the world, the USS Virginia *on trials in the summer of 2004.* (General Dynamics)

NEW/0587915

But what do the wars in Afghanistan and Chechnya, both land-locked countries, and Iraq with just a narrow exit to the Arabian Gulf through the Shatt-al-Arab waterway, teach us about the use of underwater warfare forces in such situations? Following the initial flurry of the wars in Afghanistan and Iraq where submarines played a major role and in Iraq where mine countermeasures forces carried out a major operation, underwater warfare has played virtually no part at all. Because of the virtual lack of underwater involvement in these continuing wars, some naval planners and strategists are expressing a growing concern. Air and more especially land operations form the bulk of the ongoing military involvement and it is in these areas of warfare that vast expenditures in financial, human and hardware resources is being incurred. As a result, considerable effort in time, money and resources is now being devoted to counter terrorism activities (and certainly continues to be needed) so much so that conventional military forces in many of the more militarily advanced nations are now seeing not only defence budgets coming under severe financial strain, but actual force strength being reduced in order that fiscal measures can be devoted to counter terrorism activities.

There is also a sense within the political arena that the concept of NATO can be extended among a much wider audience to enable a coalition force to be put together from a much wider spectrum of nations. For boots on the ground this idea may work very well in theory (communications problems among others excepted) but naval strengths have been so depleted since the ending of the Cold War – certainly among the NATO and former Warsaw Pact navies, that there is not a great deal in the way of reserves left from which to draw up a balanced, cohesive, coalition naval task force. This growing problem is being further exacerbated as individual governments take on the notion of a 'one for all and all for one' concept and take the attitude 'we can afford to reduce our force strength as other countries will help make up any shortfall in our contribution.' This idea has two major flaws in its thinking. Firstly it fails to take note of the fact that not all nations think alike or even can agree on foreign policy matters – not even within the EU as events in Iraq have showed. This results in situations where countries A, B, and C are willing to provide assets for a coalition force, but countries D, E and F are not. So the entire burden for forming a balanced, cohesive coalition force falls on just three countries, not six and those three countries might have a major problem providing certain specialised units such as submarines or mine countermeasures forces to make up the required force. Secondly it is now becoming apparent that some nations are unilaterally taking the decision not just



The greatest threat to the submarine is the helicopter. Platforms such as the Japanese MSDF SH-60J equipped with a variety of sensors (MAD – which can be seen on the side of the central fuselage, radar, EW, sonobuoys and dipping sonar) operating in the littoral region will force submarines to remain near the seabed, and will restrict to a degree their freedom of movement. Such is the threat from the helicopter that technology is being developed both to detect the presence of helicopters and weapons to destroy them, from a submerged position. (Michael Nitz) *NEW*/0587916

to downsize their capabilities in certain areas; but also to disband them altogether. Such actions will, in the long term, throw greater strain on those nations who do possess such specialised capabilities, but who may themselves, have decided to downsize in the interim. A situation could arise in a few years time where insufficient coalition forces are available to meet contingency requirements.

What, for example, some people are now questioning is what is the role of the UN in such situations? Certainly in Afghanistan the UN is heavily involved in the peacekeeping role. It has to be remembered that the function of the UN is to uphold peace throughout the world and not to become embroiled in war. Thus any suggestion that a UN naval force might be formed to uphold peace is unlikely to be met with much enthusiasm from individual states, bearing in mind the provisos of the UN Charter.

Naval forces are instruments of foreign policy and where tensions rise and the potential for conflict is high, then, assuming they could have a role to play, naval forces are usually first on the scene, as an active force prepared to fire in anger in order to ensure that matters are kept under control. In such a situation it is the UNs task to broker peace initiatives, not become involved in a situation where its forces might be drawn into conflict. In the run up to a crisis and potential conflict, diplomacy must be the byword. Dialogue is always a far better option than bullets! But when dialogue fails, then boots on the ground and bullets will have to be used to restore order.

Under these conditions it is up to individual like-minded nations to form a coalition naval task force to initially try and force belligerents to pull back from the brink, and secondly to intervene if required to do so, and ultimately to put those boots on the ground to restore peace and stability. It is in these circumstances that naval forces will be required to play a reactive, not a pro-active role; and this should always be under the agreement of the UN. Then underwater warfare will be tasked with playing a major role. But will there be sufficient forces available and able to readily communicate to provide such a capability? These are some of the hard questions that now have to be asked if the free world is to be in a position to counter all out threats and intimidation of war such as are posed by tyrants like Saddam Hussein and terrorist groups such as Al Qaeda and its associates.

The submarine threat

Against the backdrop of the current world situation has the submarine threat increased or diminished? In one sense it could be said to be diminishing with countries with existing submarine forces scaling down their force numbers, and in particular a reduction in the numbers of operational SSBNs. In addition, replacement of existing units (SSNs or SSKs) nearing the end of their life is not being achieved on a 1:1 basis and orders are being delayed, or build times extended to allow defence budgets to meet other perceived requirements that are considered more urgent. On the other hand, the threat could be said to be increasing with countries that have not previously operated submarines either acquiring or considering acquiring submarines – for example Malaysia, Singapore and Thailand (although the latter did possess submarines prior to the Second World War).

But a study of the accompanying table does not reveal a true picture of what might or might not constitute a submarine threat. A number of additional factors have to be taken into account in addition to pure statistics. Factors such as time between major refits which are now greatly more extended than they were 10 years ago; the much shorter

PROJECTED CHANGES IN SUBMARINE FORCE STRUCTURE BETWEEN 2004 AND 2015-2020

Navy	Current Force Strength	Planned/Projected Force Strength
Europe		
Denmark	2	0
France	4 SSBN	4 SSBN
	6 SSN	6 SSN
Germany	10	4
Greece	8	8
Italy	6	4
Netherlands	4	4
Norway	6	6
Poland	4	3
Portugal	2	3
Romania	1	?
Russia	15 SSBN	12-15 SSBN
	24 SSN	17 SSN
	13 SSK	1+? SSK
Serbia & Montenegro	2	0
Spain	6	4
Sweden	5	?3
Turkey	11	14
UK	11 SSN	6/8 SSN
	4 SSBN	4 SSBN
Ukraine	1	?
TOTAL	**145**	**108**
Africa		
South Africa	0	3
TOTAL	**0**	**3**
Middle East & North Africa		
Algeria	2	2
Egypt	4	0?
Iran	3	3
Israel	3	7
TOTAL	**12**	**12**
Far East & Australasia		
Australia	6	6
China	1 SSBN	2? SSBN
	4 SSN	5? SSN
	64 SSK	31 SSK
India	14	24*
		1 SSN
Indonesia	2	2+?
Korea, North	51	?
Korea, South	9	12+
Malaysia	0	2
Japan	16	16
Pakistan	8	5
Singapore	4	4
Taiwan	2	8
Thailand	0	?3
TOTAL	**181**	**121**
The Americas		
Argentina	3	2
Brazil	4	6
		1 SSN
Canada	3	3
Chile	2	4
Colombia	2	2
Ecuador	1	?
Peru	6	?6
US	14 SSBN	14 SSBN
	55 SSN	60 SSN/SSGN
Venezuela	2	2
TOTAL	**92**	**121**
GRAND TOTAL	**430**	**340**

* Plans to start acquiring 6 new Scorpene and 6 new Amur class submarines have still not been finalised



The mine threat is ever present and requires a considerable effort to counter. A missed mine can detonate with devastating effect, causing considerable damage and disruption to the movement of shipping. (Thales Group) *NEW*/0587917

time taken for major refits resulting from developments in importing COTS technology and basic modular construction techniques, open architecture and setting to work processes prior to fitting; the installation of much more advanced technology systems such as optical system, sonars, processing, display, stealth technologies and so on; and lastly for the diesel submarine the possibility of reconstruction with an AIP system to offer increased deep submergence capability, extended submerged endurance, improved stealth – all of which will greatly improve the capability of the SSK and allow it to offer advantages more akin to the SSN, which for most navies is unaffordable.

All these factors will help to counterbalance any overall drop in numbers of submarines capable of being deployed on a military mission. Last, but not least, is the fact that the use of modern materials, construction techniques and technology will allow the modern submarine to offer a fully effective operational life of up to around 30 years, rather than the current 20 to 25 years. However, such a statement has to be tempered with such indefinable long-term (that is about 30 years) factors as operational requirements and developments in technology, particularly sensors and stealth technology, all of which can change dramatically over a 15 to 25 year period.

So what conclusions can one draw from these comments? Firstly, that the potential submarine threat is alive and real and is becoming ever more elusive for the hunter to detect. New and developing technologies are making existing submarines more and more difficult to detect and counter for which a whole raft of different assets will be required just to counter a single boat, be it SSK or SSN. Secondly, the threat to the pursuer from the submarine is becoming increasingly severe as submarines deploy a wider range of more sophisticated weaponry and counter-countermeasures.

From the above table outlining force structure between 2004 and 2015-2020, one can see where the anticipated major changes will occur over the next 15 to 20 years or so. It is of interest to note that the bulk of the world's submarines are operated by the navies of Europe, the majority of who are members of NATO. This is no real surprise, for the strength of these submarine forces is a throw back to the days of the Cold War. The effect of the ending of the Cold War and the emergence of new asymmetric and terrorist threats is beginning to be felt. Overall it is estimated that the current submarine force strength will reduce from around 145 to 108 boats. The bulk of these losses will be sustained by Denmark, Germany, Italy, Spain, Sweden, Russia and the UK. As far as Russia is concerned, much of her nuclear powered fleet is obsolete and not really capable of operating effectively against modern, sophisticated highly trained ASW forces. In addition, since the ending of the Cold War the greater part of the fleet has been laid up, largely through lack of funding to maintain and operate it. Russia has now recognised that the current submarine inventory no longer meets the changed world situation and so large numbers of SSNs and SSBNs that have been laid up have been decommissioned and are being sent for scrapping. Since 1990 very little new construction has been undertaken, and what was on the stocks is taking a very extended time to complete – again primarily through lack of adequate funding. Completion of units on the stocks is now being delayed through indecision as to whether the design is possibly outdated – especially the equipment originally specified. This leaves the Russian Navy in a major dilemma. Whether to complete existing construction and try to modify the design to take account of technological advances since the boats were first designed, or whether to start again with new designs. This would mean that in the interim the submarine force would be operating with a very limited strength. The interesting fact is that the Russian Navy appears to be opting for an all-nuclear submarine force. This is surprising in view of the fact that the latest design of the Kilo class SSK has proved to be both a popular export design and an extremely effective underwater warfare platform. There do not even seem to be concrete plans to proceed with the latest Lada class SSK design, although further orders may well be forthcoming once the lead boat has completed its evaluation trials.

Turning to the Far East and Australasia, the table shows a surprising downturn of around 60 boats in the submarine forces of this region – and this in spite of a number of newcomers into the area of submarine operations, and a planned major increase in the size of the Indian fleet. Much of this reduction is accounted for by a run down in the strength of the PLA Navy's SSK forces from 64 to around 31 boats. This is realised by the removal from service of the large number of obsolete Romeo class boats currently held in inventory and by the fact that it does not appear as if they will be replaced on a 1:1 basis. However, this has to be tempered against the fact that the boats that will be in service in 10-15 years time will be much more modern than their predecessors and will constitute a far greater threat. Likewise, the North Korean fleet, which is now composed of obsolete boats that are probably incapable of diving to a depth of more than a few tens of metres. These will doubtless rot away at their moorings, and as of now there does not seem to be any indications that they will be replaced by new construction. North Korea has very few supporters in the world and although there is some submarine construction capacity within the country, this is aimed primarily at very small and midget type craft that are used for interdiction tasks along the South Korean coastline.

The other main region of the world where there are submarine forces are the Americas. A number of South American nations operate submarines, but only in very small numbers. Many of those are reaching the end of their operational life and any plan to replace these units is dictated by very restricted financial budgets and, on the whole, restrictive economies. Argentina, for example, has for years struggled to maintain a submarine force, and whether existing units will be replaced or not is completely dictated by the very limited naval budget which is primarily devoted towards maintaining a surface fleet.

The potential for the submarine to become the real up front player in modern network centred warfare was spelt out by the US Under Secretary for Intelligence, Dr Stephen Cambone, on 9 May 2003 on the occasion of the 103rd anniversary of the founding of the US Navy submarine service. In his speech Dr Cambone noted that ''As we transform intelligence, submarine warfare is on the cutting edge ... Submarine operations also will play a role in homeland defence, tracking, intercepting, and, if ordered to do so by the commander-in-chief, interdicting vessels that transport or employ weapons of mass destruction.'' In following up this theme it is now accepted, certainly by the world submarine community, that submarines are now capable of taking on a whole new range of missions, embracing much wider intelligence gathering and dissemination capabilities, deployment and support of special operations forces, and the deployment of UUVs and underwater-launched AUVs on a wide range of missions designed to extend the reach and influence of coalition forces against an ever increasing array and sophistication of targets both at sea and ashore.

But the character of the threat to the free world is changing, and the concept of underwater warfare must also change to meet that threat. To achieve such a step change will require radical rethinking in terms of technology, doctrine and tactics so that the threat continues to be contained on multiple fronts and across numerous theatres of operation.

As far as submarine construction is concerned, Europe is on the brink of a major contraction in capability. Yards specialising in submarine design and construction face a shrinking market that is showing no signs of rejuvenation. And in the light of comments made above, there is not likely to be any crumbs of comfort for these yards, certainly in the near to mid-term. With submarine construction yards

Force Strength 1996-2004

Navy	1996	1997	1998	1999	2000	2001	2002	2003	2004
Europe									
Albania	2	2	4	0	0	0	0	0	0
Bulgaria	2	2	2	1	1	1	1	1	0
Denmark	5	5	5	5	5	6	6	6	2
France	5 SSBN	6 SSBN	4 SSBN	4 SSBN	4 SSBN	4 SSBN	4 SSBN	4 SSBN	4 SSBN
	6 SSN	6 SSN	6 SSN	6 SSN	6 SSN	6 SSBN	6 SSN	6 SSN	6 SSN
	7	7	3	2	2	0	0	0	0
Germany	20	20	14	14	14	14	14	14	10
Greece	8	8	8	8	8	8	8	8	8
Italy	9	8	8	8	8	8	6	6	6
Netherlands	4	4	4	4	4	4	4	4	4
Norway	12	12	12	12	12	10	6	6	6
Poland	3	3	3	3	3	3	3	4	4
Portugal	3	3	3	3	3	2	2	2	2
Romania	1	1	1	1	1	1	1	1	1
Russia	39 SSBN	36 SSBN	26 SSBN	17 SSBN	17 SSBN	17 SSBN	16 SSBN	17 SSBN	15 SSBN
	70 SSN	69 SSN	39 SSN	30 SSN	30 SSN	24 SSN	22 SSN	22 SSN	24 SSN
	45	47	23	26	26	15	14	11	13
Serbia & Montenegro (formerly Yugoslavia)	5	5	4	2	2	1	1	1	2
Spain	8	8	8	8	8	8	8	6	6
Sweden	12	11	10	9	9	7	7	7	5
Turkey	17	17	16	15	15	13	12	12	11
UK	4 SSBN	2 SSBN	4 SSBN	3 SSBN	4 SSBN	4 SSBN	4 SSBN	4 SSBN	4 SSBN
	12 SSN	12 SSN	12 SSN	12 SSN	12 SSN	12 SSN	12 SSN	11 SSN	11 SSN
Ukraine	0	0	0	1	1	1	1	1	1
TOTAL	**299**	**294**	**219**	**194**	**202**	**169**	**148**	**154**	**145**
Africa									
South Africa	3	3	3	3	3	2	2	2	0
TOTAL	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**0**
Middle East & North Africa									
Algeria	2	2	2	2	2	2	2	2	2
Egypt	6	6	4	4	4	4	4	4	4
Iran	2	2	3	3	3	3	3	3	3
Israel	3	3	5	3	4	3	3	3	3
Libya	4	4	4	1	1	2	2	2	0
Syria	1	1	0	0	0	0	0	0	0
TOTAL	**18**	**18**	**18**	**13**	**14**	**14**	**14**	**14**	**12**
Far East & Australasia									
Australia	4	4	4	4	3	5	5	6	6
China	1 SSBN	1 SSBN	1 SSBN	1 SSBN	1 SSBN	1 SSBN	1 SSBN	1 SSBN	1 SSBN
	6 SSN	6 SSN	6 SSN	6 SSN	6 SSN	6 SSN	6 SSN	6 SSN	4 SSN
	77	82	60	91	90	66	68	61	64
India	18	18	17	18	18	17	16	16	14
Indonesia	2	2	2	2	2	2	2	2	2
Korea, North	22	22	44	44	44	48	48	49	51
Korea, South	3	5	7	7	7	9	9	9	9
Japan	18	17	19	18	18	17	18	18	16
Pakistan	6	6	7	7	7	7	7	8	8
Singapore	0	1	4	4	4	4	4	4	4
Taiwan	4	4	4	4	4	4	4	4	2
TOTAL	**161**	**168**	**175**	**206**	**204**	**186**	**188**	**184**	**181**
The Americas									
Argentina	4	4	3	3	3	3	3	3	3
Brazil	5	6	4	5	5	4	4	4	4
Canada	3	3	3	1	2	2	2	3	3
Chile	4	4	4	4	4	3	3	2	2
Colombia	2	2	2	2	2	2	2	2	2
Cuba	3	3	1	0	0	0	0	0	0
Ecuador	2	2	2	2	2	2	2	2	1
Peru	8	8	8	8	8	6	6	6	6
US	16 SSBN	17 SSBN	18 SSBN	18 SSBN	18 SSBN	18 SSBN	18 SSBN	16 SSBN	14 SSBN
	89 SSN	80 SSN	65 SSN	63 SSN	57 SSN	55 SSN	54 SSN	54 SSN	55 SSN
Venezuela	2	2	2	2	2	2	2	2	2
TOTAL	**138**	**131**	**112**	**108**	**103**	**97**	**96**	**94**	**92**
GRAND TOTAL	**619**	**614**	**527**	**524**	**526**	**469**	**449**	**448**	**430**

amalgamating, combing with other yards to design and build, and with greatly reduced demand for submarines, the future seems to be rather bleak. The dilemma for submarine yards in the immediate future is what to do with highly paid, motivated and expert design teams. With orders drying up and no near term plans for the next generation of boats, design teams which have taken years to train and build up will have to be dispersed and laid off. This will have a major impact on the future capability of navies to acquire the next generation of boats when the current generation begins to reach the end of its life. At a rough estimate it takes at least 10 to 15 years for a basic requirement to develop through the concept stage and initial planning to the acceptance of the final design. In todays rapidly changing world the initial requirement and concept may no longer match up to the situation when detailed design has to be undertaken. In that time there may no longer be a team available that is fully capable of realising a final detailed design.

One thing is certain, it will no longer be a national effort – there will have to be international collaboration in submarine design and construction. On the other hand in another 10 to 20 years we may well not be looking at the underwater submarine platform as we know it today.

However, there currently remains the problem of too many yards chasing too few orders. Already in 2003 the US owner of the German HDW yard announced that it was ready to put the yard up for sale, primarily as it was not proving economic to run, and through lack of progress over the Taiwanese submarine replacement programme and the political fall out which any such orders would cause with the PRC.

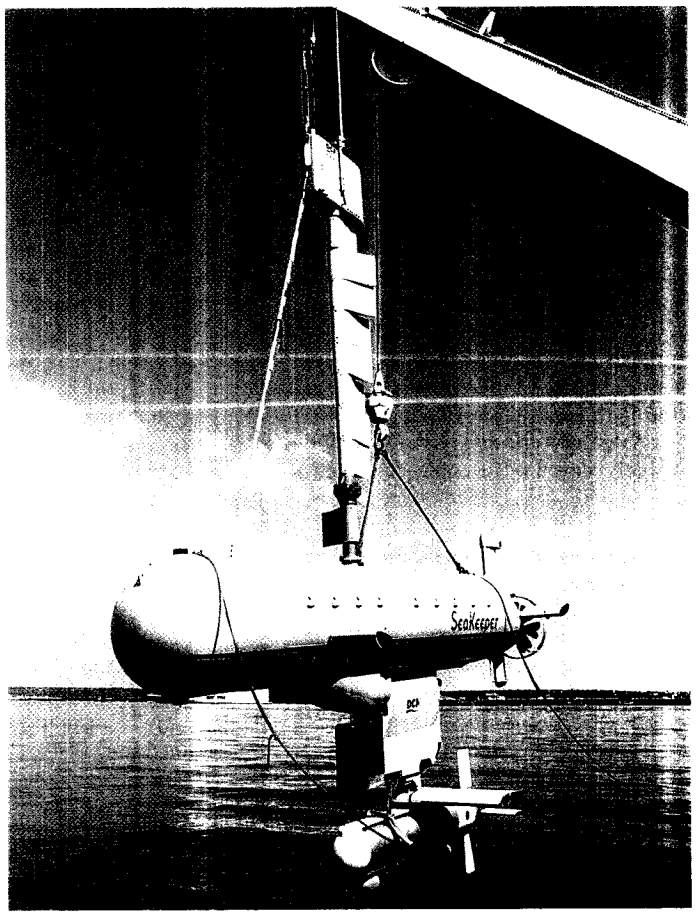
The German government granted its permission for HDW to be sold to DCN of France, but progress on this proposal has fallen through. Instead a new combine under the umbrella of ThyssenKrupp Marine Systems AG is to be formed (subject to regulatory approval), which will incorporate the naval construction yards of ThyssenKrupp Werften, HDW, Nobiskrug GmbH, Blohm & Voss, Nordseewerke as well as Kockums in Sweden, a subsidiary of HDW which through the GSC controls construction of German and Swedish designed boats assembled abroad and Hellenic shipyards of Greece. Such a marry up of some of Europe's main submarine yards will give them a world monopoly on SSK construction. However, such a move would not result in a reduction in the over capacity within Europe and across the world, for SSK construction.

Some yards must surely be in line for closure over the next 10 years – even those now setting up to assemble German designed boats. Top of the list will be those yards that have licence agreements for the assembly of German and French designed boats. Next in line would come those indigenous submarine construction yards in Europe not primarily responsible for designing boats – yards such as Izar of Spain and Fincantieri of Italy and possibly even Kockums.

Should the French DCN become fully publicly owned, then a merger with the Thales Group could well result with a final merger taking place between the French and German yards. This would go a long way towards rationalising naval construction in Europe – but it will not be easy to reconcile those yards which would inevitably close under such a plan.

In spite of what seems to be a bleak long-term future for European submarine construction yards, the near term is reasonably bright. Sea trials of the first German Type 212A AIP submarine began in 2003 and construction of the remaining boats is progressing well. The launching of the first Greek Type 214 AIP boat followed this. In addition three Type 209 boats without AIP are building for the South African Navy. In Italy Fincantieri is building two German Type 212A submarines for the Italian Navy and has an option on two more.

In France DCN is overseeing the final assembly and setting to work of the third AIP powered Pakistan Agosta 90B submarine. Other export work in progress includes two Scorpene class boats for Chile one of which has been commissioned, the second nearing completion at Izar in Spain as well as two Scorpene submarines for Malaysia, one building by DCN and the second by Izar in Spain. The Scorpene is a collaborative venture between France and Spain and with construction being split between the yards of DCN and Izar this enables Izar to maintain a submarine design and construction capability which will be ready to embark on the construction of the four S 80 type boats (derivatives of the Scorpene) for the Spanish Navy.



One system that could be used to hunt mines in restricted waters with complete safety for high value platforms and their crews is a UUV such as the French SeaKeeper. Such a system could also be used to considerable effect operating in conjunction with a static seabed defence system to provide round-the-clock surveillance and reconnaissance of vulnerable areas such as ports and the waterways leading to them.
(DCN) *NEW*/0587918

The mine warfare threat

But the submarine threat is not the only underwater threat with which navies have to contend. Closely linked to the terrorism threat is the mine threat. In some respects this is even greater than the submarine threat. The warning has been repeated so many times before by politicians to the military to naval commentators that it is in danger of becoming so hackneyed that the response is becoming 'oh no, here they go again.' But go again one must for the mine threat is very real, may come from any quarter – both the expected and the unexpected – and in any form, at any time, at any place. It is the cheapest and most easily deployed of any naval weapon and can have a sea/waterway denial capability out of all proportion to its size and cost.

For instance, Russia is believed to have a stockpile of many thousands of mines left over from the Cold War. Many of these are available for purchase on the open market through legitimate export outlets. In fact navies in the Middle East and Asia have purchased many of these mines. China too is exporting mines. While the requisite authorities doubtless do their best to ensure that any such sales reach a legitimate end user, such is the sophistication of the world's major terrorist networks that it can only be a matter of time before they manage to acquire some of these deadly weapons for themselves, or indeed start to manufacture their own.

Perhaps the easiest type of mine for the terrorist to acquire and deploy is the small, light and very easily concealed limpet mine. A few of these attached to the hull of a large merchant ship in a harbour or constricted waterway by a fanatical terrorist willing to sacrifice his own life could bring the trading ability of a major seaport to an almost complete standstill for a considerable length of time until a) the obstruction was cleared and b) divers had checked in detail the hull of every ship in the harbour, as well as the entire seabed of the port, to ensure that no other explosive devices were lying around.

To counter any such threat it is necessary for adequate ISR (Intelligence, Surveillance and Reconnaissance) measures to be in place to cover every major port. A number of systems are available on the open market and already some countries who consider this part of their economic infrastructure to be under threat have acquired some sort of underwater early warning capability. However, while such systems embrace a wide range of sensor technologies extending from

acoustics, seismic, infra-red, radar, optronic, and so on, the threat may well come in a form and from a source that is not easily recognised and detected. Already Al Qaeda is thought to have acquired a number of merchant ships that are probably legitimately trading around the world. What could be easier, therefore, than for one of those ships to carry one or two terrorists willing to sacrifice their lives and plant a few limpet mines on ships in a harbour when they dock. Even more of a threat would be to pack one of their ships with explosives and detonate it when alongside in harbour. These and many other stratagems are open to use by terrorists. The difficulty is in detecting his or her presence in the first place – which could require every crew member on board a ship to be screened before the ship entered harbour. This is not a practical step shipping companies would readily agree to for as with every commercial enterprise time is money, and a delay to a ship docking to pick up or offload cargo would cost vast sums of money. However, insurers may have something to say on this. The only relatively sure way of countering such a threat is extreme vigilance, coupled with an intensive effort to conduct ISR missions against any potential threat.

To deal with the threat outlined above may, on the face of it, seem an almost impossible task, while dealing with the moored, seabed or buried mine is a relatively much easier task. Again, however, to ensure that ports and the waterways leading to them are kept free from the threat of mines that requires constant and continual surveying of the region be undertaken. For some countries this will demand a prodigious effort, which their limited or non-existent MCM capability could not cope. Even countries operating a highly trained and effective MCM capability might find themselves with a problem in countering such a threat. The modern minehunter is an expensive platform to acquire, deploy and maintain, and even major navies possess relatively few such vessels. To provide effective cover against any mine threat therefore requires a mix of assets. Top of the list must come a highly detailed and sophisticated mine warfare database. This needs to be maintained, certainly on a frequent and regular basis, with fresh updates from surveys carried out by the minehunter or a suitably equipped survey vessel, itself not necessarily equipped for mine clearance tasks. This task could be greatly simplified and time on task for surface platforms greatly reduced if some form of static defence system protected vulnerable areas. This would enable a 24 hour watch to be maintained on highly vulnerable areas and MCMVs/survey vessels only called in to verify the presence of mines and where necessary dispose of them. This would free up the MCMV to be available as a 'flying doctor' ready to proceed to any emergency that may arise. Coupled with the MCMVs capability there needs to be an adequate pool of highly trained EOD divers also ready to fly out to any potential danger zone.

At the present time much effort is being devoted to developing organic MCM capabilities that can be deployed by major platforms in an expeditionary task force. While this is obviously a requirement for the near future, it is necessary not to neglect the potential for mine threats to be realised right on one's own doorstep, or even within one's own parlour! What has not yet been openly discussed as a possibility for providing surveillance of such an area is the use of the organic MCM system as an element of a static system. The use of a vehicle such as the US LMRS UUV system or French SeaKeeper operating on a programmed track pattern could do much to alleviate the onerous and costly (in financial, asset and manpower terms) task of carrying out a survey of a vulnerable port or waterway, providing not only an immediate picture of the areas under survey, but also valuable data to keep the mine warfare database up to date. The organic MSM system would provide an ideal platform for ISR tasks around harbours and waterways and would be a quick and cheap method with which to survey areas that for various economic and practical reasons could not be provided with an extensive static defence system.

As an example of how a potential mine threat might develop Iran, a lynch pin of George W Bush's axis of evil concept, is devoting considerable effort to procuring large mine stocks. But Iran does not intend to remain dependant on purchasing mines from China, for example, but is also developing an indigenous design and a manufacturing capability. These efforts all form part of Iran's strategy to exercise control over the Straits of Hormuz and ultimately to control the flow of oil from the region. With her three Kilo class submarines, which in the environmentally difficult ASW waters of the Gulf, she is in an ideal position to achieve this objective. Furthermore, with these submarines, small surface platforms and midget submarines (also being indigenously designed and built) she is very well placed to threaten any of the major exporting oil terminals in the Gulf, either by terrorist action or by conventional mining – and MCM forces in the region are provided primarily by coalition forces supported by the one Arab state which possesses an MCM capability – Saudi Arabia.

Against this pattern of a potential mine threat some navies are reducing their MCM capability without any form of replacement apparently under consideration. Thus the UK Royal Navy is to decommission two more Sandown class minehunters in the near future, while the Royal Netherlands Navy is to implement a major cutback in its MCMV modernisation programme with only eight ships now to be upgraded and five remaining vessels now being offered for sale. In addition plans to acquire drone craft for the MCMVs have been deferred until 2007.

In Poland little progress has been made towards starting construction of the new Kormoran class MCMVs, and with other major programmes being terminated or cut back, there must be doubts as to whether this programme will ever be undertaken.

In the Far East the only significant MCM force is that of the Japanese Maritime Self Defence Force which is committed to maintaining a force of 24 coastal MCMVs as well as the larger vessels of the Yaeyama class. All units are of modern design, and a new 570 ton class of minesweepers is being ordered to replace obsolescent units.

All told, the prospect for the future of MCM is not rosy.

Regional developments

Most navies view the fight against terrorism as an integral part of their mission and most are desperately concerned to secure the protection of their littoral waters to prevent any type of incursion, terrorist or otherwise, or threat from this quarter. Much of this effort is devoted to surveillance and intelligence gathering to both pinpoint potential threats and to cover vulnerable points such as harbours, rivers, remote spots where landings could take place unnoticed, and particularly merchant shipping which could be vulnerable to attack by frogmen armed with limpet mines. To ensure the security of these regions many navies deploy submarine, MCMVs and/or static seabed defence systems.

Northern Europe

Now that many of the former states which formed part of the Russian Communist sphere of influence have joined the European Union or moved closer to Western Europe's sphere of influence they are making prodigious efforts to build up their own security forces. So for example in southern Europe the Bulgarian Navy in the Black Sea is embarking on a programme to modernise its fleet, in particular re-equipping and modernising its minesweeping force to undertake minehunting tasks and to enable them to improve their mine warfare data collection capabilities as well as to provide security around the country's harbours and coastline. Likewise, over the next 10 to 15 years, Croatia (in the Adriatic) is to build up an integral underwater surveillance capability around its coastline to provide it with a detailed picture of events in the underwater domain within its sphere of influence. To achieve this one of the most important and urgently required assets are MCMVs that will be used both for counter terrorism activities along the Croatian littoral and to build up a detailed picture of the seabed in the area. This programme may also include the acquisition of static seabed defence systems.

In northern Europe, Belgium is one of those navies, which, while not possessing a large naval force, is, nevertheless determined to secure the waterways within its sphere of influence. Thus for the immediate future the Navy will focus on improving its MCM capabilities to ensure the myriad waterways (in particular the exit region of the large and very important Schelde river) that form part of the Belgian coastline are kept free of mines, but more particularly that the region is secured against any unwelcome intrusion by hostile terrorist type forces.

In Portugal the Navy's mine clearance diving teams will receive new equipment, which will enable them to carry out EOD tasks more effectively. Next door, in Spain, Izar is gearing up to start work on the construction of the four new S 80 class submarines to eventually replace the existing two Daphne and four Agosta class boats, which are now obsolete.

Farther to the East, Poland in the Baltic is building up her MCM force and developing an in-country design and manufacturing capability to provide the Navy with the necessary systems and equipment with which to conduct effective MCM operations. But these systems are not only being provided for the Polish Navy, but are also being offered for export, in particular countermine charges and static seabed defence systems. Within a short time the country has also

PROJECTED CHANGES IN MCMV FORCE STRUCTURE
BETWEEN 2004 and 2010-2015

Navy	Current Force Strength	Planned/Projected force Strength
Europe		
Albania	4	?4
Belgium	7	7
Bulgaria	20	6
Croatia	0	1
Denmark	4	4
Estonia	5	3
Finland	13	9
France	13	13
Germany	22	22
Greece	13	10
Hungary	3	?3
Italy	12	8 + ?
Latvia	3	?
Lithuania	2	?
Netherlands	10	8
Norway	8	8
Poland	22	?34
Romania	16	16
Russia	41	32
Serbia & Montenegro	9	2
Spain	5	8
Sweden	12	11
Turkey	25	6
Ukraine	5	3
UK	22	?15
TOTAL	**296**	**233**
Africa		
South Africa	6	4 + ?
Nigeria	2	?
TOTAL	**6**	**? + 4**
Middle East & North Africa		
Algeria	0	2?
Egypt	12	5
Libya	5	5
Saudi Arabia	7	3
Syria	5	0
Yemen	6	0
TOTAL	**35**	**13**
Far East & Australasia		
Australia	8	12
Bangladesh	5	4
India	14	18
Indonesia	12	2
Japan	29	27
Korea, North	24	15
Korea, South	15	14
Malaysia	4	4
Myanmar	0	2
Pakistan	3	3
Singapore	4	4
Taiwan	12	4 + ?
Thailand	6	4
Vietnam	13	?0
TOTAL	**149**	**113**
The Americas		
Argentina	0	?
Brazil	6	6
Canada	12	12
China	17	3
Cuba	5	2
USA	26	?10
Uruguay	3	0
TOTAL	**69**	**33**
GRAND TOTAL	**555**	**396**

developed a capability to develop minehunting sonars and combat management systems, all of which will be installed on a new generation of MCMVs.

The following table gives some idea of the importance which most navies give (or do not give as the figures demonstrate) to the importance of MCM. Overall there is a considerable downturn in the number of platforms that will be available for MCM in about 10 years time. From a total figure of 555 vessels today, it is estimated that the figure in 10 years time will be around 396. All regions show a decline in MCM capability over the next 10 to 15 years, but it is in Europe that the greatest decline is noted. Navies previously regarded as being at the forefront of MCM capability and technology are now reducing platforms by a considerable number. For example Finland, Italy and the UK. Others such as some former Warsaw Pact nations will have reduced capability, largely because much of their present fleet is based on obsolete Russian construction which can no longer be maintained, and for which no replacement budget is available. The Middle East and North Africa is another region where numbers are falling, again due primarily to the fact that many of the units are of Russian construction and are now obsolete. An area where there is a surprising drop in numbers is in the Far East and Australasia, where the figures may fall from the current 149, to 113, a drop of 36. Much of this will be accounted for by the decommissioning of obsolete hulls for which currently no replacements are envisaged. Finally the Americas will also see an overall drop in numbers of about 36 hulls. Around 10 of these may well be accounted for by the decommissioning of US units, particularly as organic MCM capability begins to enter the fleet in increasing numbers.

Obviously the projected strength is very difficult to estimate for much depends on whether some nations decide over the next five years to implement a programme of new construction to replace obsolescent units. Others have stated an intention to acquire new MCMVs but have yet to formulate any strategy with regards to numbers. Sadly MCM has always been the Cinderella of naval forces, and this shows up only too well in this table.

One thing does have to be borne in mind, however, when reading these figures. Experience has shown that MCMVs tend to be kept in service for very much longer than any other type of platform. As long as their hulls are maintained in a seaworthy condition (both wood, composite and GRP) it seems as if they can go on almost forever. For instance a number of navies are still operating MCMVs that date from the time of the mid-1950s, giving them an age of well over 40 years! However, it has to be assumed that many of these will no longer be operational, or even capable of being maintained in another 5 to 10 years time and must therefore be considered as having been removed from service for the purposes of the above table, and at present there do not appear to be any plans to replace them.

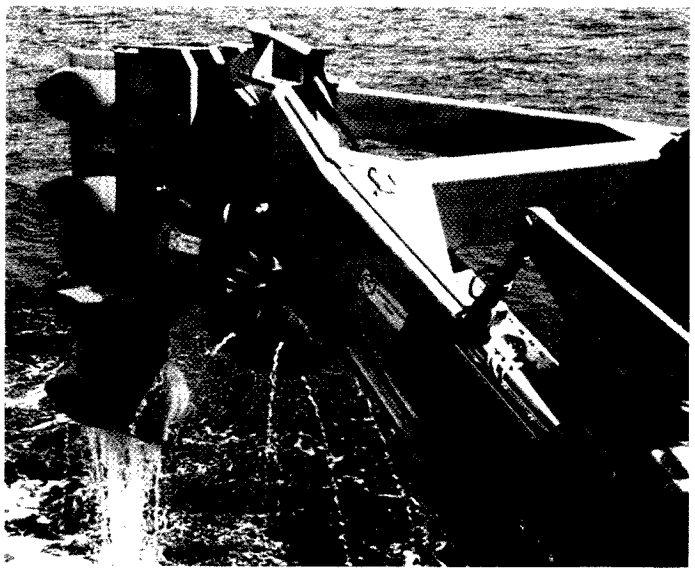
As such, therefore, the projected strength given is quite speculative for some nations and will depend on the degree to which they are either prepared to keep obsolete vessels in commission, or replace them.

Technological developments

Technological developments in the areas of submarine warfare, ASW and MCM are now moving so rapidly and in so many different directions, that it is almost impossible to embrace them all and give pointers for the future. Great strides have been made in the last decade in the design and equipment for submarines. To mention just a few there have been tremendous advances in signal processing, in acoustic and optical sensors, in display presentation, stealth technology and the development to an operational stage of AIP for SSKs. In the main such technological advances have been of primary benefit to the submarine, a factor which is reflected in the realisation that this particular platform probably still poses the primary threat to any other surface or submerged platform and will, in the future, provide a primary intelligence threat to any potential adversary.

However, the shift from blue water to brown water littoral operations has brought with it severe implications for both the hunter and the hunted. Acoustic conditions in the littoral waters can both be a help and a hindrance to the hunter and the hunted. On balance, however, the advantages lie with the submarine, which, because it is operating in a three-dimensional arena is better able to take advantage of the acoustic conditions than the surface platform that operates in only two dimensions.

The real threat to the submarine now comes from the helicopter which also operates in a three-dimensional arena and which is able to



Sonar 2087, a LF active towed sonar with passive receive array, is one of the new generation of sonars specially developed to carry out long-range surveillance and perform long-range detection of extremely quiet submarines. (Thales Group) NEW/0587919

deploy the latest acoustic sonobuoys and dipping sonar sensors in a multistatic formation with surface platform sensors and processing capabilities. This creates a very real deterrent to submarine operations, particularly when combined with the latest lightweight ASW torpedoes.

The threat from the helicopter is so restricting on submarine movement that new weapons configurations are being studied for deployment aboard submarines to counter the threat. Combined with new concepts for modular masts capable of hoisting all the latest types of optical and electronics sensors, these are now being adapted to handle guns and missiles capable of interdicting an attacking helicopter from a shallow submerged position. Also included in this armoury are additional new sensors (non-radar and EW) capable of detecting the presence of a helicopter in the submarine's operational area.

Knowledge of acoustic conditions is obviously a determining factor in both submarine warfare and ASW. To this end new technologies are being applied under Rapid Environmental Assessment (REA) Programmes designed to more accurately predict the behaviour of sound underwater in all conditions and areas and to offer both hunter and hunted a better chance to avoid/achieve detection. One area currently the subject of study is real time Matched Field Processing (MFP) that seeks to integrate knowledge of the underwater environment and mathematical inversion methods to achieve detection and localisation of sound sources in three dimensions, and as a further aid to classification.

For both surface and submerged platforms the main threat remains the torpedo and prodigious efforts have been devoted to developing sensors and signal processing algorithms capable of detecting the presence of an incoming high-speed torpedo. This work is being integrated with new torpedo countermeasures systems designed to camouflage the intended target, or to decoy the torpedo away from it. Thus a new range of mobile and stationary sound sources and jammers is being developed both for submarines and surface platforms, as well as hard kill torpedo countermeasures. However, none of these systems will be of benefit unless the intended target can gain early detection and classification of the torpedo threat and for this the passive sonar is most effective.

But torpedo design does not stand still and weapons like the British Stingray and European Impact are being provided with sophisticated algorithms that will enable them to separate false acoustics from real target signatures, allowing them to burn through decoys and jammers to search for the real target.

One of the most important aspects in underwater warfare is the need to achieve detection of a target at the earliest opportunity. For this both surface and submerged platforms require the latest sonar technology available in order to stay ahead of any potential adversary.

Recent efforts have centred on the development of LFAS (Low Frequency Active Sonar) arrays. These rely heavily on broadband transducer technology combined with high power sound sources and centre frequencies of a very low order (in the order of 500 Hz to 1 kHz). To receive returning echoes a towed passive array is used which may cover a frequency range extending from 10 Hz to 2 kHz. Such systems can achieve very large propagation distances and hence long detection ranges. With a high bandwidth, the LFAS can prove to be highly effective in shallow water, overcoming the problem of scattering reflection (from both the surface and seabed), ambient noise, reverberation and so on. To achieve this requires advanced intelligent pulse shapes. But the LFAS does not offer a 100 per cent certainty of detection. Submarines close to the seabed or coastline remain almost impossible to detect, especially if they are stationary. To achieve detection in these circumstances requires other new technologies to be employed. Other challenges in littoral waters relate to the possibly limited freedom of movement when towing a very long array. In this case the solution may lay in the development of Synthetic Aperture Sonar (SAS). Synthetic aperture processing will allow a much shorter array to be deployed while achieving the same performance as the extended array.

For submarines the development of one and two-dimensional hydrophone arrays spread along the entire length of the outer hull will offer the possibility of much more accurate detection and localisation of targets at long range. However, this will require the development of new transducer materials combined with much higher computer power.

Finally, for submarines, the development of a truly thin line array would offer tremendous advantages in reducing the volume and weight of the winch and handling system, allowing even quite small submarines the possibility of deploying towed reelable arrays.

In the field of mine warfare both minehunting and sweeping with influence and mechanical sweeps will continue to see technological developments aimed at improving their capability. Likewise OED divers and special operations forces will be provided with new systems to enable them to carry out their tasks effectively.

The main area of concern to MCM forces is the increasing sophistication and complexity of mine logic, which considerably delays the prosecution of mine clearance operations. The main counter to the development of mine logic is to use target simulation minesweeping and a number of systems are now reaching operational status. The problems with systems currently reaching service, or indeed with most influence sweep systems, is that they have to be towed by a surface platform. This immediately puts the towing platform in an extremely vulnerable position, for if the MCM forces select the wrong target simulation mode then the towing platform may well be at severe risk from mines set to react to the sweeping platform. This threat to the MCMV can be overcome by using an unmanned surface drone to deploy the influence sweep. The loss of an unmanned, relatively unsophisticated drone, is much more acceptable than the loss of a high value MCMV with its highly trained and expert crew.

The alternative to sweeping operations is to conduct minehunting operations, but this takes time, and time may not be on the side of the MCM force. In fact such is the threat facing surface forces and submarines from the mine, that an entirely new concept, organic MCM, is being developed in which surface and submerged platforms will carry their own unmanned vehicle to carry out reconnaissance in advance of the deploying platform and seek out mine free routes, recording details of the routes that have been blocked by mines. This will enable MCM forces to conduct a much more detailed and safer counter mine operation after the main task force has reached its area of operation and secured the area. However, organic MCM cannot at present provide full protection against the mine threat in constrained areas such as narrow waterways leading to a major port. To clear such a waterway for landing forces and forces bringing in back up supplies to an army ashore will require that more conventional MCM forces will have to face the possibility of retaliation by hostile forces in order to clear a safe route through to a port. This much was realised during the latest war in Iraq when MCM forces had to clear a route through to the port of Umm Qasr so that humanitarian supplies could be brought forward and back up supplies for the army landed.

Conclusion

Perhaps it is time once again for all free thinking people to heed the words of Sir Winston Churchill stated in the late 1930s ''The era of procrastination, of half-measures, of soothing and baffling expedience, of delays, is coming to a close. In its place, we are entering a period of consequences.''

Those consequences may well herald disaster unless the underwater threat is taken heed of, particularly in the current climate of terrorism.

Anthony J Watts, Newdigate, November 2004.

ACKNOWLEDGEMENTS

An editor always seeks ways and means of improving the content of a reference work, the mainstay of which is the amount of new information and illustrations that can be included. Not only is it necessary to expand and develop new coverage, but also it is necessary to ensure that existing entries are as up to date as possible. Any reference work is only as accurate as the day each entry goes to press and inevitably in such a work as this, some entries will be out of date when they appear in print, although up-to-date information is available online, and a slightly less updated version on CD-ROM. It is therefore understandable that such a wide-ranging subject as this work on underwater warfare cannot claim to be fully comprehensive, although every effort is made to make it so. Systems and equipment cannot be included if the editor is unaware of them. In spite of the fact that changes to equipment do not occur overnight, systems are continually undergoing development and hence change, which it is the duty of the editor to record. New orders are also being placed which we would like to record in this title.

The work on revising entries continues throughout the year. To achieve this, the editor relies both on the suppliers and the users of equipment to provide new information and illustrations. This is supplemented by information gleaned from other sources; news and information supplied by various contributors around the world and the editor's own extensive records and photograph library.

To assist the editor in updating the yearbook, a copy of the current entry is sent to the appropriate contractor each year with a request for amendments. It is essential that these be returned promptly to ensure that the entry is accurate and up to date. Because of the volume of change now being incorporated into the title, major contributors are asked to forward any new information as soon as it becomes available.

Readers' contributions, suggestions, information and photographs are of considerable importance and welcomed by the editor. Material can be sent in a variety of ways to the editor or the publishers at the following addresses:

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Compiling such a work as this has to be a team effort, and it is a pleasure to acknowledge the help and support from other editors and contributors and the team at Jane's. Apart from primary sources used, many of Jane's publications prove invaluable in updating and confirming information; in particular *Jane's Fighting Ships, Jane's Naval Weapon Systems* and *Jane's Underwater Technology* and their editors Commodore Stephen Saunders, Ted Hooton and Cliff Funnell. Jane's magazines, including *Jane's Navy International, Jane's Defence Weekly* and *International Defence Review* are also invaluable sources of reference. I would also like to thank Michael Nitz both for his excellent photographs, a number of which appear in the work, and also for updated information concerning submarine construction in Germany. Other major sources include the United States Naval Institute *Proceedings* and *Warship Technology* from the Institute of Naval Architects.

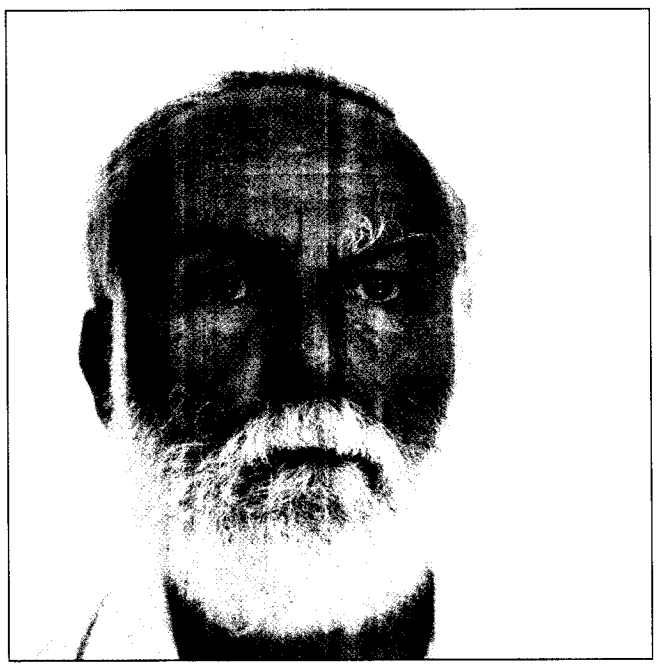
Finally, it would be impossible effectively to compile this work without the help and support of the excellent back-up team at Jane's.

Under Melanie Rovery, the in-house editorial team performs a major task and helps to sort out many problems. In revising, it is easy to miss spelling errors and quirks of phraseology that creep in, not to mention understandable typographical errors in the mass of data and specifications peculiar to the underwater engineer. It is an encouragement to know that another opinion is always available and that other checks are being made. Standardising the large number of entries, simplifying, and explaining complex technical terms and technology in a work such as this is a huge task, which is greatly eased with such a valuable team. I would also like to thank my managing editor David Shipton for all his encouragement and support.

Thanks are also due to the staff at Biddles Ltd who are responsible for the finished product.

ANTHONY J WATTS

Tony Watts has been editor of *Jane's Underwater Warfare Systems* since 1990. After training and working as a sound engineer for the BBC Overseas Service, he became editor of *Navy International* in 1978 and publisher/editor from 1985 until 1994 when he sold the magazine to Jane's. From 1969 to 1975 he acted as naval consultant to the publisher Ian Allan Ltd, editing numerous books in their naval catalogue. He has had over 25 naval books published, including a world-recognised standard reference work on 'The Imperial Japanese Navy'; 'The U-Boat Hunters', describing the history and technical developments of anti-submarine warfare in the Second World War; 'The Royal Navy — an Illustrated History' covering the development of the Royal Navy from 1815 to 1995; and a technical reference work on the 'Imperial Russian Navy', as well as numerous other books on naval aspects of the Second World War. He has also written numerous articles on naval matters for many publishers as well as presenting a paper on ASW to the North Atlantic Council and chaired conferences on ASW and Littoral Warfare. Tony has appeared on various TV and radio programmes to discuss current naval issues and written programmes on naval subjects for radio.



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SUBMARINES

The submarine

Submarine forces

Aspects of submarine design

Submarine and submersible designs

Submarine escape and rescue systems

Machinery and platform control systems

THE SUBMARINE

Introduction

Any country with a littoral and, even more so, island states are almost entirely dependent on sea lines of communication for their continued existence. The protection of those sea lines against underwater attack is vital for the safe carriage of imports and exports (food and materials and, during hostilities, reinforcements to support the war effort), as was evidenced during the First and Second World Wars. Sea lines are also vital to a continental power such as the United States because, if it were to become engaged in hostilities, it would need to support its forces wherever they were engaged, and this is now increasingly having to be undertaken in littoral waters. The enormous movements of troops and supplies prior to and during the recent war with Iraq in 2003, indicates that in the future such is likely to remain the case.

The modern submarine is the most powerful weapon that a navy can count in its order of battle. It provides considerable fighting potential, and ought to form a vital and integral element of any homogenous fleet. In recent years the underwater speed of even diesel-electric submarines has increased enormously. Their capability is now being further enhanced with the fitting of Air Independent Propulsion (AIP) systems. Modern submarines are also extremely quiet, particularly when running at slow speeds, and many new-build boats use acoustic cladding to further reduce their signature. Its high underwater speed, extended cruising range, powerful weapons, and acoustic discretion enable the submarine to take maximum advantage of the underwater environment. As such, therefore, the submarine is, and will remain, a viable and extremely potent weapon system and available for use in an ever increasing number of roles.

Types of submarine

Four main categories of submarine are currently identified. Of these, the most powerful is undoubtedly the strategic submarine (SSBN) deploying long- and medium-range strategic nuclear weapons. At present only the major powers (China, France, the Russian Federation and Associated States (RFAS), the UK, and the USA) have such lethal weapons at their disposal. However, as some smaller powers begin to acquire nuclear-powered submarines, then it is possible that at some point during the next two decades, they too will acquire the ability to deploy submarine-launched strategic missiles, unless they are willing to abide by the strategic arms limitation treaties.

The second category is the nuclear-powered attack submarine (SSN). This too, is a very powerful weapon, capable of launching not only conventional torpedoes, but also long-range anti-ship missiles, and long-range, stand-off, conventionally armed land attack missiles. One of the main roles of the SSN is Anti-Submarine Warfare (ASW), for which it is eminently suited with its high speed, powerful torpedoes and long-range capability. For the SSN this entails tracking, at extended ranges, using its highly sensitive integrated sonar suite with powerful towed and flank array sonars.

But the SSN does not always operate as a lone unit. It also has the ability to co-operate with other forces, both surface and subsurface, and is suitable for use with integrated task groups providing an advanced protective screen against hostile submarines and surface forces. This is a role within the network centric warfare concept that will become increasingly important in the years to come. However, it will only prove of value if the problems affecting communications are satisfactorily solved.

The SSN has become a key player in strike warfare, as has been proven in the Arabian Gulf region and Adriatic where it showed itself well suited to the task of theatre missions, deploying long-range land attack missiles such as the US Tomahawk. In this guise, and with its extended range anti-ship missiles and long-range torpedoes, the SSN offers a covert force multiplier to the surface task group. As such the SSN has shown that it is fully capable of dominating not just the underwater battlespace but the land battlespace as well. This has now become one of the SSNs primary missions made possible by the ability to download target data from a satellite, enabling it to conduct over-the-horizon engagements, well out of range of hostile surface forces.

A new role, which is now increasing in importance and to which SSNs are being assigned, is that of clandestine operations. For this a number of British and US submarines are being fitted with Dry Deck Shelters for the carriage of new and advanced Swimmer Delivery Vehicles (SDVs). In this role the SSN will be used to support expeditionary warfare operations. This role is also being considered for some redundant SSBNs. This role will be expanded even further with the possible inclusion of UUVs and UAVs in the submarine's armoury.

Of the major powers, Russia still possesses a submarine force of some considerable size, which continues to receive high priority in the defence budget in spite of massive cutbacks in expenditure. However, many of the former Soviet Union's nuclear-powered submarines are now being set aside for scrap. In an effort to draw in foreign currency reserves and assure its position in the market place, Russia is now engaged in a much more intensive marketing exercise world-wide, and has achieved major success in exporting its diesel-electric 'Kilo' design. However, this effort seems now to be dwindling as the world's submarine fleets complete consolidation of their forces in the new world scenario. The two nations where Russia may continue to achieve export success is China and India.

Except for the navies of China, France, Russia, the UK and the USA, the SSN has been considered to be well beyond the financial and operating capabilities of most navies. However, some navies are now actively pursuing the acquisition/construction of SSNs. India and Brazil, for example, are developing nuclear propulsion plants suitable for submarines, and developing the ability to build such vessels, and examples might well begin to enter service around the year 2015.

There are, however, some tasks which, to a degree, fall outside the scope of SSNs, and to which they are actually unsuited. Such tasks can only be undertaken with any real possibility of achievement by SSKs (non-nuclear submarines).

Because of its smaller size and greater stealth, the SSK is much more suited to very shallow water operations than the SSN.

The standard role of the SSK is to counter hostile surface forces. In this, the boat either acts alone or in conjunction with other SSKs or friendly surface and shore-based forces. Other tasks to which the SSK is highly suited include the conduct of economic warfare, a task for which it proved to be more than ideally suited in two World Wars. Furthermore, it is an ideal platform from which to carry out clandestine operations, although these roles are now being increasingly undertaken by SSNs as well.

Two other roles for which the SSK is eminently suitable include minelaying and surveillance although, SSNs are also tasked with these missions. Minelaying is a task that is not relished by submariners, for while engaged in such operations the submarine is precluded, by the nature and requirements of the task and the lack of space for other weapons, from carrying out any other mission, except perhaps that of surveillance. The SSK is most effective in the minelaying role when used to prevent or hinder the passage of high-value units or for laying coastal minefields in the face of hostile forces for defensive or offensive purposes.

Likewise, in a surveillance or reconnaissance role, until the mission is accomplished, the SSK is precluded from undertaking other roles. In some countries, where the threat of amphibious assault is considered very high, the SSK is used as an advanced line of defence to counter any such hostile operation.

The other tactical role for submarines is convoy protection. For fairly obvious reasons this too is a role that is not greatly relished by submariners, for it is fraught with the potential danger of mistaken identity by friendly forces. Even so, with its high speed and extended sonar range, the submarine can provide an important dimension to convoy protection.

Finally, in the ISR (Intelligence, Surveillance and Reconnaissance) role, the submarine (both SSN and SSK) is proving to be an important weapon in the fight against terrorism and criminal activities such as drug running, arms smuggling and illegal immigration. At the recent SUBCON2003 submarine conference held in Kiel, delegates heard how the Colombian submarine force is being used to track drug running operations in the Caribbean. Submarines are also proving invaluable in carrying out COMINT operations against terrorist groups.

The fourth category of submarine is the midget. This is a highly specialised craft designed to undertake very specific clandestine missions. Being very small, these craft are able to penetrate very close inshore virtually undetected. They are, therefore, ideally suited to laying mines in vulnerable points such as the entrances to anchorages and major ports, to attack invasion forces with mines or torpedoes, and to infiltrate specialised personnel such as saboteurs, spies, or advance reconnaissance parties prior to an amphibious assault. Twice in recent years North Korean small displacement submarines have made headlines when captured off the South Korean coast. In each instance the submarine was carrying a number of North Korean infiltrators, all of whom were killed before they could carry out their mission.

Midget submarines are fitted with the minimum of equipment, sufficient merely to carry out their assigned tasks. They have limited range capabilities, but these are adequate enough to allow them to operate unaided by other surface forces. Weapons stowage is very limited, but they can transport mines and carry a limited amount of military cargo such as explosives as well as personnel. The crew is small in number and expected to perform a variety of functions commensurate with the task in hand. Stealth is of the utmost importance to the conduct of midget submarine operations.

Whatever the tactical role and strategic requirement for the submarine, there is no doubt that, being a covert weapon, it can exercise an influence out of all proportion to its size and cost. Never was such potential more clearly displayed than in the Falklands (Malvinas) War of 1982. Although the Argentine SSKs failed to achieve any real success, their presence in the area of conflict forced the Royal Navy to expend a major ASW effort on the protection of the surface warship groups and the merchant ships sailing with the assault force. Likewise the presence of UK submarines (both SSNs and SSKs) exerted a paralysing effect on the Argentine Navy, particularly after the sinking of the *Belgrano* by a submarine-launched torpedo.

Fleet strengths

The accompanying tables list those countries currently operating submarines and the state of the fleets. In August 2004, a total of 43 countries boasted a submarine inventory of 455 boats. Five countries had in service 138 nuclear powered submarines (of which 40 were SSBNs) while 40 countries possessed 317 SSKs. A total of nine countries possess at least 63 midget submarines. Others may possess midgets, but information on these is not available.

SUBMARINES FORCES WORLDWIDE AUGUST 2004*

Country	SSBNs	SSNs	SSKs	TOTAL
Algeria			2	2
Argentina			3	3
Australia			6	6
Brazil			4	4
Bulgaria			1	1
Canada			4	4
Chile			3	3
China	2	4	64	70
Columbia			2	2
Denmark			4	4
Ecuador			2	2
Egypt			4	4
France	4	6		10
Germany			13	13
Greece			8	8
India			16	16
Indonesia			2	2
Iran			3	3
Israel			3	3
Italy			6	6
Japan			19	19
North Korea			51	51
South Korea			9	9
Libya			2	2
Malaysia			1	1
Netherlands			4	4
Norway			6	6
Pakistan			8	8
Peru			6	6
Poland			5	5
Portugal			2	2
Romania			1	1
Russia	16	23	13	52
Serbia & Montenegro			2	2
Singapore			4	4
Spain			6	6
Sweden			7	7
Taiwan			4	4
Turkey			14	14
Ukraine			1	1
United Kingdom	4	11		15
United States	14	54		68
Venezuela			2	2
TOTAL	**40**	**98**	**317**	**455**

* Not including midget submarines

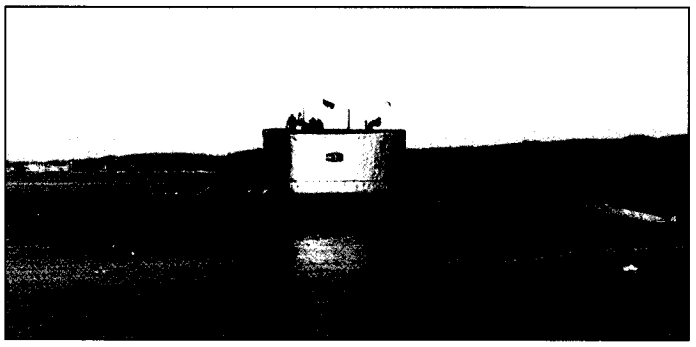
Following the acceptance of the strategic nuclear weapons treaties, both the Russian and US navies have been progressively decommissioning large numbers of older SSBNs. Once construction of the latest generation of SSBNs in the American, British and French fleets has been concluded, little construction in this category of vessel will be undertaken until at least the second quarter or middle of this century.

In all the navies currently operating SSNs, emphasis is now centred on developing the next generation of boats, for which design studies are now well under way. However, the early generation of SSNs is now in considerable need of modernisation (particularly with regard to command systems and sensors), or replacement by new construction. This is at present being undertaken in the Russian, UK and US navies.

The USA, because of her geographical and strategic position, is firmly wedded to the doctrine of the all-SSN fleet. However, the ending of the Cold War has led to a major reappraisal of the USNs submarine requirement. The SSN-21 Seawolf programme will now end at just three boats. For the future, the USN is studying plans for a less sophisticated SSN and the first of the new Virginia class has been commissioned.

However, future force projections indicate that the current level of 55 boats will be inadequate to meet the demands that will be placed upon the underwater fleet. Studies indicate that a force of at least 68 boats will be required by 2015, but this is unlikely to be met if the current low rate of construction is maintained.

The UK has ordered the first three boats of the Astute class and work on the first is well underway. A second batch is likely to be ordered towards the end of the decade. Work is also well in hand on a major upgrade to be undertaken on the earlier Trafalgar class SSNs and some of the Swiftsure class, known as the 'S & T' Update. Work has also begun on defining the requirement for the next generation submarine, and work will shortly commence on defining the replacement for the Trident strategic nuclear weapon and its launch platform. The ending of the Cold War has led to a reappraisal of the need for SSKs and the four boats of the Upholder class have been leased to Canada. The Royal Navy is adapting to the changing strategic order and the submarine service is addressing this need to embrace the maritime contribution to Joint Operations formulated by the navy. Under this concept the full potential of the SSN will be realised across a wide range of tasks. Included in the new philosophy is the concept of improved integration of



Proliferation of submarine forces is likely to continue in the foreseeable future, with units equipped with increasingly sophisticated technology. The photograph shows the Indian Russian-built Kilo class submarine Sindhuraj (Michael Nitz) 0561637

Intelligence, Surveillance, Targeting and Reconnaissance (ISTAR), especially in littoral waters. The need to operate much closer inshore means that land based targets are now often within range of electro-optical and RF sensors, which allows the boat to carry out covert observation and intelligence gathering, a vital element in the war against terrorism. The submarine service is undertaking a wholescale shift of doctrine to the network centric concept of operations. Included in this is a range of new equipment capabilities that will improve the submarine's effectiveness in littoral warfare.

France has modified her position with respect to a mixed SSN/SSK fleet. The SSKs have been withdrawn from service and will not be replaced by SSKs. Development of the SSN fleet will, however, continue, with a new generation of boats now in the early definition stage. However, the French have decided not to continue construction of the latest Amethyste class, but the existing boats and the Rubis class will be modernised to the latest Amethyste standard.

In Russia, construction of SSNs will continue at a very much reduced pace.

Most other major Western powers either cannot afford the SSN, or do not see a role for it. European NATO navies are therefore modernising existing SSK fleets, or are embarking on new construction. However, in the light of recent events and the changed world order, a number of navies are reviewing their requirements for new submarines, and with a downgrading of strengths in some navies, the potential for new construction is somewhat volatile. The latest country to revise its submarine requirement is Denmark, who in their latest projections have decided to completely disband their submarine force. This may have a major impact on Sweden's requirement for a future submarine, for both countries were to embark on the acquisition of Viking type boats.

It is interesting to note that many NATO navies, some operating 'out of area' for the first time, are routinely carrying out missions in waters that are so shallow that they can no longer 'go deep' to evade hostile forces. In this type of scenario it is imperative that the boats are provided with the means to stand and fight. Considerable effort is being paid to the submarine's self-defences with new EW systems capable of operating in a dense electromagnetic environment with other systems such as SATCOMs operating in the same bands and friendly radars operating nearby in the littoral. The ASW helicopter is now considered to be the major threat facing submarines operating in the littoral and a number of developments are underway to counter this threat.

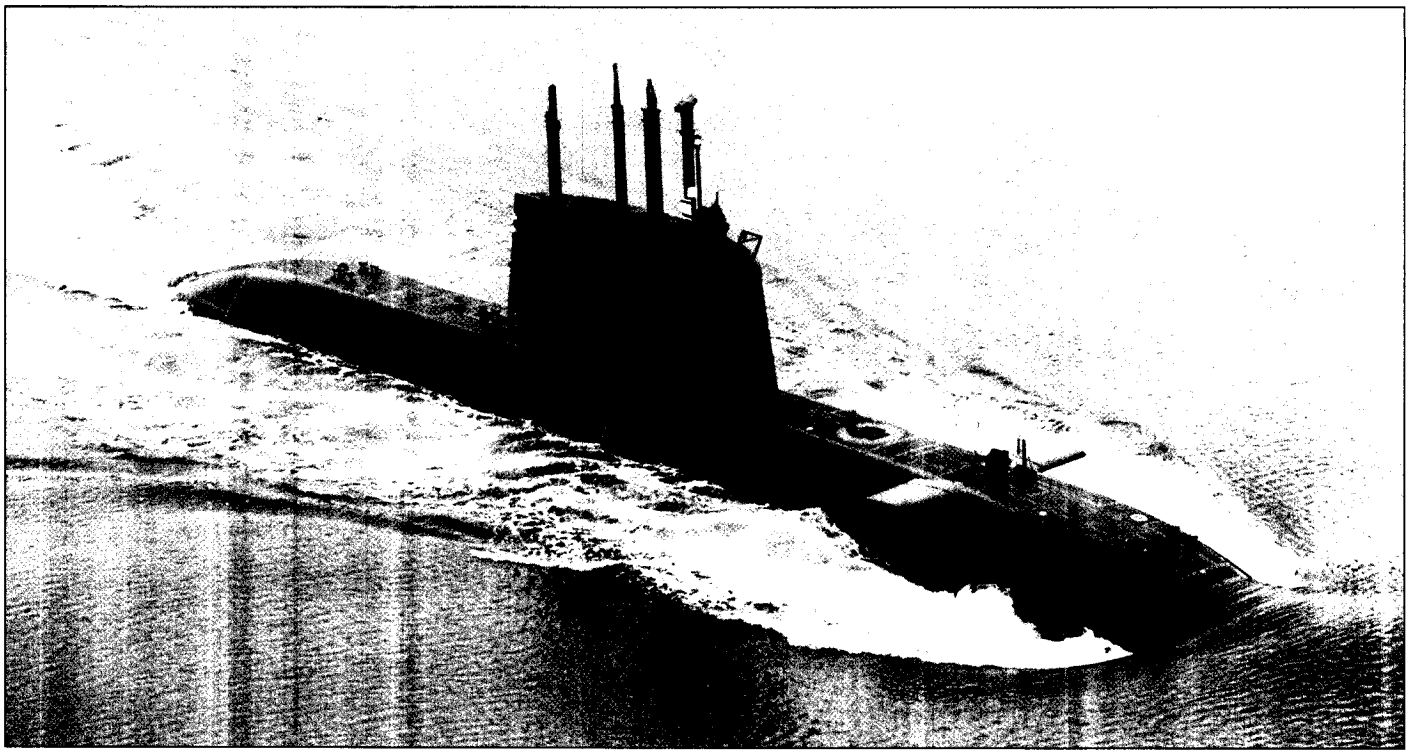
It is also of note that in smaller navies many SSKs have reached, or passed, the midway point in their lives. To continue to remain effective they require major updating of their electronic systems and weapons. Other boats have long since reached the end of their lives and need replacing. Some navies are seeking to introduce SSNs into their order of battle with a view to projecting a much more powerful underwater capability: the most notable of these being India and Brazil.

In the Far East there is a noticeable move towards recognising the role of the SSK. Those navies currently operating SSKs are giving careful consideration to the need to modernise their existing fleet, or to seek replacement construction, while others are seeking to develop a submarine force from scratch. Australia has replaced her existing SSK fleet with a new class built to a Swedish design. South Korea is now a major submarine operator in the region and is seeking to expand her fleet, while Singapore and Malaysia have embarked on the development of a submarine force.

In the Middle and Near East those navies currently operating SSKs are giving careful consideration whether to modernise existing units or to replace them with new construction. A recent entrant into the submarine field is Iran with three operational SSKs, and developments there are being watched with considerable interest. Some other Arab states in the region are also considering acquiring submarines. Egypt also has plans to modernise her underwater fleet.

In South America the economic situation has precluded any major moves towards modernising or expanding submarine fleets. However, Chile has embarked on a new programme and Brazil is still progressing, albeit at a very slow rate, in building up her submarine force and also developing a nuclear capability. Ecuador, it is understood, is also seeking to upgrade its fleet, and may acquire Israel's older boats now that the new Dolphin class is in service.

Two major factors have to be borne in mind when seeking to develop a submarine force. First, the minimum number of boats needed to ensure an effective and operationally viable force at all times is generally considered to be at least three and preferably four or five. The reasons are fairly straightforward. At any one time, one boat may be expected to be in dock undergoing maintenance or refit, one will be working up having completed a refit, and the remainder will be operational. Of these at least one would be on patrol, one going out on patrol and one returning from patrol, but this is often reduced by the need to compromise force strength vis-à-vis the surface fleet and available funding.



Diesel-electric submarines will continue to pose a major threat to surface forces and will increasingly threaten sea lines of communication in the littoral region where AIP and stealth technologies will greatly improve their influence in the tactical scenario. The photograph shows the third Israeli Dolphin class boat Tekuma *undergoing sea trials in September 2000* (Michael Nitz)

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The second factor concerns manpower. The submarine is a technologically advanced system which, because of the environment in which it operates, cannot afford to carry inexperienced crew members who, through lack of training and proper maintenance, by a simple mistake could cause the loss of the boat and her crew. Adequate and continuing training must, of necessity, be a major factor in developing a submarine force. In addition, last year's tragic loss of the Russian submarine *Kursk* has highlighted the need for adequate submarine escape and rescue plans to be in place by any navy operating an underwater fleet.

It can be seen, therefore, that there is considerable potential, primarily for updating existing submarines, and to a more limited degree in the present stringent financial climate, for building replacement boats.

UPDATED

TABLE I

Submarine construction 1990-2004

Name (Pt No)	Builder	Ordered	Laid down	Launched	Commissioned	Remarks
Australia						
SSK CLASS – Collins						
Collins (S 73)	ASC		14 Feb 1990	28 Aug 1993	27 July 1996	1st of 6
Farncomb (S 74)	ASC		1 Mar 1991	15 Dec 1995	31 Jan 1998	2nd of 6
Waller (S 75)	ASC		19 Mar 1992	14 Mar 1997	10 Jul 1999	3rd of 6
Dechaineux (S 76)	ASC		4 Mar 1993	12 Mar 1998	23 Feb 2001	4th of 6
Sheean (S 77)	ASC		17 Feb 1994	03 May 1999	23 Feb 2001	5th of 6
Rankin (S 78)	ASC		12 May 1995	26 Nov 2001	29 Mar 2003	6th of 6
Brazil						
SSN CLASS SNAC-2						
Riachuelo	Rio de Janeiro DY					Planned
SSK CLASS – Type 209/1400						
Tamoio (S 31)	Rio de Janeiro DY		15 July 1986	18 Nov 1993	12 Dec 1994	2nd of 4
Timbira (S 32)	Rio de Janeiro DY		15 Sep 1987	5 Jan 1996	16 Dec 1996	3rd of 4
Tapajo (S 33)	Rio de Janeiro DY		6 Mar 1996	5 June 1998	16 Nov 1999	4th of 4
SSK CLASS – Improved Tupi SNAC-1						
Tikuna (S.34)	Rio de Janeiro DY	1994	11 June 1996	2003	Mar 2005	
Chile						
SSK CLASS – Scorpene						
O'Higgins	DCN Cherbourg	Dec 1997	18 Nov 1999	1 Nov 2003	May 2004	1st of 2
Carrera	Izar	Dec 1997	Nov 2000	2004	2006	2nd of 2
China						
SSBN CLASS – Type 094						
Unnamed	Huludao SY	1997/1998	2001	2005	2008	Planned
SSN CLASS – Type 093						
Unnamed	Huludao SY		1994	24 Dec 2002	2005	
SSN CLASS – Han (Type 091)						
No 405	Huludao SY		1987	8 Apr 1990	Dec 1990	5th of 5
SSK CLASS – Kilo						
Unknown Project 877 (364)	Admiralty Yard	Mid-1993			Feb 1995	1st of 4
Unknown Project 877 (365)	Admiralty Yard	Mid-1993			Nov 1995	2nd of 4
Unnamed Project 636 (366)	Admiralty Yard	Mid-1993		24 Apr 1997	Jan 1998	3rd of 4
Unnamed Project 636 (367)	Admiralty Yard	Mid-1993		18 June 1998	Feb 1999	4th of 4
Unnamed Project 636	Nizhny Novgorod		17 May 2004			
7 Unnamed Type 636	Various	3 June 2002			2007	
SSK CLASS – Song Type 039						
Unnamed (320)	Wuhan SY		1991	May 1994	June 1999	
Unnamed (321)	Wuhan SY		1995	11 Nov 1999	Apr 2001	
Unnamed (322)	Wuhan SY		1996	28 June 2000	Dec 2001	
Unnamed (323)	Wuhan SY		1998	May 2002	Nov 2003	
Unnamed (324)	Wuhan SY		1999	28 Nov 2002	Dec 2003	
Unnamed (325)	Wuhan SY		2001	3 Dec 2002	2004	
Unnamed	Wuhan SY		2001	19 May 2003	2004	
Unnamed	Wuhan SY		2002	29 Sep 2003	2004	
Unnamed	Jiangnan SY		2002	2004	2005	
SSK CLASS – Ming (Type 035)						
Unnamed (305)				June 1997		14th of 22
Unnamed (306)				Sep 1997		15th of 22
Unnamed (307)				May 1998		16th of 22
Unnamed (308)				Oct 1998		17th of 22
Unnamed (310)				June 2000		19th of 22
Unnamed (311)				Sept 2000		20th of 22
Unnamed (312)				May 2001		21st of 22
Unnamed (313)				April 2002		22nd of 22
Denmark						
SSK CLASS – Viking Project						
Four unnamed						Planned
France						
SSBN CLASS – Le Triomphant						
Le Triomphant (S 616)	Cherbourg	10 Mar 1986		16 July 1993	21 Mar 1997	1st of 4
Le Téméraire (S 617)	Cherbourg	18 Oct 1989		8 Aug 1997	23 Dec 1999	2nd of 4
Le Vigilant (S 618)	Cherbourg	27 May 1993		14 April 2003	Dec 2004	3rd of 4
Le Terrible (S 619)	Cherbourg	28 July 2000		2008	July 2010	4th of 4
SSN CLASS – Project 'Barracuda'						
Six unnamed		2001				Planned
SSN CLASS – Rubis						
Amethyste (S 605)	Cherbourg		11 Oct 1994	14 May 1988	20 Mar 1992	5th of 6
Perle (S 606)	Cherbourg		27 Mar 1987	22 Sep 1990	7 July 1993	6th of 6

Name (Pt No)	Builder	Ordered	Laid down	Launched	Commissioned	Remarks
Germany						
SSK CLASS – Type 212A						
U 31 (S 181)	HDW	7 July 1994	Feb 2000	20 Mar 2002	15 Sep 2004	1/4th of 4
U 32 (S 182)	TNSW	7 July 1994	Jan 2002	4 Dec 2003	May 2005	2nd of 4
U 33 (S 183)	HDW	7 July 1994	Oct 2002	Sep 2004	Jan 2006	3rd of 4
U 34 (S 184)	TNSW	7 July 1994	June 2003	May 2005	Sep 2006	4th of 4
Greece						
SSK CLASS – Type 214						
Papanikolis (S120)	HDW	9 Oct 1998	27 Feb 2001	22 Apr 2004	Oct 2005	
Pipinos (S121)	Hellenic	9 Oct 1998	Feb 2003	Nov 2005	July 2008	
Matrozos (S122)	Hellenic	9 Oct 1998	Feb 2004	Nov 2006	July 2009	
Katsonis (S123)	Hellenic	3 Jun 2002	2005	2007	July 2010	
India						
SSN CLASS – ATV (Advanced Technology Vessel)				2006-07	2008	
Unnamed	Vishakapatnam			2001/2	2008	1st of 5 planned
SSK CLASS – Kilo Project 877EKM						
Sindhukiri (S 61)	Admiralty Yard				9 Dec 1990	7th of 12
Sindhuvijay (S 62)	Admiralty Yard				17 Dec 1990	8th of 12
Sindhurakshak (S 63)	Admiralty Yard	Jan 1997			24 Dec 1997	9th of 10
Sindhushastra (S 64)	Admiralty Yard		Aug 1998		19 July 2000	10th of 12
SSK CLASS – Type 209/1500						
Shalki (S 46)	Mazagon Dock		5 June 1984	30 Sep 1989	7 Feb 1992	5th of 6
Shankul (S 47)	Mazagon Dock		3 Sep 1989	21 Mar 1992	28 May 1994	6th of 6
SSK CLASS – Project 75 Scorpene						
Unnamed (S48)	Mazagon Dock		2001	2004	2006	1/2nd of 2
Unnamed (S49)			2003	2006	2008	
Four unnamed	Mazagon Dock					Planned
Iran						
SSK CLASS – Kilo Project 877EKM						
Tareq (901)	Admiralty Yard		10 June 2005	13 June 2005	21 Nov 1992	1st of 3
Noor (902)	Admiralty Yard		11 June 2005	14 June 2005	6 June 1993	2nd of 3
Yunes (903)	Admiralty Yard		12 June 2005	15 June 2005	25 Nov 1996	3rd of 3
Israel						
SSK CLASS – Dolphin						
Dolphin	GSC	Apr 1991	7 Oct 1994	15 Apr 1996	27 July 1999	1st of 3
Leviathan	GSC	Apr 1991	13 Apr 1995	25 Apr 1997	15 Nov 1999	2nd of 3
Tekuma	GSC	July 1994	12 Dec 1996	9 June 1998	25 July 2000	3rd of 3
Italy						
SSK CLASS – Improved Sauro						
Primo Longobardo (S 524)	Fincantieri		19 Dec 1991	20 June 1992	20 May 1994	3rd of 4
Gianfranco Gazzana Priaroggia (S 525)	Fincantieri		12 Nov 1992	26 June 1993	12 Apr 1995	4th of 4
SSK CLASS – Todaro Type 212A						
Salvatore Todaro (S 526)	Fincantieri		Jan 2001	6 Nov 2003	June 2005	1st of 2
Scirè (S 526)	Fincantieri		Apr 2002	Nov 2004	May 2006	2nd of 2
Two unnamed						Projected
Japan						
SSK CLASS – Harushio						
Harushio (583)	Mitsubishi		21 Apr 1987	26 July 1989	30 Nov 1990	1st of 7
Natsushio (584)	Kawasaki		8 Apr 1988	20 Mar 1990	20 Mar 1991	2nd of 7
Hayashio (585)	Mitsubishi		9 Dec 1988	17 Jan 1991	25 Mar 1992	3rd of 7
Arashio (586)	Kawasaki		8 Jan 1990	17 Mar 1992	17 Mar 1993	4th of 7
Wakashio (587)	Mitsubishi		12 Dec 1990	22 Jan 1993	1 Mar 1994	5th of 7
Fuyushio (588)	Kawasaki		12 Dec 1991	16 Feb 1994	7 Mar 1995	6th of 7
Asashio (589)	Mitsubishi		24 Dec 1992	12 July 1995	12 Mar 1997	7th of 7
SSK CLASS – Oyashio						
Oyashio (590)	Kawasaki		26 Jan 1994	15 Oct 1996	16 Mar 1998	1st of 10
Michishio (591)	Mitsubishi		16 Feb 1995	18 Sep 1997	10 Mar 1999	2nd of 10
Uzushio (592)	Kawasaki		6 Mar 1996	26 Nov 1998	9 Mar 2000	3rd of 10
Makishio (593)	Mitsubishi		26 Mar 1997	22 Sep 1999	29 Mar 2001	4th of 10
Isoshio (594)	Kawasaki		9 Mar 1998	27 Nov 2000	14 Mar 2002	5th of 10
Narushio (595)	Mitsubishi		2 Apr 1999	4 Oct 2001	3 Mar 2003	6th of 10
Kuroshio (596)	Kawasaki		27 Mar 2000	23 Oct 2002	8 Mar 2004	7th of 10
Takashio (597)	Mitsubishi		30 Jan 2001	1 Oct 2003	Mar 2005	8th of 10
Unnamed (598)	Kawasaki		15 Jan 2002	Oct 2004	Mar 2006	9th of 10
Unnamed (599)	Mitsubishi		23 Jan 2003	Sep 2005	Mar 2007	10th of 10
Unnamed (600)	Kawasaki		2004	2006	2008	
SSK CLASS – Improved Oyashio						
Unnamed			Mar 2005	2007	Mar 2009	
Malaysia						
SSK CLASS – Scorpene						
One unnamed	DCN		2002	2006	Sept 2008	Ordered
One unnamed	Izar		2003	2007	Oct 2009	Ordered

Name (Pt No)	Builder	Ordered	Laid down	Launched	Commissioned	Remarks
Netherlands						
SSK CLASS – Walrus						
Walrus (S 801)	RDM		11 Oct 1979	26 Oct 1985	25 Mar 1992	1st of 4
Zeeleeuw (S 802)	RDM		24 Sep 1981	20 June 1987	25 Apr 1990	2nd of 4
Dolfijn (S 808)	RDM		12 June 1986	25 Apr 1990	29 Jan 1993	3rd of 4
Bruinvis (S 810)	RDM		14 Apr 1988	25 Apr 1992	5 July 1994	4th of 4
Norway						
SSK CLASS – Ula						
Utsira (S 301)	Thyssen		15 June 1990	21 Nov 1991	30 Apr 1992	2nd of 6
Utstein (S 302)	Thyssen		6 Dec 1989	26 Apr 1991	14 Nov 1991	3rd of 6
Utvaer (S 303)	Thyssen		8 Dec 1988	20 Apr 1990	8 Nov 1990	4th of 6
Uthaug (S 304)	Thyssen		15 June 1989	18 Oct 1990	7 May 1991	5th of 6
Uredd (S 305)	Thyssen		23 June 1988	22 Sep 1989	3 May 1990	6th of 6
Four unnamed						Planned
Pakistan						
SSK CLASS – (Agosta 90B)						
Khalid (S 137)	DCN		15 Jul 1995	8 Dec 1998	6 Sep 1999	1st of 3
Saad (S 138)	DCN/Karachi	Sep 1992	2 Dec 1999	24 Aug 2002	12 Dec 2003	2nd of 3
Hamza (S 139)	Karachi		2000	2005	2006	3rd of 3
Portugal						
SSK CLASS						
Two unnamed	GSC	21 Apr 2004			2009-2010	1/2nd of 2. Ordered. Option for a third.
Russian Federation						
SSBN CLASS – Delta IV Project 667BDRM						
Novomoskovsk (K407)	Severodvinsk		Nov 1988	Oct 1989	1991	7th of 7
SSGN CLASS – Oscar II Project 949B						
Smolensk (K 410)	Severodvinsk		1986	1988	1990	2nd of 6
Cheliabinsk (K 442)	Severodvinsk		1987	1989	29 Dec 1990	3rd of 6
Orel (K 266)	Severodvinsk		1989	22 May 1992	Dec 1992	4th of 6
Omsk (K 186)	Severodvinsk		1990	8 May 1993	15 Dec 1993	5th of 6
Tomsk (K 526)	Severodvinsk		1993	18 July 1996	28 Feb 1997	6th of 6
SSN CLASS – Akula I/II Project 971/ 971M						
Magadan (K 331)	Komsomolsk		1984	1986	1990	1st of 10
Volk (K 461)	Severodvinsk		1986	11 June 1991	30 Dec 1991	2nd of 10
Kuzbass (K 419)	Komsomolsk		1984	1989	1991	3rd of 10
Leopard (K 328)	Severodvinsk		Oct 1988	28 Jul 1992	Dec 1992	4th of 10
Tigr (K 154)	Severodvinsk		1989	10 Jun 1993	Dec 1993	5th of 10
Samara (K 267)	Komsomolsk		1985	15 July 1994	29 July 1995	6th of 10
Nerpa (K 152)	Komsomolsk		1986	May 1994	1999	7th of 10
Vepr (II) (K 157)	Severodvinsk		1991	10 Dec 1994	Dec 1995	8th of 10
Gepard (II) (K 335)	Severodvinsk		1991	18 Aug 1999	29 Jul 2001	9th of 10
Cougar (II) (K 337)	Severodvinsk		1993	2004	2005	10th of 10
SSN CLASS – Sierra II Project 945B						
Pskov (K 336)	Nizhny Novgorod		May 1990	Jun 1992	12 Aug 1993	
Nizhny Novgorod (K 534)	Nizhny Novgorod		June 1986	June 1988	28 Dec 1990	
SSN CLASS – Yasen class Project 885						
Severodvinsk	Severodvinsk		21 Dec 1993	2004	2007	1st of 2
SSN CLASS – Victor III Project 671RTMK						
Obninsk (B 138)	Admiralty Yard		7 Dec 1988	5 Aug 1989	10 May 1990	6th of 8
Danil Moskovskiy (B 414)	Admiralty Yard		1 Dec 1988	31 Aug 1990	30 Dec 1990	7th of 8
Tambov (B 448)	Admiralty Yard		31 Jan 1991	17 Oct 1991	24 Sep 1992	8th of 8
SSK CLASS – Lada Project 677						
St Petersburg (S 100)	Admiralty Yard		26 Dec 1997	Aug 2004	2005	1st of 2
SSK CLASS Kilo Project 877K-636						
Novosibirsk (B 401)	Nizhny Novgorod		Jun 1988	Aug 1989	4 Jan 1990	
Vologda (B 402)	Nizhny Novgorod		Nov 1988	Sep 1989	1990	
Lipetsk (B 459)	Nizhny Novgorod				1990	
Unnamed (B 471)	Nizhny Novgorod				1990	
Unnamed (B 177)	Nizhny Novgorod				1991	
Magneto-Gorsk (B 437)	Nizhny Novgorod		Sep 1989	Aug 1990	1991	
Unnamed (B 345)	Komosmolsk		22 Apr 1993	1993	22 Jan 1994	
South Africa						
SSK CLASS – Type 209/1400 M						
Unnamed (S 101)	GSC	7 July 2000	22 May 2002	15 June 2004	Sep 2005	1st of 3
Unnamed (S 102)	GSC	7 July 2000	12 Dec 2003	2005	Sep 2006	2nd of 3
Unnamed (S 103)	GSC	7 July 2000	2004	2006	Sept 2007	3rd of 3
South Korea						
SSK CLASS – Type 214						
Unnamed	Hyundai	Nov 2000			2007	1st of 3
Unnamed	Hyundai	Nov 2000			2008	2nd of 3
Unnamed	Hyundai	Nov 2000			2009	3rd of 3

Name (Pt No)	Builder	Ordered	Laid down	Launched	Commissioned	Remarks
SSK CLASS – Type 209/1200						
Chang Bogo (061)	HDW		1989	18 June 1992	2 June 1993	1st of 8
Yi Chon (062)	Daewoo		1990	14 Oct 1992	30 Apr 1994	2nd of 8
Choi Muson (063)	Daewoo		1991	25 Aug 1993	27 Feb 1995	3rd of 8
Park Wi (065)	Daewoo		1992	20 May 1994	3 Feb 1996	4th of 8
Lee Jongmu (066)	Daewoo		1993	17 Apr 1995	29 Aug 1996	5th of 8
Jung Woon (067)	Daewoo		1994	7 May 1996	29 Aug 1997	6th of 8
Lee Sunsin (068)	Daewoo		1995	21 May 1998	15 June 1999	7th of 8
Na Daeyong (069)	Daewoo		1996	15 June 1999	Nov 2000	8th of 8
Lee Eokgi (071)	Daewoo		1997	26 May 2000	30 Nov 2001	9th of 9
Spain						
SSK CLASS – S-80 Scorpene derivative						
Unnamed (S 81)	Izar		2004	2009	2011	
Unnamed (S 82)	Izar		2005	2010	2012	
Unnamed (S 83)	Izar		2006	2011	2013	
Unnamed (S 84)	Izar		2007	2012	2014	
Sweden						
SSK CLASS – Viking Project						
Two unnamed						Planned
SSK CLASS – Västergötland						
Ostergotland (Gd)	Kockums		15 Oct 1985	9 Dec 1988	12 Jan 1990	4th of 4
SSK CLASS – Gotland						
Gotland (Gld)	Kockums	28 Mar 1990	20 Nov 1992	2 Feb 1995	2 Sep 1996	1st of 3
Uppland (Upd)	Kockums	28 Mar 1990	14 Jan 1994	9 Feb 1996	1 May 1997	2nd of 3
Halland (Hnd)	Kockums	28 Mar 1990	21 Oct 1994	27 Sep 1996	1 Oct 1997	3rd of 3
Turkey						
SSK CLASS – Atilay Type 209/1200						
Dolunay (S 352)	Gölcük DY		9 Mar 1981	22 July 1988	29 June 1990	6th of 6
SSK CLASS – Preveze Type 209/1400						
Preveze (S 353)	Gölcük DY	17 Nov 1997	12 Sep 1989	22 Oct 1993	28 July 1994	1st of 8
Sakarya (S 354)	Gölcük DY	17 Nov 1997	1 Feb 1990	28 July 1994	21 Dec 1995	2nd of 8
18 Mart (S 355)	Gölcük DY	1993	28 July 1994	25 Aug 1997	28 June 1998	3rd of 8
Anafartalar (S 356)	Gölcük DY	1993	1 Aug 1995	1 Sep 1998	22 July 1999	4th of 8
SSK CLASS – Gur						
Gur (S 357)	Pendik	22 July 1998	24 July 1998	May 2002	24 Jul 2003	5th of 8
Canakkale (S 358)	Pendik	22 July 1998	22 July 1999	Aug 2002	Jun 2004	6th of 8
Burakreis (S 359)	Pendik	22 July 1998	25 July 2001	2004	2006	7th of 8
Birinci Inönü (S 360)	Gölcük		25 Jul 2002	2005	October 2007	
SSK CLASS						
Four unnamed						Four projected with AIP
UK						
SSBN CLASS – Vanguard						
Vanguard (S 28)	VSEL	30 Apr 1996	3 Sep 1986	5 Mar 1992	14 Aug 1993	1st of 4
Victorious (S 29)	VSEL	6 Oct 1987	3 Dec 1987	29 Sep 1993	7 Jan 1995	2nd of 4
Vigilant (S 30)	VSEL	13 Nov 1990	16 Feb 1991	14 Oct 1995	2 Nov 1996	3rd of 4
Vengeance (S 31)	VSEL	7 July 1992	1 Feb 1993	19 Sep 1998	27 Nov 1999	4th of 4
SSN CLASS – Trafalgar						
Talent (S 92)	VSEL	10 Sep 1994	13 May 1986	15 Apr 1988	12 May 1990	6th of 7
Triumph (S 93)	VSEL	3 Jan 1986	2 Feb 1987	16 Feb 1991	12 Oct 1991	7th of 7
SSN CLASS – Astute						
Astute (S 20)	BAE Systems	17 Mar 1997	31 Jan 2001	Aug 2007	Aug 2008	1st of 6
Ambush (S 21)	BAE Systems	17 Mar 1997	22 Oct 2003	2009	2010	2nd of 6
Artful (S 22)	BAE Systems	17 Mar 1997	2004	2010	2011	3rd of 6
Three unnamed	BAE Systems					4/6th of 6
USA						
SSBN CLASS – Ohio						
West Virginia (SSBN 736)	General Dynamics			14 Oct 1989	20 Oct 1990	11th of 18
Kentucky (SSBN 737)	General Dynamics			11 Aug 1990	13 July 1991	12th of 18
Maryland (SSBN 738)	General Dynamics			10 Aug 1991	13 June 1992	13th of 18
Nebraska (SSBN 734)	General Dynamics			15 Aug 1992	10 July 1993	14th of 18
Rhode Island (SSBN 740)	General Dynamics			17 July 1993	9 July 1994	15th of 18
Maine (SSBN 741)	General Dynamics		1990	16 July 1994	29 July 1995	16th of 18
Wyoming (SSBN 742)	General Dynamics		1991	15 July 1995	13 July 1996	17th of 18
Louisiana (SSBN 743)	General Dynamics		2002	27 July 1996	1 June1997	18th of 18
SSN CLASS – Los Angeles						
Albany (SSN 753)	Newport News SB		22 Apr 1985	13 June 1987	7 Apr 1990	
Miami (SSN 755)	General Dynamics		24 Oct 1986	12 Nov 1988	9 June 1990	
Scranton (SSN 756)	Newport News SB		29 June 1986	3 July 1989	26 Jan 1991	
Alexandria (SSN 757)	General Dynamics		19 June 1987	23 June 1990	29 June 1991	
Asheville (SSN 758)	Newport News SB		1 Jan 1987	28 Oct 1989	28 Sep 1991	
Jefferson City (SSN 759)	Newport News SB		21 Sep 1987	24 Mar 1990	30 Jan 1992	
Annapolis (SSN 760)	General Dynamics		15 June 1988	18 May 1991	10 Apr 1992	
Springfield (SSN 761)	General Dynamics		29 Jan 1990	4 Jan 1992	9 Jan 1993	
Columbus (SSN 762)	General Dynamics		9 Jan 1991	1 Aug 1992	31 July 1993	
Santa Fe (SSN 763)	General Dynamics		9 July 1991	12 Dec 1992	8 Jan 1994	
Boise (SSN 764)	Newport News SB		28 Aug 1988	20 Oct 1990	7 Nov 1992	

Name (Pt No)	Builder	Ordered	Laid down	Launched	Commissioned	Remarks
Montpelier (SSN 765)	Newport News SB		19 May 1989	6 Apr 1991	13 Mar 1993	
Charlotte (SSN 766)	Newport News SB		17 Aug 1990	3 Oct 1992	16 Sep 1994	
Hampton (SSN 767)	Newport News SB		2 Mar 1990	28 Sep 1991	6 Nov 1993	
Hartford (SSN 768)	General Dynamics		27 Apr 1992	4 Dec 1993	10 Dec 1994	
Toledo (SSN 769)	Newport News SB		6 May 1991	28 Aug 1993	28 Feb 1995	
Tucson (SSN 770)	Newport News SB		15 Aug 1991	15 Mar 1994	9 Sep 1995	
Columbia (SSN 771)	General Dynamics		24 Apr 1993	24 Sep 1994	9 Oct 1995	
Greeneville (SSN 772)	Newport News SB		28 Feb 1992	17 Sep 1994	16 Feb 1996	
Cheyenne (SSN 773)	Newport News SB		6 July 1992	3 Apr 1995	13 Sep 1996	
SSN CLASS - Seawolf						
Seawolf (SSN 21)	General Dynamics	9 Jan 1989	25 Oct 1989	24 June 1995	19 July 1997	1st of 3
Connecticut (SSN 22)	General Dynamics	3 May 1991	14 Sep 1992	1 Sep 1997	11 Dec 1998	2nd of 3
Jimmy Carter (SSN 23)	General Dynamics	July 1996	12 Dec 1995	5 June 2004	Jan 2005	3rd of 3
NSSN CLASS - Virginia						
Virginia (SSN 774)	General Dynamics	Sep 1998	30 Sep 1998	16 Aug 2003	23 Oct 2004	1st of 4
Texas (SSN 775)	Newport News SB	Sep 1998	7 Dec 1998	2005	2005	2nd of 4
Hawaii (SSN 776)	General Dynamics	Sep 1998	13 Nov 2000	2006	2007	3rd of 4
North Carolina (SSN 777)	Newport News SB	Sep 1998	29 Jan 2002	2007	2008	4th of 4
Unnamed (SSN 778)	General Dynamics		14 Aug 2003	2008	2009	
Unnamed (SSN 779)	Newport News		29 Jan 2004	2009	2010	
Unnamed (SSN 780)	General Dynamics		2005	2010	2011	
Unnamed (SSN 781)	Newport News		2006	2011	2012	
Unnamed (SSN 782)	General Dynamics		2007	2012	2013	
Unnamed (SSN 783)	Newport News		2008	2013	2014	

NOTES

Shipyards

Admiralty (Sudomekh) Yard - Admiralty Yard, St Petersburg (formerly Leningrad), Russian Federation
ASC - Australian Submarine Corporation, Adelaide, Australia
Bazan - Bazan Shipyard, Cartagena, Spain
Cherbourg - Cherbourg Dockyard, France
Daewoo - Daewoo, Okpo, South Korea
DCN - DCN, Cherbourg Naval Dockyard, France
Fincantieri - Fincantieri, Monfalcone, Italy
General Dynamics - General Dynamics, Groton, USA
Gölcük - Gölcük Dockyard, Kocaeli, Turkey
GSC - German Submarine Consortium, Germany (comprising HDW and Thyssen)
HDW - Howaldtswerke, Kiel, Germany
Hellenic - Hellenic Shipyards, Skaramanga, Greece
Huludao - Huludao Shipyard, China
Karachi - Karachi Dockyard, Pakistan
Kawasaki - Kawasaki, Kobe, Japan
Kockums - Kockums, Malmo, Sweden
Komsomolsk - Komsomolsk, Russia
Mazagon - Mazagon Dock, Bombay, India
Mitsubishi - Mitsubishi, Kobe, Japan
Newport News SB - Newport News Shipbuilding, USA
Nizhny Novgorod - Gorky, Russian Federation
RDM - Rotterdamsche Droogdok Maatschappij, Rotterdam, Netherlands
Rio de Janeiro - Arsenal de Marinha, Rio de Janeiro Dockyard, Brazil
Severodvinsk - Severodvinsk 492 Shipyard, Russia
Sudomekh - Sudomekh Shipyard, St Petersburg (formerly Leningrad), Russian Federation
Thyssen TNSW - Thyssen Werften GmbH, Emden, Germany
VSEL - Vickers Shipbuilding & Engineering, Barrow, UK
Wuhan - Wuhan Shipyard, China

Under current construction, practice laying down dates for submarines are not often quoted, the date usually quoted being that for the cutting of the first steel. A similar practice relates to the launching date. Most submarines are now rolled out of the berth in a ceremony, and floating out dates are not normally listed.

GLOSSARY

ITT - Invitation To Tender
PD - Project Definition
RfP - Request for Proposal

UPDATED

TABLE II

Operational combat submarines 2004

Navy	No	Type	Country of build	Class	In service	Remarks
Algeria	2	SSK	Russian Federation	Kilo 877E	1987-88	Refitted mid-1990s
Argentina	2	SSK	Germany	TR 1700	1984	*Santa Cruz* underwent mid-life refit September 1999 to 2002. New motors and sonar upgrade.
	1	SSK	Germany	Type 209/1200	1974	Modernised with new engines, electronics and weapons mid-1990s.
	?	SDVs	Italy/France	Cosmos/Havas		
Australia	6	SSK	Australia	Collins	1996-2003	
Brazil	4	SSK	Germany	Type 209/1400	1989-1999	To deploy Torpedo 2000 in future. Sonar, fire control, countermeasures and navigation system to be upgraded.
Bulgaria	1	SSK	Russian Federation	Romeo	1961	Transferred from USSR 1986. Obsolete.
Canada	3	SSK	UK	Victoria	1990-93	Acquired 1998. One more to commission.
Chile	2	SSK	Germany	Type 209/1300	1984	To be fitted with SUBTICs combat management system.
	?	SDVs	France	Havas Mk 8		
China	1	SSBN	China	XIA	1987	Completed major refit 1998.
	1	SSGN	China	Golf	1966	Refitted 1995 to deploy JL-2 missile.
	4	SSN	China	HAN	1974-90	Mid-life update completed.
	8	SSK	China	Song	1999-2001	Two more building.
	2	SSK	Russian Federation	Kilo 877 EKM	1995-97	
	2	SSK	Russian Federation	Kilo 636	1995-97	More to be acquired.
	32	SSK	Russian Federation /China	Romeo	1962-87	Early vessels obsolete. Many in reserve. Being scrapped.
	20	SSK	China	Ming	1971-2002	Programme may have ended.
	?	Midget	China	n/k	?2000	Unknown number under construction.
Colombia	2	SSK	Germany	Type 209/1200	1975	Refitted 1999-2002.
	2	Midget	Italy	Cosmos	1972	Rebuilt early 1980s.
Croatia	2	SDVs	Yugoslavia	R-2		
Denmark	3	SSK	Germany	Type 207	1964-65	Acquired 1986-89. Modernised 1992-93. New sonar.
	1	SSK	Sweden	Kronborg	1980	Lease to buy from Sweden in February 2001.
Ecuador	2	SSK	Germany	Type 209-1300	1977-78	Major refit 1999-2000.
Egypt	4	SSK	China	Romeo	1982-84	Modernised with new sonar, FCS and weapons by mid-90s.
	?	SDVs	Italy	CF2 FX100		
France	2	SSBN	France	LE TRIOMPHANT	1997-99	Two more building.
	2	SSBN	France	L'INFLEXIBLE	1976-85	Scrapping as Le Triomphant class enters service.
	6	SSN	France	RUBIS	1983-93	First four modernised to standard of last two.
Germany	1	SSK/AIP	Germany	Type 212A	2004	
	11	SSK	Germany	Type 206A	1973-75	Modernised early 1990s with new sonar, combat management and periscopes.
	1	SSK	Germany	Type 205	1968-69	Obsolete.
Greece	4	SSK	Germany	Type 209/1100	1971-72	Modernised 1993-2000.
	4	SSK	Germany	Type 209/1200	1979-80	To be modernised between 2004-2012 with AIP and new combat management.
India	10	SSK	Russian Federation	Kilo 877 EM/636	1986-91	Being refitted to deploy Alfa SS-N-27 SSMs.
	11	SDVs	Italy	CE2F/FX100	1991	
	4	SSK	Germany	Type 209/1500	1986-94	Undergoing mid-life upgrade.
	2	SSK	Russian Federation	Foxtrot	1973-74	Obsolete.
Indonesia	2	SSK	Germany	Type 209/1300	1981	Refitted 1993-99 with upgraded electronics.
Iran	3	SSK	Russian Federation	Kilo 877 EKM	1992-96	Refits long overdue.
	1	SDVs	Iran			
Israel	3	SSK	Germany	Dolphin	1997	
Italy	4	SSK	Italy	Improved Sauro	1988-95	Three modernised late 1990s. One being modernised.
	2	SSK	Italy	Sauro	1979-81	Modernised early 1990s.
Japan	7	SSK	Japan	Oyashio	1998-2003	Construction continuing.
	7	SSK	Japan	Harushio	1990-97	
	5	SSK	Japan	Yuushio	1985-89	New sonars fitted.
Korea, North	22	SSK	N. Korea	Romeo	1973-75	Obsolete.
	29	SSK	N. Korea	Sang-O	1995-99	Construction continuing.
	30	Midget	N. Korea	Yugo/P-4	1960-69	Gradually being phased out.
Korea, South	9	SSK	S. Korea	Type 209/1200	1993-2001	Mid-life upgrade under consideration.
	2	Midget	S. Korea	KSS-1	1983	Being replaced by additional Italian midgets.
	9	Midget	Italy	Cosmos/Dolphin		
Libya	2	SSK	Russian Federation	Foxtrot	1976-82	Obsolete.
Malaysia	1	SSK	France	Agosta	1978	Acquired on loan 2003.
Netherlands	4	SSK	Holland	Walrus	1992-94	
Norway	6	SSK	Germany	Ula (Type 210)	1989-92	Combat management system being upgraded and boats tropicalised for long-range operations.
Pakistan	2	SSK	France	Agosta 90B	1999-2003	One more building.
	2	SSK	France	Agosta	1979-80	
	4	SSK	France	Daphne	1969-70	To start paying off.
	3	Midget	Pakistan	MG 110		Upgraded late 1990s.
Peru	6	SSK	Germany	Type 209/1200	1974-83	Obsolescent.
Poland	1	SSK	Russian Federation	Kilo 877EM	1986	
	4	SSK	Germany	Sokol	1964-67	Acquired 2002-04.
Portugal	2	SSK	France	Daphne	1968-69	Obsolete. To be replaced by new construction.
Romania	1	SSK	Russian Federation	Kilo 877E	1986	Awaiting refit.

Navy	No	Type	Country of build	Class	In service	Remarks
Russian Federation	3	SSBN	Russian Federation	TYPHOON	1981-87	May be upgraded with new strategic missile.
	6	SSBN	Russian Federation	DELTA IV	1985-92	Being refitted.
	7	SSBN	Russian Federation	DELTA III	1978-82	Paying off.
	7	SSGN	Russian Federation	OSCAR II	1986-97	
	8	SSN	Russian Federation	AKULA	1990-2001	Construction continuing.
	2	SSN	Russian Federation	SIERRA I/II	1993-97	
	5	SSN	Russian Federation	VICTOR III	1988-92	Scrapping.
	1	SSN	Russian Federation	YANKEE NOTCH	1969	Converted 1983 from SSBN.
	13	SSK	Russian Federation	Kilo	1982-93	Construction continuing for export only.
	?	SDVs	Russian Federation	4 Types	?	Unknown number of Elbrus, Sever, Siren and Triton vehicles.
Serbia & Montenegro	1	SSK	Former Yugoslavia	Sava	1978	Obsolete.
	1	SSK	Former Yugoslavia	Heroj	1968	Obsolete.
	3	Midget	Former Yugoslavia	Una	1985-89	
	2	SDV	Former Yugoslavia	R-2		
	4	SDVs	Yugoslavia	R-1		
Singapore	4	SSK	Sweden	Challenger	1968-69	Acquired 1997.
Spain	4	SSK	Spain	Agosta	1983-86	Modernised mid to late 1990s.
	2	SSK	Spain	Daphne	1973-75	Refitted to deploy F-17 torpedo.
Sweden	3	SSK/AIP	Sweden	Gotland	1996-97	AIP installed.
	4	SSK	Sweden	Västergötland	1987-90	Two boats being refitted with AIP.
	1	Midget	Sweden	Spiggen	1990	Refit mid-'90s.
Taiwan	2	SSK	Netherlands	Hai Lung	1987-88	To be modernised to launch SSMs.
	2	SSK	USA	Guppy II	1945-46	Obsolete.
Turkey	6	SSK	Turkey	Type 209/1400	1994-99	Construction continuing.
	6	SSK	Germany/Turkey	Type 209/1200	1976-90	Mid-life upgrade planned.
	2	SSK	USA	Tang Type	1952	Obsolete.
UK	4	SSBN	UK	VANGUARD	1993-99	
	7	SSN	UK	TRAFALGAR	1983-91	Being modernised with new combat management, sensors and cruise missiles.
	4	SSN	UK	SWIFTSURE	1974-81	Modernised with new combat management. Sensors and cruise missiles (the latter in one boat only).
	3	SDVs	USA	Mk VIII	1999	
Ukraine	1	SSK	Russian Federation	Foxtrot	1970s	Under refit. Obsolete.
USA	14	SSBN	USA	OHIO	1982-97	Early boats being upgraded.
	2	SSN	USA	SEAWOLF	1997-98	One more building.
	51	SSN	USA	LOS ANGELES	1976-96	Early boats being modernised.
	1	SSN	USA	VIRGINIA	2004	Construction continuing.
	10	SDVs	USA	Mk VIII		Modernised late 1990s.
Venezuela	2	SSK	Germany	Type 209/1300	1976-77	Modernised 1992-93 with new combat management.
Vietnam	2	Midget	N. Korea	Yugo	1997	

NOTE: The Russian Federation and other countries also have a number of auxiliary submarines not listed in this table as they carry no weapons. Names in capitals refer to nuclear-powered boats.

UPDATED

TABLE III

Submarine age as at August 2004

Age (yrs)	No	Class	Navy
0-5 (2000-2004)			
	2	Type 209/1200	South Korea
	2	Type 209/1400	Turkey
	1	Type 212A	Germany
	1	Khalid Agosta 90B	Pakistan
	3	Collins	Australia
	1	Dolphin	Israel
	1	Kilo 636	China
	1	Kilo 877EM/636	India
	4	Ming	China
	5	Oyashio	Japan
	2	Sang-O	North Korea
	4	Song	China
TOTAL SSK	**27**		
	1	AKULA	Russian Federation
	1	SEAWOLF	USA
	1	VIRGINIA	USA
TOTAL SSN/SSBN	**3**		
GRAND TOTAL	**30**		
6-10 (1995-1999)			
	2	Type 209/1400	Brazil
	5	Type 209/1200	South Korea
	3	Type 209/1400	Turkey
	3	Collins	Australia
	2	Dolphin	Israel
	3	Gotland	Sweden
	2	Harushio	Japan
	1	Khalid Agosta 90B	Pakistan
	1	Kilo 877EM/636	India
	1	Kilo 877EKM	Iran
	2	Kilo 877EKM	China
	1	Kilo 636	China
	8	Ming	China
	2	Oyashio	Japan
	17	Sang-O	North Korea
	1	Song	China
	1	Improved Sauro	Italy
TOTAL SSK	**55**		
	2	AKULA	Russian Federation
	5	LOS ANGELES	USA
	3	OHIO	USA
	1	OSCAR II	Russian Federation
	2	LE TRIOMPHANT	France
	2	SEAWOLF	USA
	3	VANGUARD	UK
TOTAL SSN/SSBN	**18**		
GRAND TOTAL	**73**		
11-15 (1990-1994)			
	1	Type 209/1200	Turkey
	1	Type 209/1400	Brazil
	2	Type 209/1500	India
	2	Type 209/1200	South Korea
	5	Harushio	Japan
	1	Improved Sauro	Italy
	2	Kilo 877EM	India
	2	Kilo 877EKM	Iran
	7	Kilo	Russian Federation
	5	Ming	China
	3	Romeo	North Korea
	5	Ula	Norway
	1	Västergötland	Sweden
	4	Victoria	Canada
	4	Walrus	Netherlands
TOTAL SSK	**45**		
	5	AKULA	Russian Federation
	1	DELTA IV	Russian Federation
	1	HAN	China
	15	LOS ANGELES	USA
	5	OHIO	USA
	2	OSCAR II	Russian Federation
	2	RUBIS	France
	2	TRAFALGAR	UK
	1	VANGUARD	UK
	3	VICTOR III	Russian Federation
TOTAL SSN/SSBN	**37**		
GRAND TOTAL	**82**		

Age (yrs)	No	Class	Navy
16-20 (1985-1989)			
	1	TR1700	Argentina
	2	Type 209/1300	Chile
	1	Type 209/1400	Brazil
	2	Type 209/1500	India
	2	Agosta	Spain
	2	Hai Lung	Taiwan
	2	Kilo 877E	Algeria
	6	Kilo 877EM	India
	1	Kilo 877E	Poland
	1	Kilo 877E	Romania*
	2	Kilo	Russian Federation
	2	Ming	China
	2	Romeo	China
	1	Romeo	North Korea*
	2	Improved Sauro	Italy
	1	Ula	Norway
	3	Västergötland	Sweden
	5	Yuushio	Japan
TOTAL SSK	**38**		
	4	DELTA IV	Russian Federation
	1	HAN	China
	1	L'INFLEXIBLE	France
	13	LOS ANGELES	USA
	5	OHIO	USA
	4	OSCAR II	Russian Federation
	2	RUBIS	France
	1	SIERRA II	Russian Federation
	3	TRAFALGAR	UK
	2	TYPHOON	Russian Federation
	1	XIA	China
	2	VICTOR III	Russian Federation
TOTAL SSN/SSBN	**39**		
GRAND TOTAL	**77**		
21-25 (1980-1984)			
	1	TR 1700	Argentina
	1	Type 209/1200	Greece
	2	Type 209/1300	Indonesia
	4	Type 209/1200	Peru
	2	Type 209/1200	Turkey
	1	Agosta	Pakistan
	2	Agosta	Spain
	4	Kilo	Russian Federation
	1	*Kronborg* (ex-*Nacken*)	Denmark
	1	Sauro	Italy
	4	Romeo	North Korea
	4	Romeo	Egypt*
TOTAL SSK	**27**		
	3	DELTA III	Russian Federation
	1	DELTA IV	Russian Federation
	1	HAN	China
	15	LOS ANGELES	USA
	1	OHIO	USA
	2	RUBIS	France
	1	SIERRA I	Russian Federation
	2	TRAFALGAR	UK
	1	TYPHOON	Russian Federation
TOTAL SSN/SSBN	**27**		
GRAND TOTAL	**54**		
Over 25 (pre-1979)			
	1	Type 205	Germany
	11	Type 206A	Germany
	3	Type 207	Denmark
	2	Type 209/1300	Ecuador
	1	Type 209/1200	Argentina
	2	Type 209/1200	Colombia
	4	Type 209/1100	Greece
	3	Type 209/1200	Greece
	2	Type 209/1200	Peru
	3	Type 209/1200	Turkey
	2	Type 209/1300	Venezuela
	1	Agosta	Malaysia
	1	Agosta	Pakistan
	4	Challenger (ex-Sjöormen)	Singapore

Age (yrs)	No	Class	Navy
4	Daphne	Pakistan	
	2	Daphne	Portugal
	2	Daphne	Spain
	2	Foxtrot	India
	2	Foxtrot	Libya*
	1	Foxtrot	Ukraine
	1	Golf	China
	2	Ex-US Guppy	Taiwan
	1	Heroj	Serbia & Montenegro
	1	Ming	China
	1	Romeo	Bulgaria
	19	Romeo	China
	12	Romeo	North Korea*
	1	Sauro	Italy
1	Sava	Serbia & Montenegro	
	4	Sokol	Poland
	2	Tang	Turkey
TOTAL SSK	**98**		
	4	DELTA III	Russian Federation
	1	HAN	China
	1	L'INFLEXIBLE	France
	3	LOS ANGELES	USA
	4	SWIFTSURE	UK
	1	YANKEE NOTCH	Russian Federation
TOTAL SSN/SSBN	**14**		
GRAND TOTAL	**112**		
MASTER TOTAL	**428**		

NOTE: This table does not include midget submarines
Submarines listed in CAPITALS are nuclear-powered
The age of many Chinese and Russian boats cannot be determined with any certainty and ages are approximate. Some ex-Russian submarines such as the Foxtrot and so on, may be older than indicated, the age given being as that when the boat entered service with the navy concerned.

Age has been calculated to the end of the year 2004. Figures quoted are for the year in which the boat was commissioned.
* – Indicates approximate date transferred.

UPDATED

SUBMARINE FORCES

Albania

In mid-1996 the three Whiskey V class boats were all based alongside with the fourth boat being used for harbour training. These boats are now considered obsolete and probably incapable of diving.

UPDATED

Algeria

The two Type 677E Kilo class SSKs underwent refits in Russia between 1993 and 1996.

UPDATED

Argentina

Since deciding to expand her submarine arm with TR 1700 German-designed boats, four of which were to be built locally in addition to two built in Germany, severe financial problems have forced Argentina to cease construction of the submarines. The third and fourth units were in various stages of construction and work on the fifth had begun. It has been reported that the third and fourth boats may be scrapped while material assembled for the fifth and sixth units may be used to maintain the first two boats. Type 209 boat *Salta* has completed her mid-life modernisation, but work on the *San Luis* was suspended and the boat is no longer operational. Upgrading included installing new machinery and weapons and renewing electrical installations.

UPDATED

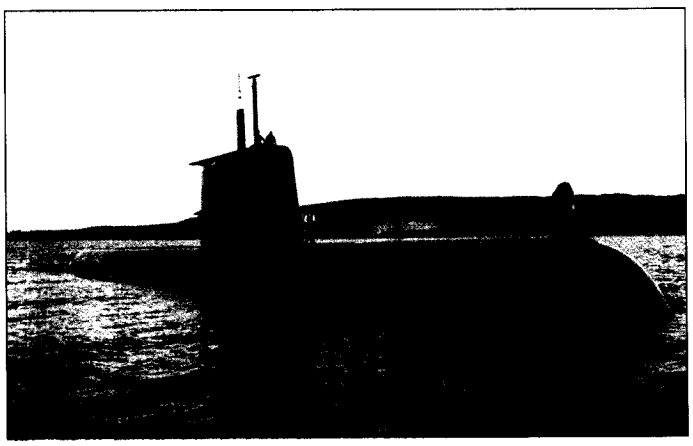
Australia

Construction of the Swedish-designed Type 471 Collins class is now well under way and four boats have been commissioned. The navy has begun to establish plans for the enhancement of its submarine capability. To be undertaken in phases the enhancements will include the capability to operate Special Forces by the Collins; a mid-life update for the Collins and the possibility of acquiring a new submarine class to enter service between 2010-12. Proposals to replace the Collins combat system with a new system have been abandoned. Instead the current system will be upgraded to overcome limitations highlighted earlier, while the possibility of adding an AIP system will be given detailed consideration and for this purpose Stirling 4V-275R AIP engines have been acquired for shore trials.

To overcome major criticism resulting from a number of problems experienced with the first of class, a programme of improvements has been initiated. The *Collins* has been modified to improve stealth capabilities with anechoic hull coating, new engine mountings to reduce vibration, the sail reconfigured hydrodynamically along the lines of the USS *Seawolf* with new EW and communications equipment being fitted in the fourth and fifth boats. The whole class will receive a new combat system in due course.

The fitting of cruise missiles remains an option, but this will not be at the expense of torpedoes and anti-ship missiles.

UPDATED



Farncomb, *the second Collins class boat for the Royal Australian Navy. This programme is now progressing towards the half way stage* (Courtesy of Royal Australian Navy) 0024653

Brazil

The fourth and last Type 209/1400 Tupi class has been launched at the Arsenal de Marinha do Rio de Janeiro. Effort is now being concentrated on the improved Tupi (S-NAC-1) boats, one of which, the *Tikuna*, is on order. However, due to budget cuts construction of the *Tikuna* has been halted. This design will form a bridge between the Tupi class and the succeeding nuclear (S-NAC-2) design. Work on this design is progressing and considerable financial resources have been poured into the project, although it has now been announced that construction will not start until 2010. A prototype nuclear propulsion plant (IPEN-MB-1) has been built for installation in a hull of about 2,800 tonnes. The oldest of the four Tupi class has been refitted with new battery and diesel motors. The Varta batteries have been replaced with Sateirnice Hawker batteries manufactured in Brazil. The two Oberon class boats have been upgraded with the STN Atlas Elektronik CSU 90 sonar system.

UPDATED

Bulgaria

With the ending of the Cold War, the future of the submarine force with two obsolete Romeos must be in doubt since a projected order for two Kilo class submarines was subsequently cancelled.

UPDATED

Canada

The Canadian government has leased (with an option to purchase) the four British Upholder class SSKs for a period of eight years. BAE Systems is reactivating the boats and is providing Canada with logistic and technical support together with training. The boats are being adapted to meet Canadian requirements which include modification to fire Mk 48 Mod 4 torpedoes; operate the Canadian new towed array sonar; installing a new communications suite and transferring the Lockheed Martin Librascope fire-control system from the Oberons. The first boat became operational about the end of 2000, delivery having been delayed to August 2000 due to minor mechanical problems found during reactivation. Long-term plans may include retrofitting an AIP fuel-cell system that is currently under development by Ballard Power Systems.

The four Upholder class boats have been renamed *Victoria*, *Cornerbrook*, *Windsor* and *Chicoutimi*. The last remaining Oberon was decommissioned on 28 July 2000.

UPDATED

Chile

The first of the two new Scorpene type boats for the Chilean Navy, the *O'Higgins*, is currently undergoing harbour trials. She will commission later this year. Work on the second boat is well advanced. It is anticipated that two more Scorpene boats will be ordered early in the next decade to replace the two Type 209 boats.

The type 209 *Simpson* is now fitted with the CSU 90 removed from the *Hyatt*, which was removed from operational service at the end of 2000. The *Thomson* will receive the CSU 90 system from the *O'Brien*, which was retired early in 2003.

UPDATED

China

The PLA Navy is expanding its strategic nuclear capability and a new SSBN design, Type 094, is being developed to deploy a new longer-range strategic missile, the CSS-NX-4. It is thought that construction began around 1999 with an in-service date of approximately 2005 onwards. Reports seem to indicate that the vessel will be powered by a Chinese nuclear reactor based on a Russian design.

In addition to the new SSBN, the PLA Navy is also working on a new SSN design, Type 093. Construction of this design, which is to succeed the Han class, has a higher priority than the Type 094, and commenced in late 1994 with entry into service scheduled for 2004. There have been reports that the Type 093 may carry a long-range land attack cruise missile which would be launched in a capsule from a torpedo tube.

All but one of the Han class have undergone extended refits.

Construction of SSKs continues with the Type 039 Song class, the first of which was completed in 1995. This boat is now undergoing a second series of intense trials, including submerged launches of a new anti-ship cruise missile, the YJ 8-2, preparatory to entering service. A second boat was launched in November 1999 and a further two Song class are under construction.

Because of problems experienced with the Type 093 design, construction of the Ming class SSKs has been reinstated and two modified Ming class have been built. These have been increased in length by 2 m indicating the possibility of future inclusion of an AIP system. On 16 April 2003 a Ming class boat (361) suffered a major mechanical problem, which led to its sinking off the Neichangshan Islands in the Yellow Sea. The boat was found on 26 April 2003 at periscope depth with the crew asphyxiated at their posts. The loss was not discovered at the time because the submarine, on a training exercise, had been ordered to maintain radio silence. It was only when it failed to contact its base at the end of the exercise that it became apparent that something had happened to the boat.

Three Kilos are operational and a fourth was delivered in the Autumn of 1998. A further eight Kilo Project 636 boats were ordered in 2002 for delivery by the end of 2007.

Some 62 Chinese-built Soviet-derived Romeo class boats remain operational or in reserve and China has supplied a number of these boats to foreign navies. Electronics and warfighting capabilities are limited, especially where Chinese technology has been used.

The US Office of Naval Intelligence (ONI) has stated that China 'will pose the most complex submarine challenge outside Russia as a result of its commitment to increased training, the steadily expanding scope and complexity of its exercises, and an active acquisition programme targeted at modern technology'. Another ONI report *World Submarine Challenge* notes that 'Submarines will have an increasing role in China's deterrence strategy'. However, new construction is slow and the overall capability of the PLA Navy submarine force lags behind other regional navies and major powers.

UPDATED

Colombia

Plans exist for the acquisition of two more Type 209 boats. So far, funding problems have prevented implementation of any further acquisitions. The navy also operates two midget submarines.

UPDATED

Denmark

The two Narhvalen class boats have been modernised with SAGEM non-penetrating optronic sensor masts, new periscopes, Racal Sealion ESM and improved radar and sonar. The three Kobben boats were fitted with new sonars in 1992-93. All five boats will be withdrawn from service between 2001-2006. A government committee examining the restructuring of the Danish Navy has recommended that they be replaced with four boats fitted with AIP systems and capable of operating outside Scandinavian and arctic waters. To meet this requirement, Denmark has joined the Scandinavian 'Viking' project.

As part of the Danish Navy's restructuring programme to be able to operate 'out of area' the submarine *Saelen* has been tropicalised.

Although Denmark will implement cuts in defence spending with consequent reduction in the strength of the armed forces, the submarine force will be retained with a strength of three active boats. Funding has been approved for the Viking project. Until the new boats are completed, Denmark may lease two non-AIP fitted Västergötland class boats from Sweden. In the meantime, to gain experience with AIP operations, Denmark has bought the Swedish *Näcken* (renamed *Kronborg)* which is fitted with the Stirling V4-275R AIP system.

UPDATED

Ecuador

The two Type 209/1300 boats were scheduled to undergo a major refit, their second, in 1992-93, but work has not yet begun.

It has been reported that Israel has offered to sell Ecuador its three Gal class submarines, once the new Dolphin class is fully operational.

UPDATED

Egypt

In a government-to-government deal Egypt will obtain funding under the FMF scheme for the acquisition and refit of two ex-Netherlands Zwaardvis class submarines, and also funding for the purchase of two new-build RDM Moray 1400 boats. The boats are due to be delivered between 2006-08 and will be fitted with the SUBICS 900 combat system.

Updating of the four Chinese Romeos has been completed and the boats are now capable of firing Sub-Harpoon missiles and Mk 37 torpedoes. Other new equipment installed includes Lockheed Martin active sonar, STN Atlas Elektronik CSU 83 passive sonar, a new fire-control system, and ARGOSystems Phoenix AR-700 ESM system. A new electro-optic system based on the Kollmorgen 90 electro-optic system is also to be fitted. The latest systems fitted to the boats is the Northrop Grumman Sperry Marine Mk 39 Mod 3A ring laser gyro inertial navigation system, with delivery and fitting completed in the Autumn of 2004. The Mk 39 Mod 3A features a high immunity to magnetic fields and an extremely low noise signature. It provides highly accurate geographic position data, with or without GPS, and precise attitude and heading data required for fire-control stabilisation and weapons initialisation.

UPDATED

France

The SSBN programme has been reduced from six Le Triomphant class boats to four, all of which will eventually deploy the new M51 missile that is planned to enter service in 2010. The second unit, *Le Téméraire,* was commissioned in December 1999. The third unit, *Le Vigilant,* is scheduled to enter service in 2004, and the fourth boat, ordered in July 2000, will deploy with the new M51 missile in 2010. A programme exists to define the requirements for a new generation of SSBN.

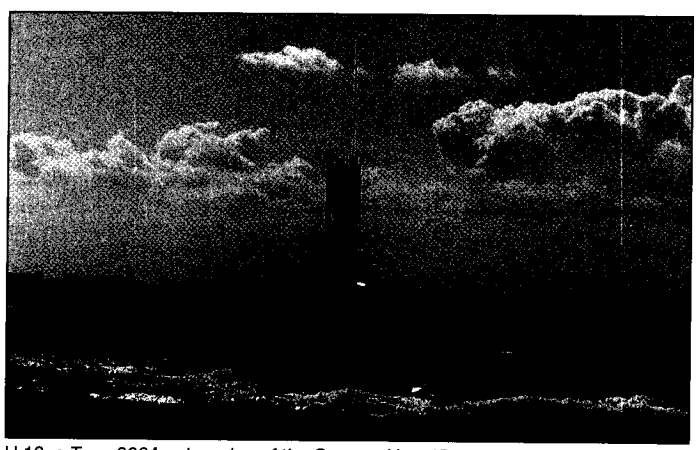
Work has commenced on the design of a new class of six SSNs (the SMAF – Sous-Marin d'Attaque Future) under the name Barracuda. An order for the first two boats is projected for around 2006 with the first boat due to enter service around 2012 to start replacing the current Améthyste class. The boats will be armed with cruise missiles, starting around 2015. The last Agosta class boat will be used as a test platform for the Barracuda Project. The last of the Daphne class boats, *Psyche*, was decommissioned on 29 September 1998.

UPDATED

Germany

The 12-boat Type 212A programme has been reduced to four boats. Further boats will not be funded until after 2005. Steel for the first boat was cut in July 1998. The first of class entered service in 2003. The Type 206A boats will remain in service longer than originally planned. Type 205 and unmodernised Type 206 boats are to be decommissioned and the latter are being sold.

UPDATED



U 16, *a Type 206A submarine of the German Navy* (Courtesy HDW) 0007206

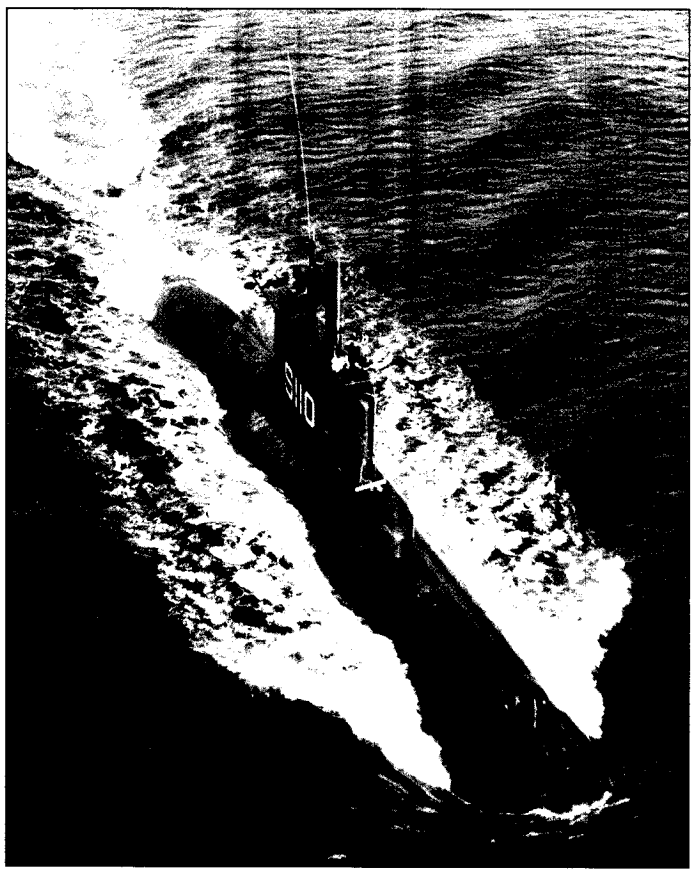
Greece

On 9 October 1998, Greece announced that it would buy four Type 214 submarines from HDW in Germany. A contract for three boats was subsequently signed in February 2000, with the first boat due for delivery in 2006. The lead ship will be built in Germany, construction commencing in 2001, with the remaining boats being built at Hellenic Shipyards, in Skaramanga, Greece. The first boat is due to be delivered in 2005. The combat system will be the STN Atlas Elektronik ISUS-90. The sensor suite will include a cylindrical MF/LF flank array, LF towed array and active ranging sonar. Two Zeiss electro-optical systems will be fitted – one a standard periscope, the other an electro-optic system. The boats will be armed with eight torpedo tubes, deploying the Black Shark torpedo. The propulsion system includes an option to fit an AIP PEM fuel cell.

Modernisation of the four German-built Glavkos Type 209/1100 boats has now been completed under Project Neptune. The update includes STN Atlas Elektronik flank array sonar, a Kanaris fire-control system, new EDO (formerly Condor) ESM and the capability to fire Sub-Harpoon. The class will remain effective for another 20 years.

Three Type 209 boats (one an option) – the *Amfitriti*, *Okeanos* and *Pontos* – are to be upgraded to include an AIP plug, integrated combat management system, optronic mast, radar, ESM, communications, datalink, and torpedo countermeasure launcher.

UPDATED



Type 209/1100 submarine Glavkos *of the Greek Navy* (Michael Nitz) 0137203

India

According to current projections, the navy's submarine strength will drop from the current 17 to 10 by 2010 and only three in 2015, unless more submarines are acquired either through overseas purchases or from indigenous construction. The navy desires to maintain a force of 24 conventional submarines. Although a submarine construction facility has been built at Mazagon Dock Ltd, to date no orders have been placed with the yard for submarine construction. Under the Indian Navy's 30-year submarine plan it is envisaged that a second facility will be built at Cambay on the west coast. This facility will be used to build the Project 75 boats. India will order three Scorpene boats with an option on a further three. The lead boat will be built in France with the remaining boats to be built at Mazagon Dock under supervision from French technicians. The boats will deploy Exocet SM39.

Work on the design of an SSN (known as the ATV – Advanced Technology Vessel) based on the Russian Charlie I class, is well under way with the submarine due to be launched in 2006/07 and commissioned around 2008. The design will be based on a Russian SSN, and fitted with a Russian/Indian-designed nuclear reactor which will shortly undergo shore trials. Three boats are planned. To speed up the progress on the ATV the Indian Navy is to lease two Akula class boats from Russia. These would be uncompleted boats laid up in Russia, but completed for leasing between 2004-05 for a five-year period. This would also ensure that Indian Navy personnel maintain an expertise in handling a nuclear submarine. The last SSN was a Charlie I class boat leased from 1988-90.

The Navy has at long last been allocated funds to build, in Mazagon Docks Ltd, six Scorpene diesel-electric boats, a project (Project 75) which has been proposed for some years. The Project 75 will incorporate a certain amount of indigenous design including, possibly, the ability to launch 3M-54E Klub anti-ship missiles from torpedo tubes. The Navy has also shown interest in purchasing the Russian Amur design. The Defence Research and Development Organisation is also believed to be developing a submarine-launched ballistic missile, which is still in the conceptual design stage. Sea-based deterrence remains critical to maintaining a second strike capability for the Indian Navy.

Early Kilo class boats are gradually being upgraded with the capability to launch the new 3M-54E Klub anti-ship missile. This weapon is the export variant of the Alfa missile and the first Indian Kilo to be refitted to fire it is the *Sindhuvir*.

New sonars and EW systems are being fitted to earlier boats to bring them up to the 877 EKM standard.

The Type 209 boats are also undergoing a mid-life refit under which the sonar suite is being upgraded with French TSM 2272 Eledone systems, but at best only have about another 10 years of life left.

UPDATED

Indonesia

Although funding had been approved for the purchase of five Type 206 submarines from Germany, the financial crisis in the region that severely affected Indonesia has led to the cancellation of the purchase. The boats had already been formally handed over and renamed towards the end of September 1997. Subsequently, only one boat, the *Nagabanda*, has been accepted into service, the Navy postponing the takeover of the remaining five Type 206 boats. Instead the Navy is seeking to acquire new batteries for its two existing Type 209 boats.

Instead of the Type 206 boats, the Navy has proposed that the Government provide funds for the purchase of two submarines from South Korea. The Navy considers that the ideal strength of the submarine arm should be 12 boats.

UPDATED

Iran

Iran has taken delivery of three Russian-built Kilo class SSKs. The Iranians complained of problems with the Kilos and persistent trouble has been experienced with the batteries. Exercises involving the Kilo class boats conducted in the Persian Gulf in the Spring of 1998 indicate that the problems have now been overcome. During the exercises live ammunition was fired at mock targets.

Iran announced late in 2000 that it had launched its first indigenously designed SDV referred to as As-Sabehat 15. With a crew of two the vehicle is capable of transporting three divers on incursion missions or carrying mines.

UPDATED

Israel

Three Dolphin class boats are operational. It has been reported that the boats are to be modified in Israel to deploy an Israeli-developed cruise missile. Israeli and US officials have also admitted that Israeli and US companies have collaborated to equip the Dolphin class boats to deploy Harpoon cruise missiles armed with nuclear warheads. Other reports quoted unnamed Israeli security forces as saying that the *Dolphin* had fired a cruise missile in the Indian Ocean in May/June of 2000. These reports, however, are unconfirmed. The boats are capable of firing Sub Harpoon missiles. The boats will be able to carry five of these weapons as well as the normal load of 16 heavyweight torpedoes. They are also capable of launching the anti-helicoptor missile Triton.

Reports, unconfirmed by the Israeli Defence Ministry, indicate that Israel would like to acquire a further two submarines, possibly of the Type 212A from Germany. The German government, however, may be reluctant to sanction such a sale.

The Gal class is being modernised with new sensors and a fire-control system.

UPDATED

Italy

Following a technological and project MoU signed on 22 April 1996 between Italy and Germany, the Italian Navy has ordered two new boats to be built to the German Type 212A design and fitted with an AIP system. Work on the boats commenced in July 1999. Known as the Salvatore Todaro class, the boats are due to enter service in 2005 and 2006. There is an option on a further two boats. The improved Sauro class submarines *Primo Longobardo* and *Gianfranco Gassana Priaroggia* are scheduled to be modernised with the German STN Atlas Elektronik ISUS 90 integrated combat system and a new sonar. The Italian Navy is also studying the possibility of defining a requirement to replace these boats with a small design of around 700 tonnes.

The *Nazario Sauro* has been decommissioned.

UPDATED

Japan

Construction of the Oyashio class will continue for a number of years to maintain a fleet strength of 16 boats.

The training boat *Asashio* has had a 9 m plug equipped with a Stirling Mk 2 4-275R AIP system installed.

UPDATED

Korea, North

Building of Romeo class boats has ceased at 22 units with construction being switched to the 250 tonne Sang-O class, two of which have now been seized off the coast of South Korea. The Navy also has about 45 midget submarines as well as 20 of the Sang-O class, construction of which is continuing. According to a South Korean defence report, North Korea has deployed an additional 10 submarines during 1999, all of the Sang-O class.

UPDATED

Korea, South

Seven Type 209/1200 boats have been completed and are in service.

The Navy has placed an order for three Type 214 AIP boats from the German Submarine Consortium for delivery between 2007-09. A total of nine of this type is planned, with an option for an additional three boats. The boats will be supplied in kit form and assembled by Hyundai. They are planned to enter service between 2007-09.

The Type 214 boats will be followed by a new class of boats which will replace the Chang Bogo class which will have reached the end of their life. A mid-life upgrade of the Chang Bogo class is under consideration for 2005-10, and which may include insertion of an AIP module. On 26 January 2004, South Korean officials announced that plans were in hand to develop a 3,500 ton submarine under a naval force improvement programme. The Navy plans to procure the boats under the SSX-Programme and deploy them in 2012.

About nine midget submarines are also operational.

UPDATED

Malaysia

On 5 June 2002 Malaysia awarded DCN and Izar a contract to build two Scorpene type submarines for the Navy. The first boat is due to commission in 2007 and the second a year later. It is not intended to equip the boats with AIP at present, but the option remains for AIP to be retrofitted during a refit. In the meantime the former Agosta class boat *Ouessant* has been transferred to the Malaysian Navy and will remain at Toulon to train the submarine crews for the Scorpene boats.

A new base is to be built for the submarine force with completion scheduled by the end of 2007. The base will be built in the Sabah state of Malaysian Borneo.

UPDATED

Myanmar

It would appear from reports emanating from Myanmar that the country's attempts to obtain two small Sang-O class boats from North Korea have been abandoned due to cost factors, although precise details cannot be confirmed.

UPDATED

Netherlands

The 'Moray' project developed by RDM continues, using limited funding provided by the government with the proviso that companies involved in developing AIP technology are involved in the design. This will enable the Dutch to retain essential submarine expertise in design and construction and allow RDM to continue seeking markets in the export field. The submarine *Zeehond* was transferred to RDM in 1990 for use as a trials vessel for AIP related to the development of the 'Moray' design. The four Walrus class boats will undergo mid-life modernisation commencing in 2009. This may include the insertion of an AIP module.

UPDATED

Norway

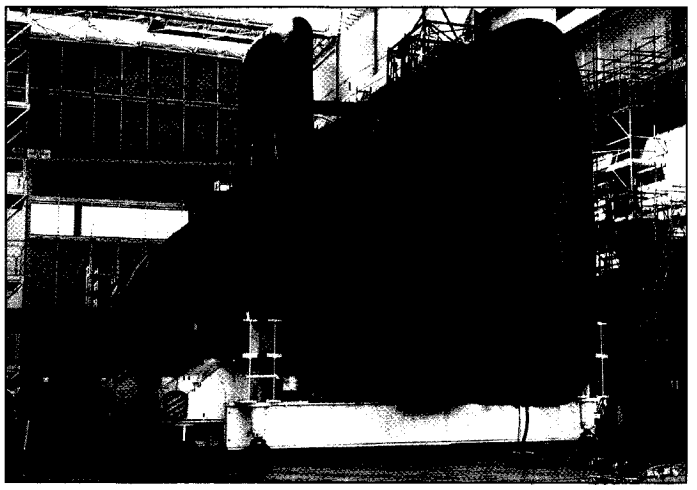
Following a reappraisal of its underwater requirement, Norway withdrew from the Viking project at the end of the first phase of definition, declaring that the six Ula class submarines with suitable refits, can remain operational until 2015.

UPDATED

Pakistan

Work is well under way on the construction of the three new Agosta 90B class boats. The first boat, *Khalid,* is now operational and the second boat successfully completed its deep dive test on 19 September 2003. The third boat *Hamza* will be built entirely in Pakistan and is scheduled to begin sea trials in 2005. The first MESMA AIP system has been accepted and will be transhipped to Pakistan where it will be installed in the *Hamza,* which is due to complete in 2005. The two earlier boats will then be retrofitted with the AIP system. These boats are fitted to fire anti-ship missiles. Four Daphne class submarines and three midgets are also operational although the Daphnes will be progressively decommissioned as the Khalid class enters service.

UPDATED



The Pakistan Navy submarine Khalid *under construction at the Cherbourg yard of DCN* 0037597

Peru

Peru is reported to have expressed interest in acquiring two Kilo class submarines sometime over the next five years or so. These may be used to replace two of the older German Type 209 boats which have now been in service for 25 years. In the meantime the diesel generators in the Casma class are to be refitted by the SIMA shipyard in Peru.

UPDATED

Poland

The Foxtrot class submarines *Wilk* and *Dzik* have been removed from operational service. The government has given the Navy permission to examine possible participation in the Scandinavian 'Viking' project and the German Type 212A. Pending acquisition of two new boats the Navy has procured four second-hand boats as an interim measure. These are the ex-Norwegian Kobben class. The first to be transferred was the *Kobben*, which was renamed *Jastrzab* in July 2002 and which is used for training with some equipment removed. The first seagoing boat to be transferred was the *Stord* renamed *Sokol* in May 2002 and recommissioned on 4 June 2002, and the second the *Skolpen* (renamed *Sep*) handed over in August 2002. The boats will remain in service until 2012-15. Weapons to be deployed will be the Swedish Type 613 (possibly up to 12 will be purchased with the submarines) and American NT37C torpedoes, of which about 30 have been acquired.

UPDATED

Portugal

Replacement of the three Daphnes is an urgent priority, as the current boats will become obsolete in 2006. An RfP for three boats was issued with five proposals due on 3 June 1998, but funding problems have reduced this to just two boats. The designs being offered were Scorpene (DCNI and Izar), Type 209/1400 (GSC), Sauro derivative (Fincantieri), Gotland derivative (Kockums), and Moray type (RDM). The Portuguese require that the boats be capable of operating in Atlantic waters and must be able to deploy Sub Harpoon. An option for an AIP system is also specified. A shortlist of contenders was announced in the Autumn of 1998 and included the Scorpene and the German Type 209 design. On 25 September 2003 the Portuguese Defence Minister said that the preferred bidder for the project was the German Submarine Consortium. On 21 April 2004 it was announced that the GSC had signed a contract with the Portuguese government for the construction and delivery of two Class 209 PN boats with an option for a third vessel. Delivery is scheduled for 2009-2010.

UPDATED

Romania

The sole Kilo class submarine in service is desperately in need of a refit, but funds are not currently available.

UPDATED

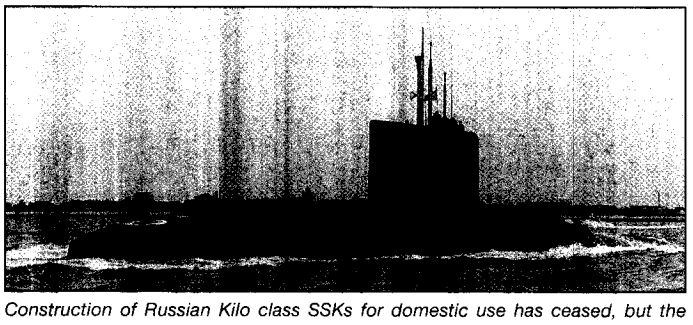
Russian Federation

The strength of the strategic missile fleet is being severely pruned. Only the Delta IV (Project 67 BDRM) boats will remain operational in the foreseeable future. These are now undergoing a major overhaul and modernisation. This includes upgrading the tactical and technical characteristics, which will enable the boats to remain operational for a further 10 years. Three boats have completed overhaul (*Verchoture*, *Yekaterinburg* and *Tula*) and a fourth is currently being upgraded. Currently just two of the giant Typhoon (Project 941) boats remain operational and other boats in the class are being scrapped with US assistance.

The two Oscar I class boats are to be scrapped. A new-generation SSN, the *Severodvinsk* (Project 885), designed to succeed the Akula class was laid down at Severodvinsk in December 1993, but she remains on the slip since work ceased on her in 1996. The design is larger than the Akula enabling new stealth measures to be incorporated. Construction of the Improved Akula class (Project 971M) continues with the second boat *Gepard* becoming operational in December 2001. Two more of the class are under construction and funding has been provided to allow this to continue. An official investigation into the cause of the loss of the Oscar class boat *Kursk* has concluded that it was caused by a leak of HTP fuel from a 65-76A 650 mm torpedo. These have now all been withdrawn from service.

All non-nuclear boats are rapidly being withdrawn from service and by the end of the decade only some Kilo class boats, together with the new Lada (Project 677) will remain operational. The first of the Project 1450 submarines *(St Petersburg)* has been launched at the Admiralty (Sudomekh) Yard at St Petersburg and is due to commission in 2005. The first sections of a second boat of the Amur (Project 1650 the export variant of the Lada) have also been laid down, but work appears to have stopped with the boat only about 7 per cent complete.

UPDATED



Construction of Russian Kilo class SSKs for domestic use has ceased, but the design is now being exported in increasing numbers (H&L van Ginderen) 0518908

Singapore

Under a Joint Technology Development Fund agreed between Sweden and Singapore, the Singapore Minister for Defence announced on 23 September 1995 that the navy was to acquire the submarine *Sjöbjörnen* for training. The boat initially renamed *Riken* and subsequently *Challenger,* was delivered at the end of 1997 and refurbishment completed in February 1998. The government has also acquired the four other boats of the Swedish Sjoormen class. Two of the boats were handed over in May 1999 (the third recommissioned in May 2001) with the fourth being used for spares.

UPDATED

South Africa

Plans have been drawn up to acquire a force of three submarines to replace the Daphnes, and feasibility studies have been undertaken. An order was placed with the German Submarine Consortium (GSC) in July 2000 for three Type 209/1400 MOD boats with delivery to take place between 2004 and 2006. The Daphne class has been modernised to extend its operational life to around 2005. Included in the update are two multifunction sonar operator consoles, providing a new long-range passive sonar display, a new triple transducer intercept sonar, new triple transducer array passive ranging sonar and new sonar classifier system, with library: two multifunction interchangeable displays for time-bearing and tactical plots, new electronics charting navigation subsystem, new ESM sensor head and console, a Zeiss E/O search periscope upgrade with split image range-finding and low light and day video recording: attack periscope upgrade being undertaken by the Eloptro Division of Denel, new communications suite and new radar. Much of the work was undertaken by UEC. A new combat system is being provided by African Defence Systems. The *Maria van Riebeeck* is now laid up and non-operational due to a major defect in one of her electric motors.

UPDATED

Spain

Plans are in hand to build four new boats designated S-80 to replace the obsolete Daphne class. An order is anticipated and the design will probably be based on the Scorpene that is being developed in collaboration with France. A project definition contract for the S-80 was awarded at the end of 1998. It is planned that the S-80 boats will be armed with a land attack missile.

The Agosta class boats are undergoing a major upgrading with new ESM, towed array sonar (not yet selected), periscopes with IR imaging and improved fire-control system. The fire-control system of the Daphnes has been modernised to enable them to launch F17 torpedoes.

UPDATED

Sweden

Under the New Defence Bill presented by the government in November 1999, the submarine fleet will be reduced to five operational units. Under an agreement signed with Denmark and Norway the three countries will proceed with the first stage of the PDP for the Viking project. This has released further funding for the project, which will result in detailed design and costing. A decision on procurement is due in 2005, with an in-service date of around 2010. The aim is to produce a modularised design so that each of the participating members can adapt it to meet its own requirements. Under a long-term plan, studies are in hand to develop a

submarine-launched variant of the RBS-15 missile, which might begin to enter service aboard the Västergötland class from 2005 onwards.

In a move to consolidate submarine expertise Kockums Naval Systems (builders of submarines in Sweden) and HDW in Germany have merged their operations. The main centres of expertise will be located at Kiel in Germany (HDW), Malmö and Karlskrona in Sweden (Kockums Naval Systems) and at Adelaide in Australia (Australian Submarine Corporation). The agreement will enable the two companies to strengthen their R & D resources.

In a new announcement, the Swedish Defence Materiel Administration (FMV) has signed a contract with Kockums to carry out a SLEP on two Västergötland class submarines. Under the SLEP, the vessels will be modernised and generally upgraded and equipped with an advanced Stirling AIP system and new active sonar. The Gotland class will also receive a new active sonar. Sweden will then have a force of five submarines operational.

UPDATED

Taiwan

Taiwan remains determined to acquire more SSKs and up to 12 boats are projected. The navy has now stated that it will build new boats locally. This would probably have to involve some form of technology transfer as no national shipbuilders have a submarine capability. The navy has said that the design will be based on the Hai Lung design already in service.

UPDATED

Thailand

In July 2002 the Chief of Staff cancelled all planning for the acquisition of two submarines.

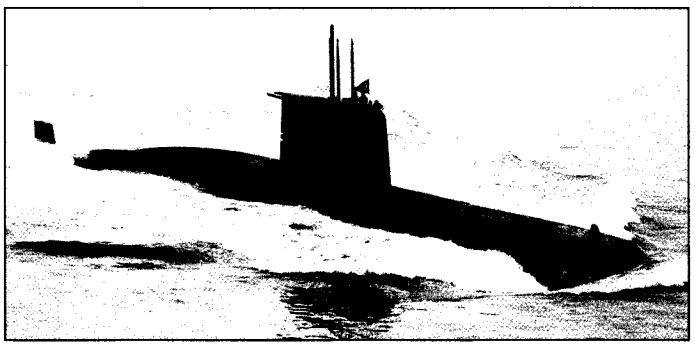
UPDATED

Turkey

April 2004/October 2006 – Four Gur class to enter service.
2003-2011 – Project for four submarines fitted with AIP.
2000 – Work on first two Gur class commences.
July 1998 – Turkey signs contract with HDW for four improved Preveze class (known as Gur class).

Three Preveze class boats are in service and one more is under construction.

Four of the six boats of the Atilay class (Type 209/1200) are to be modernised up to Preveze standard with new torpedo firing, sensor and navigation systems.



Type 209/1400 submarine 18 Mart *of the Turkish Navy seen in July 2000* (Michael Nitz) 0137206

Ukraine

The sole Foxtrot class submarine in the Ukrainian Navy has been restored and repaired, and re-entered service during 2003. The boat has been completely refurbished and fitted with new batteries supplied by the Sunlight Company of Greece.

UPDATED

United Arab Emirates

It has been reported that the old Italian submarines of the Toti class have been offered to the UAE under a draft MoU on defence co-operation. As part of the deal, the boats would be upgraded to fire the new Black Shark torpedo. The Navy has also expressed an interest in acquiring two Type 206A boats from the German Navy when they become due for retirement in 2002-04.

UPDATED

United Kingdom

The publication of the Labour government's Strategic Defence Review in 1998 revealed that the submarine force will be reduced from 12 to 10 SSNs by 2006, the *Splendid* and *Spartan* being decommissioned early in 2003 and 2006 respectively. All remaining SSNs will be adapted to fire the Tomahawk land-attack cruise missile. The Swiftsure and Trafalgar class boats will be progressively replaced by the new Astute class. The fourth Vanguard class SSBN, *Vengeance*, was launched on 20 September 1998, commenced her demonstration and shakedown cruise at the end of November 1999, during which she fired a Trident missile and has now been accepted into service.

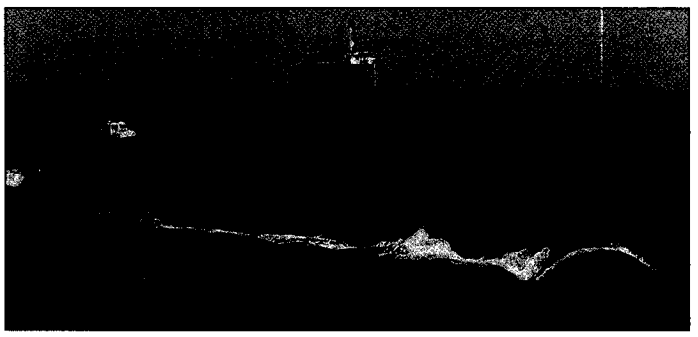
Seven Trafalgar class boats are now operational. The first of the succeeding Astute class have been ordered and it has been confirmed that two more will be built to make a class of five. An order will be placed shortly. The first Astute was laid down on 31 January 2001. The Astute class will be fitted with the more modern PWR2 reactor (the same as in the Vanguard class), the SMCS command system, Type 2076 integrated sonar system, electro-optical sensors and weapon system improvements. Delivery will be delayed owing to design, engineering and programme management difficulties.

The Trafalgar class is being modernised with SMCS, Type 2076 sonar and the capability to fire land-attack Tomahawk cruise missiles. Swiftsure class boats will also be upgraded to the same degree. *Splendid* deployed the first full warload of Tomahawk missiles for her class in 1998, sailing from Rosyth on 1 May 1999 and carrying out the first successful firing of the Block IIIC missile on 19 November 1999. A total of 65 Tomahawk missiles were ordered in 1995, and three were fired during trials in 1998, together with an undisclosed number fired by *Splendid* during operations in the Adriatic against Serbia during the crisis in Kosovo in March-April 1999 and in the war against Iraq, 2003. Subsequent to this, it was announced that 15 more Tomahawk missiles (with an option on a further 15) were to be purchased.

Early SSNs are being retired and stored pending a decision on how to dispose of their nuclear reactors and prefeasibility studies are in hand for a replacement boat for the Trafalgar class. Referred to as the Future Attack SubMarine (FASM) the boats will begin to enter service from about 2017.

Under the 1998 Strategic Defence Review the UK government announced that the Vanguard class SSBNs would be tasked with a much wider range of roles other than purely strategic defence. As part of this initiative HMS *Vanguard* conducted deep water tests firing the British Spearfish torpedo against the US Spruance class destroyer *O'Bannon* at the AUTEC range in the Bahamas in the Summer of 2000.

UPDATED



All seven UK Trafalgar class SSNs are now operational. Turbulent *is illustrated. Plans are now in hand for the Batch 2 design* (Courtesy of VSEL) 0518909



HMS Vigilant *of the Royal Navy, third of the Vanguard class SSBNs* (H & L van Ginderen) 0092001

United States

The ending of the Cold War has led to a major reappraisal of the USNs submarine requirement. Under the FY97 defence budget, funds were approved to complete SSN-23, the third Seawolf and this was ordered from General Dynamics Electric Boat near the end of 1999. A follow-on class of SSN originally referred to as the 'New Attack Submarine' (NSSN) class now called the Virginia class, has been authorised and work on the lead ship has begun. Following a US Joint Chiefs of Staff study into submarine threats, work on speeding up the procurement of the class is under consideration. The design will incorporate some 75 per cent of the Seawolf capability. A revolutionary approach to the design will offer a variety of functions on a common hull, propulsion and command system. A replaceable module will offer additional cruise missiles, ballistic missiles, or the ability to transport up to 200 Special Forces troops. The Los Angeles class SSNs are gradually being upgraded with the Raytheon Combat Control System Mk 2 (CCS Mk 2) which is being integrated with the AN/BQQ-5E and TB-29 sonars and as it is fitted, the AN/BQG-5 Wide Aperture Array (WAA). Of the 18 Ohio class SSBNs, four of the earlier boats will be converted to a tactical role (SSGN), while the four remaining boats deploying the Trident 1 strategic missile will be upgraded to deploy the Trident 11 (D-5) missile.

The four Ohio class SSGNs will be converted by the Electric Boat Corporation, Groton which has been awarded a detail design, procurement and manufacturing of long lead time material contract. The object is to produce a complete and workable design for the conversion, together with procurement and manufacture of long lead items. The work is due to be completed by September 2007. General Dynamics Advanced Information Systems will provide the Attack Weapons Control System (AWCS), with work due for completion in December 2008. Northrop Grumman is to design, develop and manufacture a multiple all-up-around guided nuclear missile canister (MAC) subsystem.

The Defense Advanced Research Projects Agency (DARPA) is working with the US Navy under a MoA to study future design concepts for the NSSN. The main focus of the study is on alternative payloads and sensor systems and the impact they would have on the design of the submarine. The aim is to enhance the submarine's effectiveness.

The construction programme for the Virginia class SSN was given a major boost in 2003 with a contract being awarded to General Dynamics Electric Boat in partnership with Northrop Grumman Newport News Shipbuilding. The contract provides for the construction of six Virginia class SSNs at the rate of one per year from FY03 through to FY06, with two boats in FY07. This could be further boosted with a potential multi-year order for an additional two boats in FY08.

UPDATED

Venezuela

The two Type 209 boats have very recently completed a half-life refit with new engines, fire control, sonar and attack periscopes being fitted. The hull has been slightly lengthened to accommodate the new equipment.

UPDATED

Vietnam

Following a visit by a Russian delegation to Cam Ranh Bay in November 1997, it is reported that Vietnam has expressed interest in acquiring Kilo class submarines now considered as surplus to Russian requirements. Vietnam has asked India to provide training for submariners as part of a plan to develop a small force of two or three submarines. Two small coastal submarines (either Yugo class or Sang-O class) were acquired from North Korea in 1997.

UPDATED

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ASPECTS OF SUBMARINE DESIGN

Introduction

The design of a submarine can generally be considered to comprise three main areas: the propulsion system; combat information area; and the weapons handling area – all encompassed within the hull.

Integrated into these areas is crew accommodation and messing facilities, ballast tanks, fuel compartments and so on. The arrangement of these areas falls into a distinct pattern: the forward end houses the weapons systems and ballast/trim tanks; the central, slightly forward portion accommodates the combat information area; while the propulsion system forms the central to after part, together with other ballast/trim tanks. The arrangement in strategic nuclear submarines differs slightly with the strategic missile stowage usually sited forward of the machinery section, which contains the nuclear reactor in a completely sealed unit, and abaft the combat information area. The torpedo weapons handling area remains in the forward end which also encompasses the combat information area and crew accommodation.

The long-term trend in SSN design is to increase a boat's payload capacity, whereby payload refers not just to weapons but to any equipment directly related to the boat's warfighting capability. This relates to any systems directly associated with intelligence, surveillance and a reconnaissance (a primary task of any submarine). Payloads can be increased in four ways:

- increase in volume
- weapons carried outside the hull
- towing weapons, sensors, communications in watertight canisters which are subsequently moored in a strategic site
- reducing the size of equipments mounted inside the hull.

Operational requirements

Size has always been a major factor in submarine design. On the whole submariners prefer a boat to be as small as possible, in spite of the fact that this results in extremely cramped accommodation. A small boat presents much less of a target to hostile forces, as well as being more manoeuvrable, than a large one. However, size is to a very large degree dictated by the space requirements of propulsion, combat information and sensors and weapons systems. The submarine's role also affects its size. Diesel-electric submarines (SSKs) which are intended for long-range patrols require large fuel reserves, large weapons stowage space and larger crews to provide a full watch-keeping system.

Such limitations do not, however, affect nuclear submarines (SSNs) to the same degree. SSNs are generally much larger than SSKs, and there is adequate space for accommodation and even recreation to ensure acceptable crew habitability. SSKs designed for short patrols and coastal duties, on the other hand, can be much smaller. Large fuel reserves are not required, a weapon reload capability may not be essential or could be much smaller, and a much smaller crew can be accommodated as a simplified watch-keeping system can be adopted. All this is based on the fact that the coastal boat will frequently return to its base or mobile mother ship for replenishment of disposable stores, allowing the crew the chance to relax ashore. They may not even be expected to sleep on board, merely embarking to undertake the mission, which further reduces accommodation requirements.

In recent years, the trend has been towards building larger SSKs. This has, to some extent, been dictated by the increasing sophistication of weapons and combat systems and the perceived need for increased weapons stores. Of greater significance, however, has been the demand by a number of navies for SSKs with ocean-going patrol capabilities, rather than boats designed more for coastal patrol missions. On the other hand, modern technology has enabled systems to be considerably reduced in size and weight, together with savings in manpower resulting from the greater use of automation. However, at the forefront of all considerations must remain the need to ensure the safety of the crew and the boat. More recently, however, the trend has been towards the acquisition of boats in the 1,500 to 2,000 ton displacement range – a trend indicative of the need perceived by a number of nations to safeguard their littoral zones, and by navies seeking to develop a submarine force.

With Air Independent Propulsion (AIP) systems now at sea the full impact of this revolutionary propulsion system on SSK design is currently being assimilated. As AIP systems for SSKs begin to grow in popularity their incorporation in the submarine will affect its future size. In addition, the development of AIP will offer the SSK increased deep submergence endurance, a capability that it currently lacks, and in which the SSN has to date proved to be superior.

In the area of deployable systems, weapons payloads are being supplemented by UUVs (unmanned underwater vehicles) and, in the longer term, UAVs (unmanned aerial vehicles) and swimmer delivery systems for Special Forces. UUVs will become of increasing importance to submarines operating in the littoral zone in support of surface battle groups, providing advance warning of underwater mine threats and obstacles. UAVs will provide an additional element in the intelligence, surveillance and reconnaissance role while swimmer delivery systems will form an essential element for covert operations.

Such is the degree to which the normal role of the submarine is being widened, that designers of non-nuclear submarines will have to address the problem of how to incorporate the increasing demand for a wider diversity of payloads. One proposal suggested by Prof. Dr Jurgen Ritterhoff at SUBCON2003 in Kiel was the modular submarine. This concept, referred to as Hydra, envisages using a basic design for a boat with certain areas being planned with replaceable modules, thus allowing a boat to be reconfigured to undertake a different role. Such replaceable modules may cover systems such as: communications, sensor systems, UAVs, additional weapons, analysis capabilities for ISR missions, modules for covert operations using SOF/divers, energy systems, and so on.

These specific modules could be upgraded ashore separately from the rest of the boat, without it needing to come in for a special refit. Such modules could then be held in storage ready to be installed at an opportune time during the boats' operating pattern. Such a concept would have considerable implications for through life, costing of individual boats and for overall force strength and its cost. Additionally, such modules with new systems installed could be fully trialled and set to work before installation in the boat. This would mean that the only trials then required would be to ensure any necessary integration with other systems in the boat, thus reducing the time a boat was out of commission for major upgrading or change of role.

However, repair or replacement by exchange is not an entirely new concept in itself, and while it works reasonably well for surface ships, there could be penalties to pay in adopting such a concept for submarines. Continual cutting open of the hull to replace internal modules or sections of the boat would inevitably weaken the hull structure. Over time this might result in restrictions having to be imposed on the operational depth of the boat – particularly if the average life of the boat is anticipated as being extended to the region of 25 to 30 years.

Hull design

The two most significant features of a submarine's design are its ability to withstand pressure and shock. These two factors determine to what depths the boat can operate with safety and, more importantly, what is the safety factor or depth below the normal operating depth to which it can sink before the hull implodes or is crushed. This can be some considerable depth below the normal operating depth (usually considered to be in the region of 1.5 to 2 times normal operating depth), and is relied on in emergency to evade hostile attack.

In recent years improvements in calculating various stress factors and new construction techniques have removed many areas of uncertainty relating to the behaviour of bodies underwater, and there is now a tendency to accept the lower safety factor. The shape of a submarine also affects its safety factor. For example, in long submarines, changes in trim may lead to the bow or stern being at a much greater depth than the rest of the submarine and so the safety factor should also take into account the overall length of the submarine. Underwater explosions can have a peculiar effect on submarine hulls, creating sudden and wide-ranging increases and decreases in pressure. The hull must be built, therefore, so that it is able to flex itself to absorb these violent pressure changes without fracturing and without weld joints cracking and so on.

To avoid being damaged, equipment must be carried on special shock absorbing mountings and individual components must exhibit a very low failure rate. To further ensure safe operation, equipment must incorporate a high degree of redundancy. Hence, wherever possible, vital systems are duplicated.

The shock and pressure factors depend not only on the shape of the hull, but also on the material used in its construction. It is now common practice to use high-tensile steel for hull construction of at least the minimum of HY 80 steel and the increasing use of the equivalent of HY 100 steel. Highly specialised welding techniques are used to ensure that joints maintain the same strength as the rest of the hull. To ensure that welding has been correctly carried out, it is necessary to ultrasonically check all pressure hull welds and preferably to X-ray them as well. While steel has always been used for the pressure hull and free-flooding end section, GRP or aluminium is frequently used for the casings and the sail. However, some submarine builders are now giving consideration to the possibility of using non-magnetic steel for submarine construction. While such steels offer good anti-corrosion properties with no inherent magnetic signature they are not as strong as HY 80 or HY 100 and may thus limit diving capability.

For their Typhoon class SSBNs the Soviets used HY 130 steel which exhibited a much greater tensile strength than the steel used in US Navy submarines. For a few selected nuclear attack submarines, the Soviets even used titanium for the hull (Alpha, Mike, Papa, Sierra and Uniform classes).

As well as having the ability to withstand sudden changes in pressure and violent shockwaves, the submarine must also be able to manoeuvre adeptly at both high and low speeds. To achieve this a perfect hydrodynamic shape is required. Because the modern submarine is not expected to have to transit for any distance on the surface, the familiar 'teardrop' design has been developed to exploit to the full the submerged performance and handling characteristics.

Manoeuvrability is further enhanced by the cruciform arrangement of rudders and hydroplanes at the stern. However, some designs favour an X-form arrangement for the control planes. To achieve optimum manoeuvrability demands a low length/beam ratio in the region of 6 to 8. This enables a higher speed at a given displacement/power ratio to be achieved; decreases the surface area, so reducing the sonar target strength for a given displacement; and allows greater flexibility in the use of available space.

The ability of a submarine to carry out high-speed manoeuvres in both horizontal and vertical planes is governed not just by its maximum speed, but by overall performance levels in all areas. To carry out an emergency dive at high speed, a manoeuvre possibly required to avoid a torpedo attack, demands complete freedom of movement in the vertical plane, which in turn requires a greater permissible diving depth.

In addition, by achieving greater diving depth a submarine is enabled to make greater use of thermal layers that hinder hostile sonar operations. Conversely, by using a deep-lying sound channel the submarine can use its sonar to detect hostile forces at much greater ranges. The ability to operate at greater depths also offers

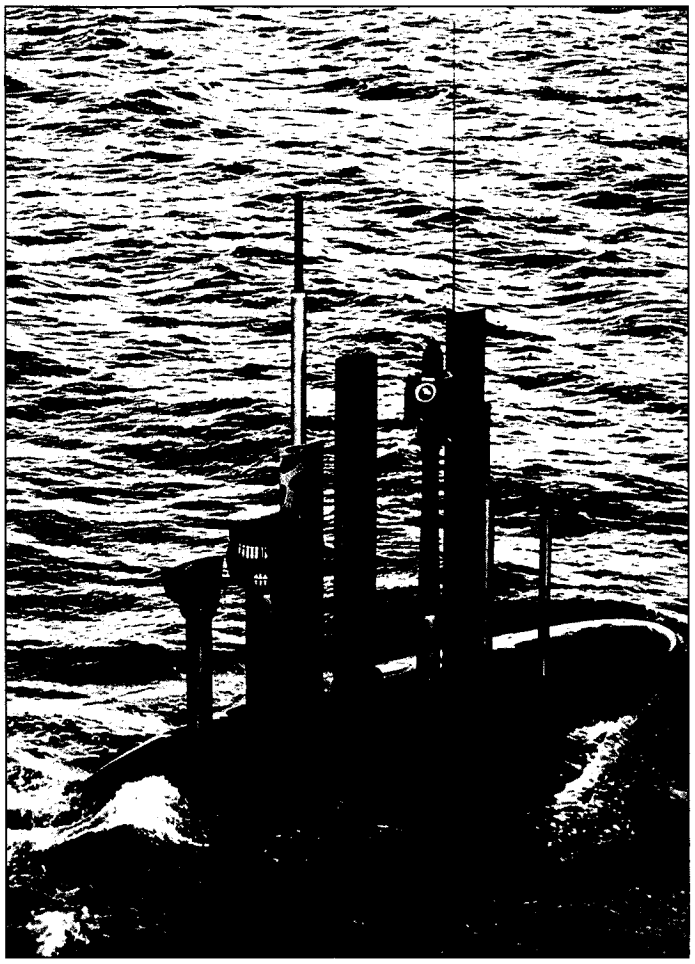
the submarine greater protection against attack as it is more difficult to detect and weapons may not be so effective at great depths.

Intensive operations in the littoral scenario now demand even greater attention, especially to hydrodynamic hull design, particularly of non-nuclear submarines. This is becoming evident to an increasing degree with the new designs emanating from HDW in Germany. A look at the Israeli Dolphin class and the new Type 212A boats for the German Navy clearly show how the dynamic form of the hull of these boats has changed form earlier designs.

Operations in littoral waters, particularly very shallow waters, may yet see more changes to hull forms as designers seek to minimise the possibility that the submarine may be detected. A submarine displaces water, and the heavier the boat the greater the volume of water that is displaced. For a submarine operating at shallow submergence this results in a distinctive travelling 'hump' on the surface – a feature clearly visible in the film of Jules Verne's book '20,000 Leagues under the Sea.' In deep waters where a boat may be transiting at the shallowest at periscope depth or a little more deeply, this will only result in a 'hump' a few centimetres in height – hardly detectable. However, while invisible at surface level this 'hump' does have the effect of slightly modulating the overall surface wave pattern. Such a change in the surface pattern is detectable by satellites using wide-aperture radar, which can reveal the distinctive Kelvin wave system of the submerged submarine's resultant surface 'hump'.

In very shallow waters this effect is considerably more marked and much more easily detectable. In this scenario, where the water column is much reduced and where there is less space for the displaced water to disperse, the 'hump' can become easily visible on the surface. The effect is the same as when the wind operates on the sea surface in shallow water – it creates very distinctive short steep waves on the surface.

So not only does a submarine more easily reveal its presence in very shallow water, particularly when proceeding at speed when the 'hump' is greater, it is also considerably restricted in its freedom to manoeuvre to avoid or reduce the effect of detection. Moving slowly near the surface to reduce the 'hump' may not be an option. Greatly reducing the size of the sail would, of course, assist in reducing the effect of the 'hump', but the sheer overall size of the boat means that it can never be completely removed. A boat travelling near the surface will always produce a 'hump'! Alternatively, perhaps the majority of the sail, if sail there is, could be manufactured of some form of fibre reinforced plastic. Using such a material would enable the sail to be moulded into almost any form required to accommodate various sensor masts and/or other different types of payload and cargoes that may be required. This could result in a considerable modification to its size and shape and its resultant magnetic, acoustic and optical signature.



The modern submarine is fitted with a wide range of masts to carry a variety of antennas relating to various functions. Reading from right to left these are: radar, attack periscope and communications mast alongside each other, EW mast, communications mast, search periscope, and snorkel induction masts. The adoption of a concept such as the UMM would considerably reduce the complexity of masts in the sail and possibly allow a reduction in its size. New modular mast structures housing a wide variety of antennas and other systems such as AUVs and anti-air self-defence systems will revolutionise sail design and size (Courtesy Racal Radar Defence Systems) 0007207

Minimum target signature

Apart from the need to ensure that the submarine can withstand pressure and shock, the third major feature to be considered by the submarine designer is stealth. In order to avoid being detected and to enhance its own ability to detect targets, the submarine must be as stealthy as possible in all respects. Signature management is therefore now a primary consideration in submarine design, and stringent measures are necessary in order to minimise any unwanted signatures. Not only must the submarine be as acoustically silent as possible but all non-acoustic signatures must also be reduced to a practicable minimum. This is necessary for Anti-Submarine Warfare (ASW) forces will use every means at their disposal in the fight against the submarine, and this includes a variety of non-acoustic methods of detection.

Included among the latter are the following features:

- IR detection of heat emitted by the submarine and also detection of any change in surface temperature caused by the passage of a submarine and its resultant wake, and the detection of the disturbed nature of the surface itself. Conventional propulsion systems emit hot exhaust gases and hot cooling water whilst snorkelling. These can be reduced by feeding hot cooling water into a ballast tank and then feeding it out through the wake of the propeller, or cooling the gases by water injection and expelling the mix just beneath the surface. However, both methods still leave a trace of warm water in the wake of the boat surrounded by the cooler sea water that remains for some time after the boat has passed and which can be detected.
- Radar to detect any part of the submarine which pierces the surface (any masts and so on) and which may create a radar return and also to detect surface disturbance created by a submarine operating near the surface. Radar cross-section on masts is reduced by the use of special coatings. Careful and judicious use of masts, however, is one of the surest ways of reducing radar cross-section.
- Chemical detection to sense the presence of any exhaust fumes from a snorkel, or any other fumes from waste or changes in the chemical composition of the sea in the vicinity where a submarine has passed.
- Magnetic Anomaly Detector (MAD) to detect any changes in the earth's magnetic field caused by the presence or passage of a submarine. This can be reduced by the use of non-magnetic steel in construction and by the installation of a degaussing system.
- Changes in the electrical potential in the vicinity of a submarine; that is creating an ELF signature from its machinery and hull.
- Finally, the means to detect changes in bioluminescence in the water caused by the passage of a submarine.

To reduce the possibility of detection by a MAD, submarines are regularly degaussed. However, some boats have zinc coatings, which are designed to contain the magnetic field of the boat and also to prevent it from altering the earth's magnetic field.

To overcome the capability of the next generation of ASW sonars (low-frequency active down to 1 kHz) every effort is being devoted to reducing low-frequency narrowband noise radiation. This frequency band allows sensors to detect targets at extremely long ranges, especially if they are nuclear-powered boats or are SSKs recharging batteries using a snorkel. To overcome this problem the machinery producing discrete frequencies or tonals has to be acoustically treated or alternative equipments selected.

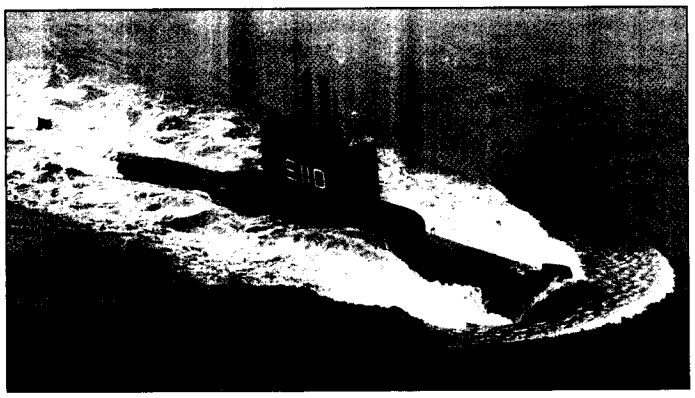
However, a submarine cannot be completely 'silent' for even when 'shut down' some machinery must still remain in operation. Minimal power must be applied to the propellers, or the boat will gradually sink and other systems too must remain operative, for example, hydroplanes and rudders, the hydraulic system, trim and compensating tanks and air conditioning plant. These systems produce what is termed 'pulse' noises (or transients) which can be detected using low-frequency sonar arrays with special processing and memory comparison libraries.

The bow area is one of the most significant areas of hull design. Not only does it affect the pressure and sound signatures, but it is also a significant design factor that can affect the boat's ability to acoustically detect. The foremost bow section houses the sonar, and to achieve maximum detection capability its aperture must be as wide as possible. Furthermore, this area of the hull has to accommodate the weapons discharge and handling equipment and trim tanks. To incorporate all this equipment into a highly sensitive hydrodynamic and acoustic area poses considerable constraints on the designer.

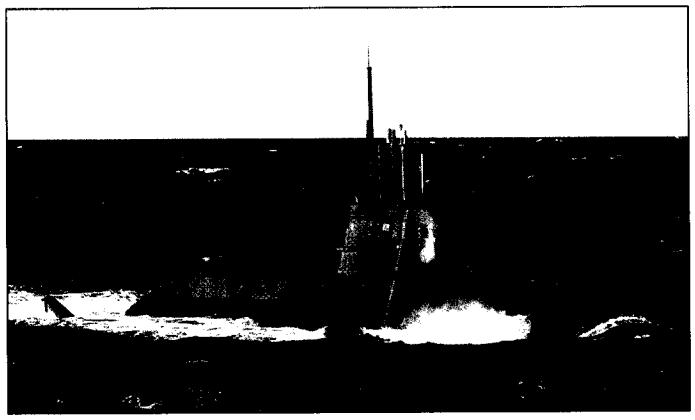
Likewise, the after body of the submarine housing the shafting and propeller has to be very carefully designed to reduce cavitation and self-generated noise to an absolute minimum.

The overall aim of the designer, therefore, is to obtain the best possible flow of water from the bow, along the hull, to the propeller and to ensure maximum efficiency of operation and optimum manoeuvrability.

In the United States new technologies are being investigated for the next generation of SSNs. At the Naval Undersea Warfare Center experiments have shown that the effects of the boundary layer between water and the hull can be manipulated. Because this effect follows a distinct pattern, scientists would be able to characterise and manipulate the water/hull interface to provide significant benefits in the form of noise reduction and reducing drag and so improve both fuel efficiency, hydrodynamic manoeuvrability and stealth. Control can be exercised through the addition of a special external skin consisting of a large number of magnets and electrodes arranged orthogonally and energised to create electromagnetic forces which can control the turbulence. This technology, known as Electro-Magnetic Turbulence signature Control (EMTC), has shown that drag can be reduced by as much as 45 per cent.



The hull form used in older non-nuclear submarine designs is now outdated and no longer suitable to meet the requirements of littoral warfare scenarios in very shallow waters where absolute stealth is required. The picture shows the Greek submarine Glavkos *commissioned in September 1971* (Michael Nitz) 0561635



Submarine hull form design in non-nuclear submarines has undergone radical changes in the last five years or so as depicted by the latest boat to be built, the U31 *of the Type 212A for the German Navy. But even this type of design may be outmoded in the future and some form of revolutionary design adopted.* (Michael Nitz) 0561639

By siting all propulsion and machinery aft, the designer achieves a measurable improvement in noise reduction and considerably improves the boat's ability to use its acoustic sensors. The maximum amount of noise reduction from the propulsion system is achieved by connecting the electric motor directly to the shaft. The noise factor is further reduced by the almost universal adoption of the highly skewed seven-bladed propeller revolving at very low revolutions per minute.

To reduce the target echo strength and noise radiated by a submarine, hulls and spaces where noise is created are treated with tiling and cladding. In the latest generation of submarines this acoustic cladding is also being fitted internally as well as externally. Two types of stealth control are used – anechoic tiles to reduce the target echo strength (that is the backscatter return from hostile active sonars) and decoupling materials that create an impedance mismatch between the boat's hull and the surrounding water. This reduces self-radiated noise and any energy transmitted as noise from the hull to the near-field region of the flank array sonar, which degrades the sonar's performance and reduces the range at which the submarine can detect a target.

This treatment is frequently composed of compressible layers of visco-elastic and other materials which undergo changes in thickness as the submarine changes its depth in the water. As a result, the acoustic performance of the treatment may vary. This compression can, at great depths (between about 300 and 500 m) substantially degrade the performance of baffles in specific areas on the hull and lead to an overall degradation in the platform's stealth with regard to radiated noise and flank array sonar self-noise.

Such is the importance attached to achieving minimum sonar target strength that it is now essential for submarines also to be equipped with some form of noise monitoring and diagnostic system, and these are being increasingly retrofitted to operational submarines, as well as being incorporated in new designs.

To achieve a satisfactory measure of signature control with regard to noise requires a careful balance in deciding where to place the two types of treatment. In some cases, for example around the machinery compartment and weapon discharge areas, it will be necessary to apply both types of material in a hybrid arrangement.

Other developments related to masts and sensors, particularly electro-optic sensor systems and non-hull penetrating masts, will enable the number of masts to be reduced, leading, possibly, to a smaller sail and improved hydrodynamic performance. The operations room will be free of all mast encumbrances, which will enable designers to develop an entirely new concept for the layout of the control room and the position and relationship of the various members of the command team. The use of fibre optic links between mast and control room may also enable the sail to be re-sited in a better position to enhance hydrodynamic performance. Finally, future systems will incorporate the latest developments in Artificial Intelligence (AI) and expert systems architecture that will greatly assist in reducing the time and possibly increase accuracy in carrying out classification and identification of targets.

As a result of these developments, a complete redesign of the submarine's control room is a possible consideration for the next generation of submarine. Such a concept will, however, only be possible with a high degree of automation and with systems that are completely reliable.

Also under investigation in the US by the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research (ONR) and the Space and Naval Warfare Systems Command (SPARWAR) are a new generation of submarine antennas equipped with multifunction conformal arrays. These will also improve stealth and offer increased performance. These new arrays are needed to provide increased data rate submarine communications in the SHF band (phased array antennas incorporated in a conformal or folding configuration). They will also offer improved intelligence data and millimetric wave imaging to provide the command team with an increasing availability of intelligence relating to the strategic and tactical scenario. Also under investigation are buoyant cable antennas for 2-way communication at depth. Furthermore, conformal sonar arrays would drastically reduce the space referred to as Conformal Acoustic Velocity Sensor (CAVES) and weight presently required by the current generation of large, heavy spherical bow arrays. This would enable the bow section of the submarine to be completely redesigned further improving hydrodynamic and stealth capability as well as improving acoustic sensor capability. All of these systems result in a considerable wealth of data and the need is now perceived for submarines to be capable of handling, in real time, two-way information exchange. This will be particularly relevant to navies that foresee their submarine forces forming an integral element in network-centric concepts of maritime warfare, involving sea control and force projection.

Another area of concern relates to the various masts housed in the sail. Studies are underway to determine the optimum design for non-hull penetrating universal modular masts. These would be fully integrated systems built to a standard design to house, erect and support a wide variety of sensors and antennas.

The design of the submarine sail itself is undergoing a major metamorphosis. In the US the Carderock Division of the Naval Surface Warfare Centre, in association with the Naval Undersea Warfare Center, Electric Boat Corporation, Newport News and the Applied Research Laboratory of Pennsylvania State University have, for the last six years, been working on a radical new design, the Advanced Sail. It is hoped to be able to insert this new technology into the Virginia class at some future date, without major impact on the rest of the boat. The new doubly curved sail is of low-drag shape that will house all the systems currently found in a submarine sail. The new design, which superficially resembles some designs seen on Russian submarines, is said to be more drag efficient per unit volume than earlier airfoil designs. The new sail will provide a major increase in the volume available for advanced systems and payloads. It is hoped the design will enable SSNs to operate with greater degree of safety and stealth in near-shore areas, without reducing their ability to carry out more conventional missions in the open ocean. If the sail is proved and installed in the Virginia class, it will provide a significant increase in space in which to stow a wide range of equipment required by Special Forces, as well as new data transfer antennas, countermeasures, littoral warfare missiles and other payloads.

A by-product of such a design would be increased underwater speed for the same output power, improved ship control near the surface (vital in littoral areas) and reduced flow and cavitation noise, thus improving stealth.

It is also being claimed in some sectors in the US that to improve still further on the stealth capabilities of Seawolf and Virginia classes, the US Navy will have to give consideration to electric propulsion. This would be in the form of permanent electric magnet motors and advanced high-power electronics.

The impact on sail design of the various masts and antenna it houses was a subject addressed by Calzoni SpA at the SUBCON2003 conference at Kiel in Germany in August 2003. The concept developed by Calzoni is based on the Universal Modular Mast (UMM – which is being installed in the US Virginia class SSNs). The modular structure is a telescopic 2-stage fairing which can accommodate any type of sensor. Being a common structure, the UMM can be exchanged with any other UMM. In the Calzoni concept a block of up to eight UMM (the Virginia class does in fact feature eight UMM) could be used to form the central structure of the sail, with an additional schnorkel mast if required. This configuration would permit a fully integrated sail to be developed allowing a greater diversity of functions with more complex payloads (even including UAVs and possibly self-defence gun/missiles). In addition, it eliminates or reduces the need for the additional steel structure currently required to support the sail and masts, as the UMM forms its own rigid central structural element. This would allow a fully moulded GRP sail of smaller, superior hydrodynamic form to be developed resulting in a reduced signature (acoustic, RCS, optical, IR and so on) in that region of the boat and resulting in more effective operations in littoral waters.

To overcome the problems briefly outlined here it is necessary for the submarine to be designed as a single unit – platform, machinery, weapons and sonar sensor suite.

Communications

To be effective in their new strategic roles, modern submarines need to be equipped with highly sophisticated communications facilities. Systems now available do not provide the submarine with all that it may require in this area of technology. This will become increasingly vital as submarines begin to co-operate more closely with surface forces at long range – providing direct support and ISR (Intelligence, Surveillance and Reconnaissance) capability within network-centric warfare and joint operations concepts of maritime warfare.

To provide this coherent support and contribution to network-centric warfare demands that the submarine is able to exchange all the information that it has gathered with the surface battle group in real time. This requires much more sophisticated communications facilities than are at present available to the submarine.

Among the areas that are now having to be addressed are those dealing with SATellite COMmunications (SATCOM) and in particular the extreme regions of the spectrum. EHF offers enormous advantages in communications, but it currently suffers from restricted bandwidth and a length of time to transmit information that is not acceptable in warfare. Increased bandwidth and shorter transmission time in the EHF band is essential if submarines are to contribute effectively to the overall tactical picture. At present, comparative studies are being carried out into UHF, as opposed to SHF as opposed to EHF in the SATCOM arena. Until these studies have reached a more definite conclusion, then submarines will have to accept the limitations posed by UHF SATCOM systems and HF low data rate communications.

Self-defence

An area that is now receiving increasing attention in the submarine community is self-defence. In the face of increasingly sophisticated anti-submarine weapons launched from the air, surface and subsurface, submarines are having to employ increasingly sophisticated methods to evade attack. Self-defence against both torpedoes and helicopters is of primary concern to submariners and systems that provide detection and countermeasures will become increasingly important. Already systems designed to attack helicopters, while a submarine remains submerged, are under development. Allied to this are the boats' various sensor systems. Two major areas, currently the subject of research and development, are anti-torpedo systems and electronic warfare.

Other areas of study and evaluation relate to the deployment of autonomous underwater vehicles for a variety of roles from submarines. This will have a major impact on the design of the forepart of the submarine. Launching is in some ways similar to the systems available for firing/launching missiles/torpedoes. The major problem in AUV deployment relates to recovery of the vehicles and space on board for subsequent maintenance and storage.

Habitability and crew safety

Because of the nature of the submarine, its role, and the design constraints imposed by the medium in which it operates, crew accommodation has always been very cramped. However, accommodation should be to the highest possible standards commensurate with the boat's safety and mission profile in order to ensure that the crew remains fit for action both physically and psychologically.

Undoubtedly SSNs offer much higher standards of habitability than SSKs, but conditions in both types of submarine have been considerably improved in recent years. One of the major benefits has been the consolidation of modern technology to improve life support systems.

Boats should be fitted with efficient air conditioning systems and air purification equipment, including oxygen generating plant and extractors to remove contaminants from the air. Future systems may apply biotechnology with plant cells absorbing carbon dioxide and releasing oxygen.

In larger submarines it is considered better for officers and crew to have separate messing and washing facilities, and cabins and bunks should be sited as far away as possible from noise and working areas so that the crew can get the maximum amount of rest during off-duty periods.

Safety in a submarine is of prime importance and in general safety standards applied to submarines are considerably better than those of surface ships. The one safety factor most vital to the submariner is that of adequate escape facilities. In the past crews have had to rely on the standard depth-limited free ascent method which, in a modern submarine, may not be at all practicable to use. In addition, there are considerable risks attached to this method of escape. It places a severe physical strain on the body that, in the case of an injured man, may well prove fatal.

For escape from depths below 150 m it is now becoming standard practice for submarines to be fitted with special attachments to enable a Deep Submersible Rescue Vehicle (DSRV) to clamp itself on to the escape hatch. This allows the crew to exit from the submarine at great depths and in the dry.

To further improve safety, all except the smallest boats are now fitted with a pressure-tight bulkhead that divides the boat into two pressurised compartments. Thus, if one compartment is damaged and flooded, at least the remainder of the crew in the other compartment are enabled to survive and have a reasonable chance of escape using either free ascent or the DSRV.

Decommissioning

One of the major problems now facing countries with nuclear-powered submarines is how to dispose of the radioactive material when the boats are decommissioned. Russia, in particular, is faced with a major dilemma for, with the collapse of communism and faced with considerable financial and other problems, large numbers of nuclear-powered submarines, many of them obsolete, were very rapidly decommissioned. Consequently, many hulls are now rusting away in various inlets and harbours around Russia, posing a potential hazard to the local population and to the natural environment. The United States has provided a measure of assistance in this area, but the size of the task is enormous. The United States herself is also faced with a growing problem of increasing numbers of redundant nuclear-powered submarines. Burying the old reactors and radioactive contaminated equipment in gigantic landfill sites in the desert is solving the problem. The United Kingdom too is now facing a similar problem, but on a smaller scale, as redundant nuclear-powered boats are stored in secure military port facilities around the country pending a government decision on the best and safest way to dispose of contaminated large items of equipment. It is currently accepted that land storage of systems offers the best and safest solution, but as yet no suitable sites have been identified.

Modernisation

Although submarine forces worldwide are no longer expanding at the rate they were before the ending of the Cold War they are, nevertheless, carrying out extensive modernisation of their fleets. These modernisation programmes will extend the life of existing boats to almost 30 years, making them highly effective units in a modern naval scenario. New forces are being organised and those with obsolete boats are seeking to acquire replacements.

Altogether there is a very considerable market for both modernisation and new build. The most important aspect to be considered must be weapon control, sensor and command functions. To be capable of carrying out effective missions the modern submarine must be equipped with a fully integrated combat suite comprising sensors, combat management and fire-control system. With budgets tight, however, some areas may have to be left unmodernised. If this is the case then priority has to be given to updating the combat and sonar systems. It would also be advisable, wherever possible, to update the optical and EW capabilities of a boat, especially in view of the extended roles now being envisaged for submarines. Major technological advances have been made in all these areas and current models are far superior to those of even 10 years ago. In addition, to maintain the stealth capabilities of the platform, considerable attention needs to be paid today to noise reducing techniques — especially in the light of developments with low-frequency active towed array sonars.

As far as propulsion systems in SSKs are concerned, the diesels, as long as they are in reasonable condition, are probably worth retaining, for they are very hard wearing and have a long life expectancy. Likewise the electric motors could be retained. With the batteries, however, a different situation exists. There have been considerable advances in recent years in battery design. When modernising an older boat, consideration should be given to replacing old batteries with new designs capable of charging at a high rate in a short time. In addition the need to extend the battery compartment to give the boat a greater submerged endurance should be considered.

One development that is now attracting increasing consideration is the closed-cycle Air Independent Engine (AIP). Already, Germany and Sweden have developed such systems, which are operational at sea. France too has a system under development and Pakistan has ordered three new Agosta 90B type boats from France, the last of which will be fitted during build with the Mesma AIP system, while the two earlier boats will be retrofitted with the system later. Greece is to acquire a new class of submarine from Germany fitted with AIP and the next-generation of Japanese submarines will also most likely also incorporate AIP.

The future for submarine design

Whatever the outcome of all the aspects noted above, however, one factor cannot be avoided. That is, that submarine hulls today are designed for a life of between 20 and 25 years, and in the light of current rapidly changing strategic and tactical viewpoints, how will navies come to define their submarine requirements in the future? How will the need for flexibility be defined? These aspects, which affect submarine design in a major way, will pose considerable problems for military planners and submarine designers alike. There will be no simple solution. The weapons of today, for example, will no longer be viable tomorrow. The current generation of sensors will not meet the requirements of tomorrow. What type of sensor technologies will be the subject of development to meet the next threat? What form will that threat take? Even if it can be defined, what type of countermeasure will be required to deal with it? It might be said that current attempts to meet future requirements are merely tinkering with the problem. Perhaps a radical rethink is required for the whole concept of the submarine. In fact all that remains is the need for an underwater vehicle capable of undertaking extended time and range operations and of such a flexible design that it can accommodate any type of weapons, sensors and communication payload that may be deemed necessary. High underwater speed, for example, may not even be a requirement. These ideas may result in a totally different form of underwater vehicle, a concept so far removed from present designs that it is almost unrecognisable as a submarine!

UPDATED

SUBMARINE AND SUBMERSIBLE DESIGNS

TABLE IV

Inventory of submarine equipments in service or on order August 2004

Class	Sonars	Command/ Weapon Control	Missiles	Torpedoes	Radars	Countermeasures	Periscopes
EUROPE & NORTH AMERICA (including Canada, RFAS (CIS) & USA)							
BULGARIA				SAET-60	Snoop Plate	Stop Light	
CANADA	Subtass Type 2007 Type 2019 Type 2040 Type 2046	SFCS		Mk 48	Type 1007	AR 900	CH 85 CK 35
DENMARK	CSU-83 FAS-3 PSU 83	IPS-17 TACTICS		Type 431 Type 613	FR 265	AR-700-S5 Sea Lion	CK 35
FRANCE	DMUX 20 DMUX 80 DSUV-22 DSUV 61B DSUV 62C DSUX 21B DUUX 5	DLA 1A DLA 4A LAT SAD/SAT Sycobs TIT	M4 M45 M51 SCALP SM 39 Exocet	F17 Mod 2 L5 Mod 3	DRUA 33 Type 1007	DR 3000U/Arur 12/13	
GERMANY	DBQS-21D DBQS-40 DUUX 2 FAS-3 SRS M1H	Mk 8 MSI-90U SLW 83		DM2A3 DM2A4	Calypso II Type 1007	DR 2000U FL 1800U Sarie 2 TAU 2000	
GREECE	CSU 3-4 CSU 83-90 PRS 3-4	ISUS 90 Kanaris Sinbads	Sub Harpoon	DM2A4 SST-4 SUT Mod 0	Calypso II Milnav Sphynx	AR-700-S5 CIRCE DR 2000 TIMNEX II	
ITALY	DBQS-40 FAS-3 MOA 3070	ISUS 90-20 MSI 90U SACTIS		A184 Mod 3 Black Shark	BPS 704 Type 1007	BLD-727 C303 CIRCE FL 1800U	Model 76
NETHERLANDS	DUUX 5 TSM 2272 Type 2026	Gipsy SEWACO VIII	Sub Harpoon	Mk 48 Mod 4	ZW 07	AR 700	CH 74 CK 24
NORWAY	CSU 83	MSI-90U		DM2A3	Type 1007	Sealion	
POLAND	CSU-83 MGK-400 (Shark Teeth) MGK-519 (Mouse Roar)	MSI-70U MVU-110	SA-N-5	53-56 53-65 SET-53M TEST 71 Type 61 (?)	Bridgemaster Type 1007	Brick Group Quad Loop	CK 30
PORTUGAL	DSUV 2 DUUA 2	DLT D3		E14/15 L3	Type 1007	Arur	
ROMANIA	Mouse Roar Shark Teeth/Fin	MVU-110EM		53-65 TEST 71	Snoop Tray	Brick Group Quad Loop	

Class	Sonars	Command/ Weapon Control	Missiles	Torpedoes	Radars	Countermeasures	Periscopes
RUSSIAN FEDERATION							
	Amfora Mouse Roar Pelamida Shark Gill Shark Hide Shark Rib Shark Teeth Skat 3	3R 65 MVU-110EM MVU-119EM Punch Bowl	SA-N-5/8 SS-N-15 SS-N-16 SS-N-18 SS-N-19 SS-N-20 SS-N-21 SS-N-23 SS-N-27	53-65 APR-2 APR-3 AT-2 SAET 60 SET 65M SET 72 Shkval TEST 71 USET 80 USET 95 UMGT-1M	Snoop Pair Snoop Tray Snoop Half	Bald Head Brick Group Brick Spit Brick Pulp MG 34/44 Park Lamp Rim Hat Squid Head	
SERBIA & MONTENEGRO							
	PRS-3 Eledone			SET-65E TEST 71ME	Snoop Group	Stop Light	
SPAIN							
	DSUV 22 DUUA 2A/2B DUUX 2A Solarsub	DLA 2A DLT 3A		F17 Mod 2 L5 Mod 3/4	DRUA 31 DRUA 33A DRUA 33C	Manta E	
SWEDEN							
	CSU-83 CSU-90-2	IPS-17 IPS-19		Type 431 Type 451 Type 613 Type 62	Scanter	AR-700-S5 CS 3701 Manta S	CK 38
TURKEY							
	BQG 4 BQR 2B BQS 4 CSU 3 CSU 83 TAS 3	ISUS 83-2 M8 Mk 106 Sinbads	Sub Harpoon	DM2A4 Mk 37 SST 4 Tigerfish Mod 2	BPS 12 S 63B	DR 2000 Porpoise Sealion WLR-1	
UKRAINE							
	Pike Jaw				Snoop Tray	Stop Light	
UNITED KINGDOM							
	Type 2019 Type 2043 Type 2054 Type 2072 Type 2076 Type 2077 Type 2082	SMCS	Sub Harpoon Tomahawk Trident 2 (D5)	Spearfish	Type 1007	Type 2066 Type 2071 UAP 3 SAWCS	
UNITED STATES OF AMERICA							
	BQG-5D BQQ-5D BQQ-6 BQQ-10 BQR-15 BQR-19 BQS-13 BQS-15 BQS-24 (MIDAS) TB-16 TB-23 TB-29	BSY-1 BSY-2 CCS Mk 1/2 CCSM Mk 98 Mk 117 Mk 118	Tomahawk Trident I (C4) Trident 2 (D5)	Mk 48 ADCAP	BPS-16	BLD-1 BLQ-10 BRD-7 WLQ-4(V)1 WLR-1H WLR-8(V)2/6 WLR-10 WLY-1 WSP-5	
AFRICA							
SOUTH AFRICA							
	CSU 90	ISUS 90					
MIDDLE EAST & NORTH AFRICA							
ALGERIA							
	MG-519 (Mouse Roar) MGK-400 (Shark Fin) Shark Teeth	MVU-110		53-65 TEST 71ME	Snoop Tray	Brick Pulp	
EGYPT							
	CSU 83	Mk 2	Sub Harpoon	Mk 37F Mod 2		AR 700-S5	

Class	Sonars	Command/ Weapon Control	Missiles	Torpedoes	Radars	Countermeasures	Periscopes
IRAN							
	MG-519 (Mouse Roar) MGK-400 (Shark Teeth)	MVU-119EM		53-65 TEST 71/96	MRP-25 (Snoop Tray)	Quad Loop Squid Head	
ISRAEL							
	CSU-90 FAS-3 PRS-3	ISUS 90-1	Sub Harpoon Triton	DM 2A4	Elta	Timnex 4CH(V)1	
LIBYA							
	Feniks Herkules			SAET-60 SET-65E	Snoop Tray	Stop Light	
FAR EAST & AUSTRALASIA							
AUSTRALIA							
	Narama Scylla TB 23	CCS Mk 2	Sub Harpoon	Mk 48 Mod 4	Type 1007	CS 5600	
CHINA, PEOPLE'S REPUBLIC							
	DUUX 5 Herkules Mouse Roar Pike Jaw Shark Teeth Tamir 5 Trout Cheek	MVU-119EM	C-801 JL-1 JL-2	SAET-60 SET-65E Shkval? TEST 71-96 53-65 53-51	Snoop Plate Snoop Tray	Brick Pulp Squid Head Type 921-A	
INDIA							
	CSU 83 DUUX-5	Mk 1 MVU-119EM	SA-N-8 SS-N-27	SAET-60 SET-65E	Calypso MRP-25 (Snoop Tray)	C303 Phoenix II AR 700	
	Feniks Herkules MG-519 (Mouse Roar) MGK-400 (Shark Fin/Teeth)	SUBTICS		SUT Mod 1 TEST 71/96 53-65		Sea Sentry Squid Head Stop Light	
INDONESIA							
	CSU 3-2 PRS 3-4	Sinbad		SUT Mod 0	Calypso II	DR 2000 U	
JAPAN							
	ZQQ 5B ZQQ 6 ZQR 1	ZYQ-1 ZYQ-3	Sub Harpoon	Type 80 Type 89	ZPS 6	NZLR-1B ZLR-5/6	
KOREA, NORTH							
	Feniks Pike Jaw			53-56? SAET-60?	Furuno Snoop Plate	Type 921-A	
KOREA, SOUTH							
	CSU 83	ISUS 83		SUT Mod 2		AR-700	
MALAYSIA							
	DSUV 2H DUUA 2	DLA 2A SUBTICS	SM 39 Exocet	F-17 L 5 Black Shark		ARUR DR 3000U	
PAKISTAN							
	DUUA 1D DUUA 2A/2B TSM 2233 TSM 2933	SUBTICS Mk 2	SM 39 Exocet Sub Harpoon	F17P Mod 2 L3 E14 E15	DRUA 31 DRUA 33 Type 1007	DR-3000U Arud	J 95 STS 95
SINGAPORE							
	CSU-83 Hydra	SUBTICS		Type 431 Type 613			
TAIWAN							
	BQR 2B BQS 4C DUUG 1B SIASS-Z	Sinbads M		SUT	SS 2 ZW 06	AR 700 SF Timnex 4CH(V)2 WLR-1/3	

Class	Sonars	Command/ Weapon Control	Missiles	Torpedoes	Radars	Countermeasures	Periscopes
LATIN AMERICA & CARIBBEAN							
ARGENTINA	CSU 3 CSU 3/4 DUUG 1D DUUX 2C DUUX 5	M8 Sinbads		Mk 37 Mk 48 SST 4	Calypso II Calypso IV	DR 2000 Sea Sentry III	
BRAZIL	CSU 83-1	ISUS 83-13 KAFS	SM 39 Excoet Sub Harpoon	Tigerfish Torpedo 2000	Scanter	DR 4000	Model 76
CHILE	CSU 3 CSU 90	SUBTICS		Black Shark SUT Mod 1	Calypso II	DR 2000 U AR 900	APS SMS
COLOMBIA	CSU 3-2 PRS 3-4 PSU 83-55	M8/24		SUT	Calypso II	DR 2000	
ECUADOR	CSU 3 DUUX 2	M8/24		SUT	Calypso	DR 2000 U	
PERU	CSU 3 DUUX 2C PRS 3	M8/24 Mk 3		SST 4	Calypso		
VENEZUELA	CSU 3-32 DUUX 2	ISUS		SST 4	Scanter	DR 2000	

Note: Table does not include midget submarine equipment, or mines.

TABLE V

Submarine designs September 2004 – specifications and electronics

Class	Navy	Displacement	Dimensions	Weapon Control	Sonars	Radar	EW
Type 093	China	/6,000	107 × 11 × 7.5				
Type 205	Germany	419/450	43.9 × 4.6 × 4.3	Mk 8	SRS M1H	Calypso II	ESM
Type 206A	Germany	450/498	48.6 × 4.6 × 4.5	CSU 83	DUUX 2, DBQS-21D	Calypso II	DR 2000U + Sarie 2
Type 207 (Tumleren)	Denmark	459/524	47.4 × 4.6 × 4.3	Tactics	PSU 83	Furuno 211	Sealion
Type 207 (Sokol)	Poland	459[1]/524	47.4 × 4.6 × 4.3	MSI-70	CSU 83	Type 1007	AR 700
Type 209/1100-1200 (Glavkos)	Greece	1,125/1,2101,235/ 1,285 (Type 1200)	54.4 × 6.2 × 5.5 (Type 1200 55.9 m)	Kanaris/Sinbads	CSU 83/CSU 3-4, PRS 3-4	Calypso II/ MILNAV	AR-700-S5/DR 2000
Type 209/1200 (Salta)	Argentina	1,140/1,248	55.9 × 6.3 × 5.5	M8	CSU 3, DUUX 2C, DUUG 1D	Calypso II	DR 2000
Type 209/1200 (Pijao)	Colombia	1,180/1,285	55.9 × 6.3 × 5.4	M8/24	PSU 83-55, PRS 3-4	Calypso II	DR 2000
Type 209/1200 (Chang Bogo)	South Korea	1,100/1,285	56 × 6.2 × 5.5	ISUS 83	CSU 83	I-band	AR-700
Type 209/1200 (Angamos/Islay)	Peru	1,185/1,290	56 × 6.2 × 5.5	Sepa Mk 3[2]	CSU 3, DUUX 2C/ PRS 3	Calypso	ESM
Type 209/1200 (Atilay)	Turkey	980/1,185	61.2 × 6.2 × 5.5	Sinbads[3]	CSU 3, DUUX 2	S63B	DR 2000 or Porpoise or Sealion
Type 209/1300 (Thomson)	Chile	1,260/1,390	59.5 × 6.2 × 5.5		CSU 3	Calypso II	DR 2000U
Type 209/1300 (Shyri)	Ecuador	1,285/1,390	59.5 × 6.3 × 5.4	M8/24	CSU 3, DUUX 2	Calypso	DR 2000U
Type 209/1300 (Cakra)	Indonesia	1,285/1,390	59.5 × 6.2 × 5.4	Sinbads	CSU 3-2, PRS-3/4	Calypso	DR 2000U
Type 209/1300 (Sabalo)	Venezuela	1,285/1,600	61.2 × 6.2 × 5.5	ISUS	CSU 3-32, DUUX 2	Scanter Mil	DR 2000U
Type 209/1400 (Tupi)	Brazil	1,453/1,590	61 × 6.2 × 5.5	KAFS	CSU 83/1	Scanter	DR-4000
Type 209/1400 (Preveze)	Turkey	1,454/1,586	62 × 6.2 × 5.5	ISUS 83-2	CSU 83, TAS-3, FAS-3	S 63B	Porpoise or Sealion
Type 209/1400 MOD	South Africa	1,454/1,594	62 × 7.6 × 5.5	ISUS 90	CSU 90	Scanter	Grintek Avitronics
Type 209/1500 (Shishumar)	India	1,450/1,660	64.4 × 6.5 × 6	SFCS Mk 1	CSU 83, DUUX 5	Calypso	Phoenix II AR 700
Type 212A	Germany	1,450/1,830	56 × 7 × 6	MSI-90U	DBQS-40, FAS-3, TAS-3, MOA 3070	Type 1007	FL 1800U
Type 212A (Salvatore Todaro)	Italy	1,450/1,830	56 × 7 × 6	MSI-90U	DBQS-40, FAS-3, TAS-3, MOA 3070	Type 1007	FL 1800U
Type 214 (Papanikolis)	Greece	1,700/1,980	65 × 6.3 × 6	ISUS 90		Sphynx	Timnex II
Type 214	South Korea	1,700/1,860	65 x 6.3 x 6			I-band	ESM
Agosta (Hashmat)	Pakistan	1,490/1,740	67.6 × 6.8 × 5.4	Subics Mk 2	TSM 2933D, TSM 2233D, DUUA 2B	DRUA 33	Arur, Arud
Agosta (Galerna)	Spain	1,490/1,740	67.6 × 6.8 × 5.4	DLA 2A	DSUV 22, DUUX 2A/5 DUUA 2A/2B, Solarsub	DRUA 33C	Manta E
Agosta 90B (Khalid)	Pakistan	1,510/1,750	67.57 × 6.8 × 5.4	SUBTICS Mk 2	TSM 2233	Type 1007	DR 3000U
AKULA (Project 971/ 971U/09710)	Russian Federation	7,500/9,100	110 × 14 × 10.4		Shark Gill, Skat 3, Mouse Roar	Snoop Pair/Half	Rim Hat
ASTUTE	UK	6,500/7,800	96 × 11.3 × 10	ACMS	Type 2076	I-band	UAP-4
Challenger	Singapore	1,130/1,210	51 × 6.1 × 5.8	SUBTICS	CSU 83, Hydra	Terma	
Collins	Australia	3,051/3,353	77.5 × 7.8 × 7	Rockwell	Scylla, Kariwara or TB 23	Type 1007	CS 5600
Daphne (Hangor)	Pakistan	869/1,043	57.8 × 6.8 × 4.6	-	DSUV 1, TSM 2233D, DUUA 1	DRUA 31	Arud
Daphne (Albacora)	Portugal	869/1,043	57.8 × 6.8 × 5.2	DLT D3	DSUV 2, DUUA 2	Type 1007	Arur
(Delfin) Daphne	Spain	869/1,043	57.8 × 6.8 × 4.6	DLT 3A	DSUV 22, DUUA 2A	DRUA 31 or DRUA 33A	Manta E
DELTA III (Project 667BDR)	Russian Federation	10,550/13,250	160 × 12 × 8.7	n/k	Shark Teeth Mouse Roar, Pelamida, Shark Hide	Snoop Tray	Brick Group
DELTA IV (Project 667BDRM)	Russian Federation	10,800/13,500	166 × 12 × 8.7	n/k	Shark Gill, Mouse Roar, Pelamida, Shark Hide	Snoop Tray	Brick Group
Dolgorae*	South Korea	150/175	n/k	None fitted	ATLAS HF	None fitted	None fitted
Dolphin	Israel	1,640/1,900	57.3 × 6.8 × 6.2	ISUS 90-1	CSU-90, PRS-3, FAS-3	Elta	Timnex 4CH(V)2
Dolphin**	South Korea	70/83	25 × 2.1	None fitted	STN ATLAS HF	None fitted	None fitted
Foxtrot (Type 641)	India	1,952/2,475	91.3 × 7.5 × 6		Herkules/Feniks	Snoop Tray	Stop Light
Foxtrot (Type 641)	Libya	1,950/2,475	91.3 × 7.5 × 6		Herkules/Feniks	Snoop Tray	Stop Light
Foxtrot (Type 641)	Ukraine	1,952/2,475	91.3 × 7.5 × 6		Pike Jaw	Snoop Tray	Stop Light
Golf	China	2,350/2,950	97.5 × 8.6 × 6.6		Pike Jaw	Snoop Plate	
Gotland (A 19)	Sweden	1,450/1,590	60 × 6 × 5.6	IPS-19 (Sesub 940A)	CSU-90-2 Suite	Scanter	Manta S
Guppy II	Taiwan	1,870[1]/2,420	93.7 × 8.3 × 5.5	-	AN/BQR 2B, AN/ BQS 4C, DUUG 1B	SS 2	WLR-1/3
Hai Lung	Taiwan	2,376/2,660	66.9 × 8.4 × 6.7	Sinbads M	SIASS-Z	ZW 06	AR 700SF, Timnex 4CH(V)2
HAN	China	4,500/5,500	98[4] × 10 × 7.4	n/k	Trout Cheek, DUUX 5	Snoop Tray	Type 921-A
Harushio	Japan	2,450[1]/2,750	77 × 10 × 7.7	-	ZQQ 5B, ZQR 1	ZPS 6	NZLR 1
Heroj	Serbia & Montenegro	615/705	50.4 × 4.7 × 4.5	-	Eledone	Snoop Group	Stop Light
Intrepido**	Colombia	58/70	23 × 4	None fitted	None fitted	None fitted	None fitted

Class	Navy	Displacement	Dimensions	Weapon Control	Sonars	Radar	EW
Kilo (Project 877E)	Algeria	2,325/3,076	73.8 × 9.9 × 6.6	MVU-110	Shark Teeth, Shark Fin, Mouse Roar	Snoop Tray	Brick Pulp
Kilo (Project 877EKM/636)	China	2,325/3,076	73.8 × 9.9 × 6.6	MVU-119	Shark Teeth, Mouse Roar	Snoop Tray	Squid Head/Brick Pulp
Kilo (Project 877EKM/636)	India	2,325/3,076	72.6 × 9.9 × 6.6	MVU-119EM	Shark Teeth, Shark Fin, Mouse Roar, Shark Gill	Snoop Tray	Squid Head
Kilo (Project 877EKM)	Iran	2,356/3,076	73.8 × 9.9 × 6.6	MVU-119EM	Shark Teeth, Mouse Roar	Snoop Tray	Squid Head
Kilo (Project 877E)	Poland	2,325/3,076	73.8 × 9.9 × 6.6	MVU-110	Shark Teeth, Mouse Roar	Snoop Tray	Brick Group
Kilo (Project 877E)	Romania	2,325/3,076	72.6 × 9.9 × 6.6		Shark Teeth, Shark Fin, Mouse Roar	Snoop Tray	Brick Group
Kilo (Project 877/877K/877M)	Russian Federation	2,325/3,076	72.6 × 9.9 × 6.6	MVU-110EM or MVU-119EM	Shark Teeth, Shark Fin, Mouse Roar	Snoop Tray	Squid Head or Brick Pulp
Kronborg (A 14)	Sweden	1,015/1,085	57.5 × 5.7 × 5.5	IPS-17 (Sesub 900C)	CSU 83, FAS-3	FR 2105	AR-700-S5
Lada (Project 677)	Russian Federation	1,765/2,650	68 × 7.1 × 4.5		Lira MF & LF	I-band	ESM
LE TRIOMPHANT	France	12,640/14,335	138 × 12.5 × 17	SAD, SAT, DLA 4A	DMUX 80 Suite, DUUX 5, DSUV 61	I-band	ARUR 13/DR 3000U
L'INFLEXIBLE	France	8,080/8,920	128.7 × 10.6 × 10	SAD, SAT, DLA 1A	DSUX 21, DUUX 5, DSUV 61	DRUA 33	ARUR 13/DR 3000U
LOS ANGELES	USA	6,082/6,927	110.3 × 10 × 10	CCS Mk 2[5], BSY-1, Mk 117	BQQ-5D/E, BQG-5D[6], TB 23/29 or TB 16/93, MIDAS, BQS-15	AN/BPS-16	BRD-7, WLR-8(V)2, WLR-10, WLR-1H, BLQ-10
MG 110**	Pakistan	n/k/118	27.8 × 5.6	None fitted	HF	None fitted	None fitted
Ming (Type 035)	China	1,584/2,113	76 × 7.6 × 5.1		Pike Jaw, DUUX 5	Snoop Tray	Type 921-A or DR 2000U
OHIO (SSBN)	USA	16,600/18,750	170.7 × 12.8 × 11	CCS Mk 2, Mk 118, Mk 98	AN/BQQ-6, AN/BQS-13, AN/BQS-15, AN/BQR-15, TB23, AN/BQR-19	AN/BPS-15A	WLR-8, WLR-10
OHIO (SSGN)	USA	16,600/18,750	170.7 × 12.8 × 11	CCS Mk 2, Mk 118, Mk 98	AN/BQQ-6, AN/BQS-13, AN/BQS-15, AN/BQR-15, TB23, AN/BQR-19	AN/BPS-15A	WLR-8, WLR-10
OSCAR II (Project 949A)	Russian Federation	13,900/18,300	154 × 18.2 × 9	Punch Bowl	Shark Gill, Shark Rib, Mouse Roar, Pelamida	Snoop Pair	Rim Hat
Oyashio	Japan	2,750/3,000	81.7 × 9 × 7.4		ZQQ 5B/6, ZQR 1	ZPS 6	NZLR 1B
Romeo	Bulgaria	1,475/1,830	76.6 × 6.7 × 4.9		HF	Snoop Plate	Stop Light
Mod Romeo Type 033G	China	1,650/2,100	76.6 × 6.7 × 5.2		Herkules or Pike Jaw	Snoop Plate and Snoop Tray	Type 921-A
Romeo (Type 033)	China	1,475/1,830	76.6 × 6.7 × 5.2		Herkules or Tamir 5, DUUX 5	Snoop Plate or Snoop Tray	Type 921-A
Romeo (Type 033)	North Korea	1,475/1,830	76.6 × 6.7 × 5.2		Pike Jaw, Feniks	Snoop Plate/ Snoop Tray	Type 921-A
Improved Romeo (Type 033)	Egypt	1,475/1,830	76.6 × 6.7 × 4.9	SFCS Mk 2	CSU 83, Loral		AR-700-S5
RUBIS	France	2,410/2,670	73.6 × 7.6 × 6.4	TIT, LAT	DMUX 20, DSUV 62C, DSUV 22	Type 1007	ARUR 13/DR 3000U
Sang-O	North Korea	256/277	35.5 × 3.8 × 3.7	None fitted	Russian type	Furuno I-band	None fitted
Santa Cruz (TR 1700)	Argentina	2,116/2,264	66 × 7.3 × 6.5	Sinbads	CSU 3-4, DUUX 5	Calypso IV	Sea Sentry III
Improved Sauro	Italy	1,476/1,662, 1,653/1,862[7]	64.4[8] × 6.8 × 5.6	ISUS 90-20	CSU 90	BPS 704	BLD-727
Sauro (Type 1081)	Italy	1,456/1,631	63.9 × 6.8 × 5.7	ISUS 90	CSU 90	BPS 704	BLD 727
Sava	Serbia & Montenegro	830/960	55.7 × 7.2 × 5.1	—	PRS-3	Snoop Group	Stop Light
Scorpene	Chile	1,450/1,668	66.4 × 6.2 × 5.8	SUBTICS		I-band	AR-900
SEAWOLF	USA	8,060/9,142[9]	107.5[10] × 13 × 11	BSY-2, Mk 2	AN/BQQ-5D, TB16, TB 29, AN/BQS-24	BPS 16	WLQ-4(V)1, BLD-1
SIERRA I (Project 945)	Russian Federation	7,200/8,100	107 × 12.5 × 8.8	n/k	Shark Gill, Shark Rib, Mouse Roar, Skat 3	Snoop Pair	Rim Hat/Bald Head
SIERRA II (Project 945A)	Russian Federation	7,600/9,100	111 × 14.2 × 8.8	n/k	Shark Gill, Shark Rib, Mouse Roar, Skat 3	Snoop Pair	Rim Hat
Song	China	1,700/2,250	75 × 8.4 × 5.3	n/k	MF & LF	I-band	Type 921-A
Spiggen II*	Sweden	n/k/17	10.6 × 1.7 × 1.4	None fitted	None fitted	None fitted	None fitted
SWIFTSURE	UK	4,400[1]/4,900	82.9 × 9.8 × 8.5	SMCS	Type 2074, Type 2072, Type 2046, Type 2077, Type 2019 or 2082	Type 1006	UAP
Tang	Turkey	2,100/2,700	87.4 × 8.3 × 5.8	Mk 106	AN/BQR 2B, AN/BQS 4, AN/BQG 4	AN/BPS-12	WLR-1
Tikuna (SNAC-1)	Brazil	1,450/1,600	61 × 8 × 5.5	ISUS 83-13	CSU 83/1	Scanter	DR-400
TRAFALGAR	UK	4,740/5,208	85.4 × 9.8 × 9.5	SMCS	Type 2074 or 2076, Type 2046, Type 2077, Type 2019 or 2082, Type 2072	Type 1007	UAP
TYPHOON (Project 941)	Russian Federation	18,500/26,500	171.5 × 24.6 × 13	3R65	Shark Rib, Mouse Roar, Pelamida	Snoop Pair	Rim Hat
Ula	Norway	1,040/1,150	59 × 5.4 × 4.6	MSI-90(U)	CSU 83	Type 1007	Sealion
Una*	Serbia & Montenegro	76/88	18.8 × 2.7 × 2.5	None fitted	PP 10, PSU 1-2	None fitted	None fitted

Class	Navy	Displacement	Dimensions	Weapon Control	Sonars	Radar	EW
VANGUARD	UK	n/k/15,900	150 × 12.8 × 12	SMCS	Type 2054 = Type 2046, Type 2043, Type 2082	Type 1007	UAP 3
Vastergotland (A 17)	Sweden	1,070/1,143	48.5 × 6.1 × 5.6	IPS-17 (Sesub 900A)	CSU 83	Terma	AR-700-S5 or CS 3701
VICTOR III (Project 671 RTM)	Russian Federation	4,850/6,300	107 × 10.6 × 7.4	n/k	Shark Gill, Shark Rib, Mouse Roar, Skat 3	Snoop Tray 2	Brick Group
Victoria (ex-Upholder type)	Canada	2,168/2,455	70.3 × 7.6 × 5.5	SFCS Mk1	Type 2007, TSM 2040, Type 2019	Type 1007	AR 900
VIRGINIA	USA	n/k/7,800	114.9 × 10.4 × 9.3	CCSM	TB16, TB29, LWAA[11]	AN/BPS-16	WLQ-4(V), BLQ-10
Walrus	Netherlands	2,465/2,800	67.7 × 8.4 × 7	SEWACO VIII, GIPSY	TSM 2272, Type 2026, DUUX 5	ZW 07	AR 700
XIA	China	n/k/6,500	120 × 10 × 8		Trout Cheek	Snoop Tray	Type 921-A
YANKEE NOTCH (Project 667 AR/AT)	Russian Federation	8,500/10,300	141.5 × 11.6 × 8.1		Shark Teeth, Mouse Roar	Snoop Tray	Brick Group
YASEN (Project 885)	Russian Federation	5,900/8,600	111 × 12 × 8.4		Irtysh Amfora suite	I-band	ESM
Yugo/P-4***	North Korea	76/90	20 × 3 × 4.6	None fitted	None fitted	I-band	None fitted
Yugo***	Vietnam	90/110	20 × 3.1 × 4.6	None fitted	None fitted	None fitted	None fitted
Yuushio	Japan	2,250[1]/2,450	76 × 9.9 × 7.4	—	ZQQ 5, ZQR 1	ZPS 6	ZLR 5-6
Not known****	Iran	76/90	19 × 2.8	None fitted	None fitted	None fitted	None fitted

* Midget submarine
** Midget submarine. Italian COSMOS type
*** Midget submarine. Yugoslav design
**** Midget submarine. North Korean design based on Italian design
Names in capitals are nuclear boats described in text
[1] Standard
[2] Or Sinbad M8/24
[3] M8 in S347/348
[4] 104 m in last three
[5] SSN 688/750
[6] SSN 710, 773
[7] Last two boats
[8] Last two boats 66.5 m
[9] SSN 23, 12,139 dived
[10] SSN 23, 138.1
[11] LWAA – Lightweight Wide Aperture Array

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TABLE VI

Submarine designs September 2004 – weapons

Class	Navy	Torpedo tubes	Torpedoes	Missiles	Mines[1]
Type 093	China	6/533		SLCM, SSM	
Type 205	Germany	8/533	8		
Type 206A	Germany	8/533	8		16 (+24[2])
Type 207 (Tumleren)	Denmark	8/533	8		
Type 207 (Sokol)	Poland	8/533	8		
Type 209/1100-1200 (Glavkos)	Greece	8/533	14[4]	Sub-Harpoon[3]	
Type 209/1200 (Salta)	Argentina	8/533	14		
Type 209/1200 (Pijao)	Colombia	8/533	14		
Type 209/1200 (Chang Bogo)	Korea, South	8/533	14		28
Type 209/1200 (Angamos/Islay)	Peru	8/533	14		
Type 209/1200 (Atilay)	Turkey	8/533	14		
Type 209/1300 (Thomson)	Chile	8/533	14		
Type 209/1300 (Shyri)	Ecuador	8/533	14		
Type 209/1300 (Cakra)	Indonesia	8/533	14		
Type 209/1300 (Sabalo)	Venezuela	8/533	14		20
Type 209/1400 (Tupi)	Brazil	8/533	14		
Type 209/1400 (Preveze)	Turkey	8/533	14[4]	Sub-Harpoon	
Type 209/1400 MOD	South Africa	8/533	14		
Type 209/1500 (Shishumar)	India	8/533	14		24[2]
Type 212A	Germany	6/533	12		24[2]
Type 212A (Salvatore Todaro)	Italy	6/533	12		24
Type 214 (Papanikolis)	Greece	8/533	16[4]	Sub-Harpoon	
Type 214	Korea, South	8/533	16		
Agosta (Hashmat)	Pakistan	4/533	20[4]	Exocet	Stonefish
Agosta (Galerna)	Spain	4/533	20		19[6]
Agosta 90B (Khalid)	Pakistan	4/533	16[4]	4 × Exocet	Stonefish
AKULA (Project 971/971U/09710)	Russian Federation	4/533, 4/650, 6 × 533 external in some	40	40 × SS-N-21, SS-N-15, SS-N-16, 18 × SA-N-5/8	
ASTUTE	UK	6/533	38	Tomahawk, Sub-Harpoon	
Collins	Australia	6/533	22[4]	Sub-Harpoon	44
Daphne (Hangor)	Pakistan	12/550	12[4]	Sub-Harpoon	Stonefish
Daphne (Albacora)	Portugal	12/550	12		
Daphne (Delfin)	Spain	12/550	12		12
DELTA III (Project 667BDR)	Russian Federation	4/533	16	16 × SS-N-18 SLBM	
DELTA IV (Project 667BDRM)	Russian Federation	4/533	18	16 × SS-N-23 SLBM, SS-N-15	
Dolgorae*	Korea, South	2/406	2		n/k
Dolphin	Israel	6/553, 4/650	16 + 5 SSM	5 × Sub-Harpoon	
Dolphin**	Korea, South	2/533	2		
Foxtrot (Type 641)	India	10/533	22		44
Foxtrot (Type 641)	Libya	10/533	22		44
Foxtrot (Type 641)	Ukraine	10/533	22		44
Golf	China	10/533	12	1 × JL-2 SLBM	
Gotland (A 19)	Sweden	4/533	12		12 (+48[2])
		2/400	6		
Guppy II	Taiwan	10/533			
Hai Lung	Taiwan	6/533	20		
HAN	China	6/533	20	YJ 8-2	36
Harushio	Japan	6/533	20[4]	Sub-Harpoon	
Heroj	Serbia & Montenegro	4/533	6		12
Intrepido**	Colombia	None	None		6 or 8
Kilo (Project 877E)	Algeria	6/533	18	8 × SA-N-5/8?	24
Kilo (Project 877EKM/636)	China	6/533	18	SA-N-8?	24
Kilo (Project 877EKM/636)	India	6/533	18[4]	SA-N-8, SS-N-27	24
Kilo (Project 877EKM)	Iran	6/533	18	SA-N-10 SAM?	24
Kilo (Project 877E)	Poland	6/533	18		24
Kilo (Project 877E)	Romania	6/533	18	6-8 × SA-N-5/8	24
Kilo (Project 877/877K/877M)	Russian Federation	6/533	18	6-8 × SA-N-5/8	24
Kronborg (A 14)	Sweden	6/533	8		48[2]
		2/400	4		
Lada (Project 677)	Russian Federation	6/533	18		
LE TRIOMPHANT	France	4/533	18[4]	16 × M45 SLBM, Exocet	None
L'INFLEXIBLE	France	4/533	18[4]	16 × M4 SLBM, Exocet	None
LOS ANGELES	USA	4/533	26[4]	Tomahawk[7] Sub-Harpoon	
MG 110**	Pakistan	2/533	2		12 limpet
Ming (Type 035)	China	8/533	16		32
OHIO (SSBN)	USA	4/533		24 × Trident 1/II SLBM	
OHIO (SSGN)	USA	4/533		154 × Tomahawk	
OSCAR II (Project 949A)	Russian Federation	4/533, 2/650	28[4]	24 × SS-N-19, SS-N-15, SS-N-16, 32 SA-N-5/8	
Oyashio	Japan	6/533	20[4]	Sub-Harpoon	
Romeo	Bulgaria	8/533	14		28
Mod Romeo (Type 033G)	China	8/533	22[8]	6 × YJ-1 Eagle Strike	28
Romeo (Type 033)	China	8/533	14		28
Romeo (Type 033)	Korea, North	8/533	14		28
Improved Romeo (Type 033)	Egypt	8/533	14[4]	Sub-Harpoon	28
RUBIS	France	4/533	14[4]	Exocet	32
Sang-O	Korea, North	2 or 4/533	2 or 4		16
Santa Cruz (TR 1700)	Argentina	6/533	22		34

Class	Navy	Torpedo tubes	Torpedoes	Missiles	Mines[1]
Improved Sauro	Italy	6/533	12		
Sauro (Type 1081)	Italy	6/533	12		
Sava	Serbia & Montenegro	6/533	10		20
Scorpene	Chile	6/533	18		30
SEAWOLF	USA	8/660	50[4]	Tomahawk	100
SIERRA I (Project 945)	Russian Federation	4/533, 4/650	40[4]	SS-N-21, SS-N-16 12 × SA-N-5/8	42
SIERRA II (Project 945A)	Russian Federation	4/533, 4/650	40[4]	SS-N-21, SS-N-16 12 × SA-N-5/8	42
Sjoormen (A 12)	Singapore	4/533	10		8
		2/400	4		
Song	China	6/533	n/k	YJ 8-2	
Spiggen II*	Sweden	None	None		
SWIFTSURE	UK	5/533	20	Tomahawk, Sub-Harpoon	
Tang	Turkey	8/533	21		
Tikuna (SNAC-1)	Brazil	8/553	16[4]	Exocet or Sub-Harpoon	32
TRAFALGAR	UK	5/533	20	Tomahawk, Sub-Harpoon	
TYPHOON (Project 941)	Russian Federation	6/533	22	20 × SS-N-20, SS-N-15	
Ula (Type P 6071)	Norway	8/533	14		
Una*	Serbia & Montenegro				4
VANGUARD	UK	4/533	n/k	16 × Trident II SLBM	4
Vastergotland (A 17)	Sweden	6/533	12		48[2]
		3/400	6		
VICTOR III (Project 671 RTM)	Russian Federation	4/533	16[4]	SS-N-21, SS-N-15, SS-N-16	36
		2/650	8		
Victoria (ex-Upholder type)	Canada	6/533	18		
VIRGINIA	USA	4/533	38[4]	Tomahawk (12 VLS tubes), Sub-Harpoon	
Walrus	Netherlands	4/533	20[4]	Sub-Harpoon	40
XIA	China	6/533		12 × JL-1 SLBM	
YANKEE NOTCH (Project 667AR/AT)	Russian Federation	6/533	18	35 × SS-N-21	
YASEN (Project 885)	Russian Federation	8/533	c30[4]	24 × SS-N-27 (8 VLS tubes), SS-N-15	
Yugo/P-4***	Korea, North	2/406 or 533			
Yugo***	Vietnam	None	None		
Yuushio	Japan	6/533	20[4]	Sub-Harpoon	
Not known ****	Iran	None	None		

* Midget submarine
** Midget submarine. Italian COSMOS type
*** Midget submarine. Yugoslav design
**** Midget submarine. Korea, North design based on Italian design
Names in capitals are nuclear boats described in text
[1] In lieu of torpedoes
[2] Carried in containers either side of hull or in external girdle
[3] Can only be launched from 4 tubes
[4] Including missiles
[5] Also 1 × 127 mm gun
[6] With torpedo load of 9 weapons
[7] 12 VLS tubes in SS-N 719/773
[8] Including six missiles
n/k: not known

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TABLE VII

Submarine designs September 2004 – machinery

Class	Navy	Nuclear/Diesels[1]	EM[1]	Shafts	Speed[2]	Range[3]	Depth[4]	Endurance[5]	Crew
Type 093	China	2 × PWR/150 MW		1	30				100
Type 205	Germany	2/882 kW	1/1.32	1	10/17/?		159		22
Type 206A	Germany	2/882 kW	1/1.32	1	10/17/?	4,500/5			22
Type 207 (Tumleren)	Denmark	2/880 kW	1/1.25	1	12/18/?	5,000/8[6]	200		24
Type 207 (Sokol)	Poland	2/880 kW	1/1.32	1	12/18/?	5,000/8[6]	200		18
Type 209/1100/1200 (Glavkos)	Greece	4/1.76	1/3.38	1	11/21.5/n/k	8,600/4[6]	250	50	31
Type 209/1200 (Salta)	Argentina	4/1.76	1/3.36	1	10/22/11	6,000/8//400/4	250	40	31
Type 209/1200 (Pijao)	Colombia	4/1.76	1/3.38	1	11/22/n/k	8,000/8//400/4	250	30	34
Type 209/1200 (Chang Bogo)	Korea, South	4/2.8	1/3.38	1	11/22/11	7,500/8//n/k	250	50	33
Type 209/1200 (Angamos/ Islay)	Peru	4/1.76	1/3.38	1	11/21.5/11	11,300/4//240/8	250	40	35
Type 209/1200 (Atilay)	Turkey	4/1.76	1/3.38	1	11/22/n/k	7,500/8//n/k	250	50	38
Type 209/1300 (Sabalo)	Venezuela	4/1.76	1/3.38	1	10/22/n/k	7,500/10//n/k	250	50	33
Type 209/1300 (Thomson)	Chile	4/1.76	1/3.38	1	11/21.5/n/k	8,200/8[6]//400/4		50	32
Type 209/1300 (Shyri)	Ecuador	4/1.76	1/3.38	1	11/21.5/11	8,400/8//445/4		45	33
Type 209/1300 (Cakra)	Indonesia	4/1.76	1/3.38	1	11/21.5/n/k	8,200/8	240	50	34
Type 209/1400 (Tupi)	Brazil	4/1.76	1/3.36	1	11/21.5/11	8,200/8//400/4	250	50	30
Type 209/1400 (Preveze)	Turkey	4/2.8	1/3.38	1	15/21.5/15	8,200/8//400/4	280	50	30
Type 209/1400 MOD	South Africa	4/2.8	1/3.7	1	10/21.5/n/k	>10,000/n/k	250	45	30
Type 209/1500 (Shishumar)	India	4/1.76	1/3.38	1	11/22/n/k	13,000/10//8,000/8[6]	260	50	40
Type 212A	Germany	1/3.12 1-AIP/300kW	1/2.85	1	12/20/n/k	8,000/8//420/8		30	27
Type 212A (Salavatore Todaro)	Italy	1/3/12 1-AIP/300 kW	1/2.85	1	12/20//n/k	8,000/8//420/8		30	27
Type 214	Greece	2/4.17 and 2-AIP/240 kW	n/k	1	11/20/n/k	12,000/6	>400	50	27
Type 214	Korea, South	1/3.12 and 1-AIP/306kW		1	12/20//n/k	12,000/6	>400	50	27
Agosta (Hashmat)	Pakistan	2/2.65	1/3.4	1	12/20/n/k	8,500/9[6]//350/3.5	300	45	54
Agosta (Khalid) (Galerna)	Spain	2/2.7	1/3.4	1	12/20/n/k	8,500/9[6]//350/3.5	300	45	54
Agosta 90B	Pakistan	2/2.65	1/3.4	1	12/>20/n/k	8,500/9[6]//350/3.5	320	60	50
Lada (Project 677)	Russian Federation	2/2.5	1/4.1	1	10/21 /n/k	6,000/7//650/3	250	45	37
ASTUTE	UK	PWR-2		1	n/k/29/–				98
Collins	Australia	3/4.42	1/5.4	1	10/20/10	11,500/10//n/k	70		42
Daphne	France	2/1.8	2/1.9	2	13.5/16/n/k	10,000/7//n/k	300		53
Daphne (Hangor)	Pakistan	2/1.8	2/1.9	2	13/15.5/n/k	4,500/5//n/k	300		53
Daphne (Albacora)	Portugal	2/1.8	2/1.9	2	13.5/16/n/k	2,710/12//2,130/10[6]	300		55
Daphne (Delfin)	Spain	2/1.8	2/1.9	2	13.2/15.5/?	2,710/12//4,300/7.5[6]	300		47
DELTA III (Project 667BDR)	Russian Federation	2 PWR/180 MW	2/450	2	14/24/		320		130
DELTA IV (Project 667BDRM)	Russian Federation	2 PWR/180 MW	2/450	2	14/24/		400		130
Dolgorae*	Korea, South	1/n/k	1/n/k	1	9/6				6
Dolphin	Israel	3/3.12	1/2.85	1	12/20/11	8,000/8//420/8	350	30	30
Dolphin**	Korea, South	1n/k	1/n/k	1	9/6	1,600/7//60/4.5	n/k	20	6
Foxtrot (Type 641)	India	3/4.4	3/3.97[7]	3	16/15/?	20,000/8//380/2	250		75
Foxtrot (Type 641)	Libya	3/4.4	3/3.97	3	16/15	20,000/8//380/2	250		75
Foxtrot (Type 641)	Ukraine	3/4.4	3/3.97	3	16/15	20,000/8//380/2	250		75
Golf	China	3/4.41	3/4	3	17/13/	6,000/15//			86
Gotland (A 19)	Sweden	2/n/k[8]	1/n/k	1	11/20			14	28
Guppy II	Taiwan	3/3.3	2/4	2	18/15/n/k	8,000/12//n/k			75
Hai Lung	Taiwan	3/3	1/3.74	1	12/20/n/k	10,000/9//n/k			67
Harushio	Japan	2/4.1	2/5.3	1	12/20	n/k	350		74
Heroj	Serbia & Montenegro	2/880 kW	1/1.15	1	10/15/?	n/k//4,100/10[6]	150		31
Intrepido**	Colombia	1/n/k	1/221kW	1	11/6	1,200/7//60/7	n/k		4
Kilo (Project 877E)	Algeria	2/2.68	1/4.34[9]	1	10/17/9	6,000/7[6]//400/3	350	45	52
Kilo (Project 877EKM636)	China	2/2.68	1/4.34[9]	1	10/17/8-10	6,000/7[6]//400/3	350	45	52
Kilo (Project 877EKM636)	India	2/2.68	1/4.34[9]	1	10/17/9	6,000/7[6]//400/3	300	45	52
Kilo (Project 877EKM)	Iran	2/2.68	1/4.05[9]	1	10/17/8-10	6,000/7[6]//400/3	350	45	53
Kilo (Project 877E)	Poland	2/2.68	1/4.34[9]	1	10/17/9	6,000/7[6]//400/3	350	45	52
Kilo (Project 877E)	Romania	2/2.68	1/4.34[9]	1	10/20/9	6,000/7[6]//400/3	350	45	52
Kilo (Project 877/ 877K/877M)	Russian Federation	2/2.68	1/4.34[9]	1	10/17/9	6,000/7[6]//400/3	350	45	52
Kronborg (A 14)	Sweden	1/1.27[8]	1/1.32	1	12/20		300		27
LOS ANGELES	USA	1/26Φ	1/242kWυ	1	-/32/-	Unlimited	450		133
MG 110**	Pakistan	1/n/k	1/n/k	1	7/4.5	1,200/7//60/4.5	150	20	6
Ming (Type 035)[10]	China	2/3.82		2	15/18/10	8,000/8[6]//330/4	300	60	57
OHIO (SSBN)	USA	1 × PWR/44.8		1	?/24	Unlimited	244		155
OHIO (SSGN)	USA	1 × PWR/44.8		1	?/24	Unlimited	244		155
Oscar II (Project 949A)	Russian Federation	2 × PWR/380 MW		2	15/28/	Unlimited	300 (?600)		107
Oyashio	Japan	2/4.1	2/5.7	1	12/20				69
Romeo	Bulgaria	2/2.94	2/1.98	2	15/13//10	9,000/9		45	54

Class	Navy	Nuclear/Diesels[1]	EM[7]	Shafts	Speed[2]	Range[3]	Depth[4]	Endurance[5]	Crew
Modified Romeo Type 033	China	2/2.94	2/1.98	2	15/13/10	14,000/9//330/4	300	60	54
Romeo (Type 033)	China	2/2.94	2/1.98	2	15.2/13/10	14,000/9//330/4	300	60	54
Improved Romeo	Egypt	2/2.94	2/1.98	2	16/13/n/k	14,000/9//330/4	300		54
Romeo (Type 031)	Korea, North	2/2.94	2/1.98	2	15/13/n/k	9,000/9//n/k		60	54
Sang-O	Korea, North	1/n/k	1/n/k	1	7.6/8.8/7.2	2,700/7//n/k	180		19
Santa Cruz (TR 1700)	Argentina	4/4.94	1/6.6	1	15/25/15	12,000/8//460/6	270	70	29
Improved Sauro	Italy	3/27	1/2.3	1	11/19/12	11,000/11//250/4	300	45	50
Sauro (Type 1081)	Italy	3/2.46	1/2.36	1	11/19/12	11,000/11//250/4	300	35	49
Sava	Serbia & Montenegro	2/1.18	1/1.5	1	10/16/n/k		300		35
Scorpene	Chile	4/2,500 kW	1/2.8	1	12/20/n/k	6,400/8//550/4	>300	>60	32
SEAWOLF	USA	1/38.8Φ	1/n/kυ	1	n/k/35/ -	Unlimited	c610		133
SIERRA I (Project 945)	Russian Federation	1 × PWR/190 MW	2/1.5	1	10/34/	Unlimited	750		61
SIERRA I I (Project 945A)	Russian Federation	1 × PWR/190 MW	2/1.5	1	10/32/	Unlimited	750		61
Sjoormen (A 12)	Singapore	2/1.62	1/1.1	1	12/20/n/k		150	21	23
Sodermanland (A 17)	Sweden	2/1.62 and 2 AIP/150 kW	1/1.32	1	10/20/		300		27
Song	China	4/4.48	1/n/k	1	15/22/n/k	n/k/72/3			60
Spiggen II*	Sweden	1/n/k		1	n/k/5		100	14	6
Tang	Turkey	3/3.4	2/4.2	2	16/16/n/k	7,600/15//n/k			87
TRAFALGAR	UK	1 × PWR 1/11.2		1	n/k/32	Unlimited		85	130
Tikuna	Brazil	4/2.76	1/3.38	1	11/22/11	11,000/8//400/4	300	60	39
Ula (Type P 6071)	Norway	2/1.98	1/4.41	1	11/23/n/k	5,000/8//n/k	250	40	18-20
Una*	Serbia & Montenegro	-	2/36 kW	1	6/7	n/k//200/4	120		4
VANGUARD	UK	1 × PWR 2/20.5		1	n/k/25				135
Vastergotland (A 17)	Sweden	2/1.62	1/1.32	1	10/20		300	45	27
Velebit	Croatia	1/105 kW	2/80 kW	1	6/7	n/k//200/4	120	6	4
VICTOR III (Project 671 RTM)	Russia	2 × VM4 PWR/150	2/n/k	1	10/30	Unlimited		80	98
Victoria (ex-Upholder)	Canada	2/2.7	1/4	1	–	n/k/8,000/8	>200	49	47
VIRGINIA	USA	1/29.84Φ	1/n/kυ	1	n/k/34/-	Unlimited			113
Walrus	Netherlands	3/4.63	1/5.1	1	12/20/n/k	10,000/9[6]	300	60	52
XIA	China	1 × PWR/90		1	n/k/22	Unlimited			140
YANKEE NOTCH (project 667 AR/AT)	Russia	2 × VM4 PWR/155		1	16/26	Unlimited			109
YASEN	Russia	1 × PWR/195		1	17/28	Unlimited		100	55
Yugoψ	Korea, North	1/120 kW		1	10/4	550/10//50/4			2
Yugo/P4 ***	Korea, North	2/236 kW		1	12/8	550/10/50/4			4
Yuushio	Japan	2/5	2/5.3	1	12/20/n/k		275		75
Not known ß	Iran	2/236 kW		1	12/8	1,200/6/n/k	c100		3

* Midget submarine
** Midget submarine. Italian COSMOS type
ψ Midget submarine. Yugoslav design
β Midget submarine. Korea, Northn design based on Italian design
Names in capitals are nuclear boats described in text
Φ PWR S6G power plant in Los Angeles. Seawolf PWR S6W, NSSN PWR S9G nuclear systems
υ Auxiliary or secondary motor
[1] Number/MW output (total output listed)
[2] Speed: surfaced/dived/snorting in kt
[3] Range: n miles at kt surfaced/submerged
[4] Maximum depth in m under normal conditions. Crushing depth is considerably greater. Operating depth gradually reduces as a boat ages to the extent that boats beyond 30 years are usually restricted to operating at periscope depth
[5] Days
[6] Under snorkel and 7,500 @ kt in the Project 636
[7] Plus 1 auxiliary motor 103 kW
[8] Also 2 Stirling AIP 150 kW
[9] Also 2 auxiliary motors 150 kW, and 1 economic speed motor 95 kW
[10] Were Type ES5C/D. Modified ES5E design
[11] SNAC-1
[12] PWR S8G power plant
n/k: not known

UPDATED

China

Type 093

Type
Nuclear-powered submarine.

Description
This is the second-generation SSN design to emerge from China and is the successor to the Han class. The design has apparently been developed with technical assistance from the Rubin Design Bureau in Russia and seems to be based on the 'Victor III' design. In performance and quietness it appears to be similar to the Russian Victor III class from which it may be derived.

The vessel is powered by two PWR nuclear reactors developing 150 MW that it is thought have been developed using Russian technology. These will drive two steam turbines to power the single skewed propeller that may also be of Russian design and offer a much quieter performance.

It is assumed that the submarine will be capable of deploying most torpedoes currently available in the PLA Navy inventory and also have the ability to launch anti-ship cruise missiles and also land-attack cruise missiles when they are available. These will be deployed from six 533 mm torpedo tubes.

The sensor fit will comprise the usual hull-mounted passive attack sonars as well as flank and towed arrays.

Operational status
Work on the design has progressed extremely slowly. Prefabrication of the unit began in 1994 and was launched in December 2002 with completion due in 2005. A second unit is understood to be under construction.

Specifications
No specific details have been released.

Contractor
Huludao Shipyard.

VERIFIED

Croatia

R-2

Type
Two-man Swimmer Delivery Vehicle (SDV).

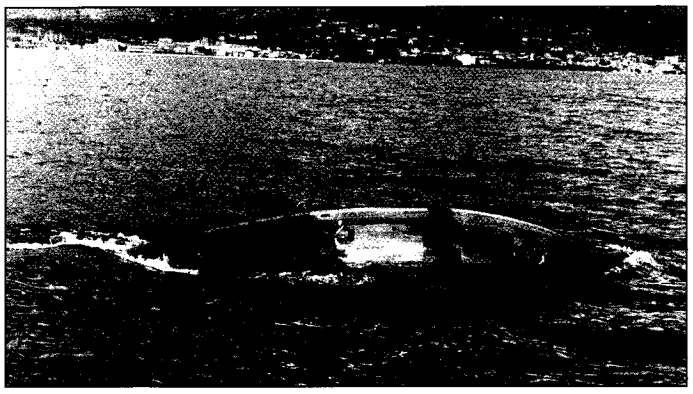
Description
The 1.22 m diameter R-2 is designed for the transport of frogmen and underwater limpet mines (up to 250 kg payload), for carrying diversionary equipment and for underwater reconnaissance. The hull is constructed of aluminium alloy resistant to saltwater corrosion. The front upper part of the submersible is made of Plexiglas. The spindle-shaped hull is free flooding, except for watertight cylinders which house the storage battery, propulsion unit, navigation equipment, compressed air and ballast tanks.

The built-in ballast system is used for blowing and flooding the ballast tanks to achieve static diving in seas of specific gravity 1.01 to 1.03 t/m^3 and at depths of 0 to 60 m, as well as for compensation of air consumed by the frogmen's respiratory system.

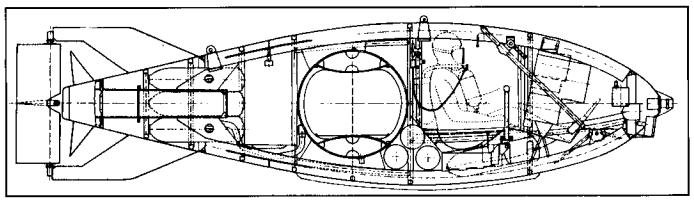
The vehicle is powered by a DC electric motor which derives its power from a storage battery. The three-bladed propeller is driven via an electromagnetic clutch. With lead acid batteries the vehicle has a range of 18 n miles at maximum speed, and 23 n miles at 3.7 kt cruising speed; and with silver-zinc batteries of 310 Ah it has a range of 38 n miles at maximum speed, and 46 n miles at a cruising speed of 3.7 kt.

Navigation equipment comprises an aircraft-type gyro compass, a magnetic compass, depth gauge with scale 0 to 100 m, echo-sounder, sonar, two searchlights and so on. All navigation equipment is housed in a waterproof container.

Control is exercised through fore and aft hydroplanes and a conventional cruciform tail arrangement with rudder mounted behind the screw.



R-2M (dry delivery) 0009589



Schematic of the R-2 two-man submersible

Operational status
Three units are in service with Croatian forces. Two units have been reported as sold to Syria, and one has been sold to Sweden.

Specifications

Displacement:	
surface:	1.41 t
Dimensions:	
length:	4.9 m (oa)
beam:	1.4 m (max over hydroplane)
height:	1.32 m (max over appendages)
Electronics:	
combat management system:	none
sonars:	none
periscopes	none
radar:	none
electronic warfare:	none
Weapons:	
torpedo tubes:	none
torpedoes:	none
missile tubes:	none
mines:	2 × 50 kg limpets
Machinery:	
diesels:	none
AIP:	none
batteries:	4 16 Ag/Zn 24 V, 192 Ah
electric motor:	1 × DC
power output:	3.3 kW
nuclear plant:	none
auxiliary system:	none
shafts:	1
Speed:	
surfaced:	4.4 kt (max)
Range:	
surfaced:	18 n miles @ 4.4 kt
operating depth:	60 m
Personnel:	2

Contractor
Brodosplit, Split.

UPDATED

Velebit

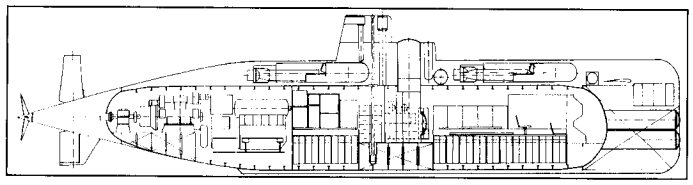
Type
Midget submarine.

Description
A number of naval units were captured from Yugoslavia during the civil war and put into service by the newly independent state of Croatia. Included among these was a Una class midget submarine, one of six built during the mid-1980s.

The single-hull boat is built of micro-alloy steel with a glass fibre sail. The hull is divided into three compartments with two watertight bulkheads. The forward compartment provides accommodation for the crew of four and six combat divers, as well as command and control for all the boat's systems. The centre compartment houses the lock in/lock out chamber with the main hatch cover, and the after compartment houses the propulsion system.

The hull of *Velebit* has been lengthened by 2.3 m to incorporate a MTU 6R 009TA 105 kW diesel generator that further extends the boat's capabilities and range. This enables the two 128-cell batteries to be charged at sea, rather than in harbour as with the five other boats in the series still in service with the Yugoslav Navy. The generator powers two newly developed Koncar permanent magnet DC electric motors with a combined output of about 80 kW controlled by an electronic converter. These drive a specially designed single 7-bladed skewed low noise propeller giving the boat a maximum speed of 7 kt submerged. The new propulsion system is claimed to develop a much lower noise signature than the previous system.

Platform control is exercised through an X-plane configuration at the stern, controlled by autopilot and two bow-mounted dive planes. The craft is fitted with a



General arrangement layout of Yugoslav Navy Una class midget 0007208



A Croatian Una class midget submarine

lock in/lock out chamber for divers and can carry four heavy ground mines or four SDVs with limpet mines.

The boat is manned by a crew of four and can carry up to six combat divers. Space is provided for a demolition team with four berths and storage for their equipment. Other payloads can include four R-1 SDVs and, as an option, two torpedoes. Alternatively the boat can carry four large demolition charges or 12 light limpet mines which can be stored in the divers lockout. Other options include four heavyweight or six lightweight seabed mines.

Velebit is fitted with an STN ATLAS Elektronik PSU 1-2 passive sonar and a high-frequency passive/active cylindrical search sonar. Recent reports indicate that the boat has been fitted with a snorkel induction mast and exhaust.

Operational status
One unit in inventory, but may not be in service.

Specifications
Displacement:
surface: 88 t
submerged: 99 t
Dimensions:
length: 20.9 m
beam: 2.7 m
draft: 2.4 m
Electronics:
combat management system: none
sonars: PSU 1-2
Weapons:
mines: 12 limpet or 4 seabed
other: 4 × SDV
Machinery:
diesels: 1 × MTU 6R 009TA
power output: 105 kW
electric motor: 2 × Koncar
power output: 40 kW
shafts: 1
Speed
surfaced: 6 kt
submerged: 7 kt
Range:
submerged: 200 n miles @ 4 kt
operating depth: 120 m
Personnel: 1 officer, 4 crew, 6 divers

Contractor
BrodoSplit, Split.

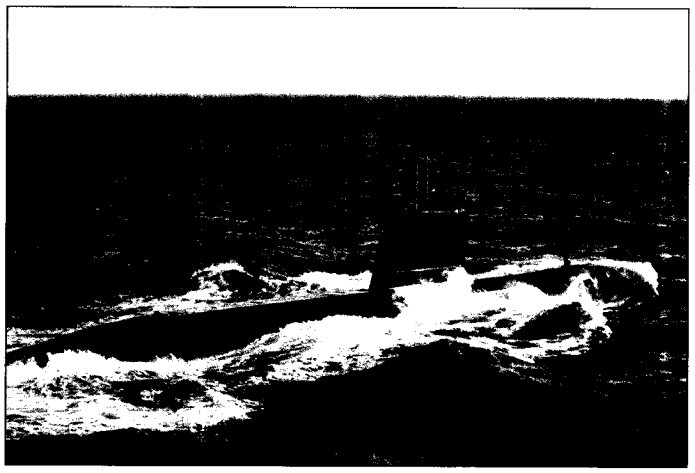
UPDATED

France

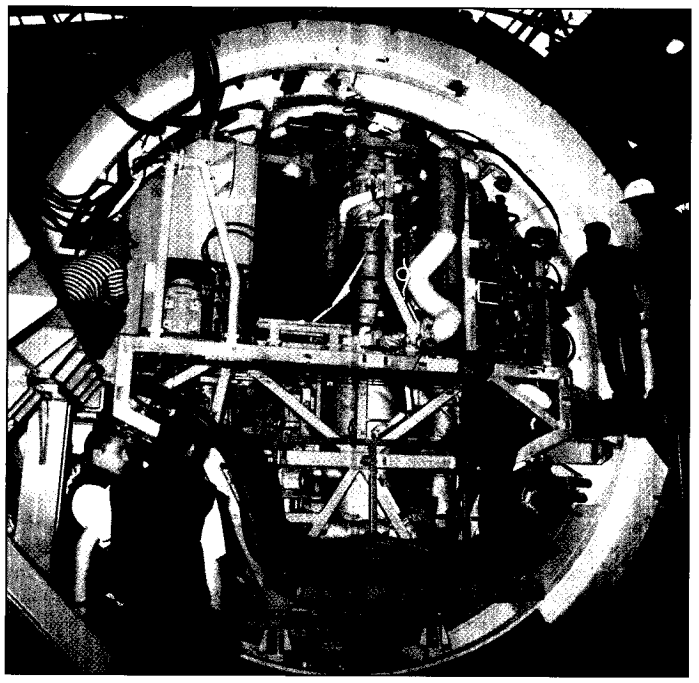
Agosta class

Type
Diesel-electric patrol submarine.

Description
The 'Agosta' features a circular outer hull of 6.8 m maximum, which surrounds the pressure hull. At the bow the cross-section of the outer hull narrows to an oval shape, ensuring the minimum underwater hydrodynamic resistance. Considerable efforts have been made to reduce self-generated noise resulting in a clean, streamlined casing and noise damping of all equipment. An array of 36



The second Khalid class submarine Saad (DCN) ***NEW***/0562934



The first MESMA unit for the Pakistan Navy under assembly in France (DCN) 0111764

hydrophones is fitted all around the hull to measure the radiated noise level and provide immediate identification of areas of self-generated noise.

The boats are armed with four bow torpedo tubes fitted with a pneumatic ram discharge system. The tubes allow weapon discharge, irrespective of the speed of the submarine, down to its maximum diving depth. The design also incorporates a rapid reload system. Units of the French Navy have been modified to fire the Aerospatiale submarine-launched SM 39 Exocet anti-ship missile. The Pakistan units were modified in 1985 to fire the Sub-Harpoon missile, but the US has banned sales of this equipment to Pakistan and any missiles Pakistan may have acquired must now be considered to be beyond their shelf life as they have had no support.

Fire control is exercised through a single, centralised computer using the DLA 2A system. This features an automatic navigational plotting system. Sensors include an 8 kHz active search/attack DUUA 2D sonar, passive ranging and passive towed array sonars. Arur and Arud intercept and warning systems are also fitted, except in the Spanish boats which are fitted with the British Manta system.

The propulsion system comprises two SEMT-Pielstick 16 PA4 V 185 VG diesels developing 2.65 MW driving two Jeumont-Schneider 1.7 MW alternators. A single water-cooled 3.4 MW electric motor with double armature directly drives the propeller. There is no intermediate clutch in order to reduce noise level to a minimum. In addition, a 23 kW electric motor is provided for cruise speeds. The two independent banks of batteries of 320 elements use an electrolyte agitation system with water circuit cooling to extend service life and improve efficiency. Two 850 kW generators on flexible mountings provide hotel services, the alternating current being provided by means of five converter sets with two solid-state inverters.

The space between the external and pressure hull accommodates four pairs of ballast tanks. On diving, the air in each pair of tanks is released by a vent valve operated from the central control position. The expulsion of water ballast, likewise operated from this position, is effected by means of compressed air. The two bow tanks are also provided with a special blowing system which, in the event of excessive dip, makes possible the rapid expulsion of the water ballast from the bow, even at great depth.

A single operator facing the bows exercises submarine control. The joystick control operates simultaneously the steering, rudder and depth rudder in coupled control. Opposite the operator are various indicators and a synthesiser presenting a symbolic image on the screen enabling the pilot to move the control intuitively.

Specifications

	Khalid	Hashmat	Galerna
Displacement:			
surface:	1,510 t	1,490 t	1,490 t
submerged:	1,760 t	1,740 t	1,740 t
Dimensions:			
length:	67.6 m	67.6 m	67.6 m
beam:	6.8 m	6.8 m	6.8 m
draft:	5.4 m	5.4 m	5.4 m
Electronics:			
combat management system:	SUBTICS	SUBICS Mk 2	DLA 2A
sonars:	TSM 2233, DUUX 5, TSM 2933	DUUA 2B, TSM 2233, TSM 2933	DSUV 22, DUUX 2A/5, DUUA 2A/2B, Solarsub
radar:	Type 1007	DRUA-33	DRUA 33C
electronic warfare:	DR-3000U	Arur, Arud	Manta E
Weapons:			
torpedo tubes:	4 × 533 mm	4 × 533 mm	4 × 533 mm
payload:	16 weapons	20 weapons	20 weapons
torpedoes:	F 17P	F 17P	F17 Mod 2, L5
missiles:	Exocet SM 39	UGM-84A Sub Harpoon	None
mines:	Stonefish	Stonefish	19 (torpedo load 9)
Machinery:			
diesels:	2 × 16 PA4 V185	2 × 16 PA4 V185	2 × 16 PA4 V185
electric motor:	1 × Jeumont-Schneider	1 × Jeumont-Schneider	1 × Jeumont-Schneider
power output:	2.2 MW	3.4 MW	3.4 MW
auxiliary system:	1 × 23 kW electric motor	1 × 23 kW electric motor	1 × 23 kW electric motor
shafts:	1	1	1
Speed:			
surfaced:	12 kt	12.5 kt	12 kt
submerged:	20 kt	20.5 kt	20 kt
Range:			
surfaced:	8,500 n miles @ 9 kt (snorting)	8,500 n miles @ 9 kt (snorting)	8,500 n miles @ 9 kt (snorting)
submerged:	350 n miles @ 3.5 kt	350 n miles @ 3.5 kt	350 n miles @ 3.5 kt
autonomy:	60 days	45 days	45 days
operating depth:	320 m	300 m	300 m
Personnel:	7 officers, 29 crew	8 Officers, 51 crew	6 Officers, 48 crew

The steering and diving systems functions in either:
- automatic control (steering and diving)
- manual computer assisted control
- manual and emergency control

Crew accommodation includes a bunk for every crew member each with ventilation and light. The boats are fully air conditioned for operation in the tropics and are equipped with oxygen generating units and independent CO_2 absorption units. Air is conditioned by two installations generating 27,000 frigories/hour, which are used to cool the vessel. During diving, air is regenerated through the chemical burning and absorption of CO_2 granules based on soda-rich lime.

The 'Agosta 90B', building for Pakistan, is an improved variant of the basic Agosta class already in service with the Pakistan Navy. The boats feature higher performance and a new combat system, the UDS SUBTICS 6-console integrated combat system with an associated sonar suite comprising cylindrical bow, flank, ranging and intercept arrays, an active array and a clip-on towed array. The ESM system is the DR-3000U. A SAGEM Minicin Mk 3 inertial navigation unit will aid navigation. Propulsion is provided by two SEMT Pielstick PA4.185 SM 850 kW diesel engines and a Jeumont Industrie single 2,200 kW electric propulsion motor, mounted on a new suspension for quieter running. A new battery system developed by CEAC and comprising two 160-cell units offers increased range capability. Control of the boat will be carried out with the SAGEM SS Mk 1 control station to control heading and submersion either manually or through the autopilot. The last boat in the series will be fitted with the MESMA AIP system (which will extend the hull length by 9 m). This system will also be retrofitted to the first two boats in the series. These units will also have much improved acoustic quieting and a fully integrated sonar suite including flank, intercept and towed arrays. The hulls are being constructed of HLES 80 steel (equivalent to HY100) that should allow the boats to reach diving depths of 350 m. Armament consists of four torpedo tubes with space for 16 weapons including a mix of F17 Mod 2 torpedoes and EXOCET SM 39 anti-ship missiles. Two weapons can be simultaneously controlled in any combination being fired with a pneumatic ram discharge system.

A feature of this new 'Agosta' design is the reduced crew requirement. This has been reduced from the 54 of the earlier design to 36 including just seven officers. The control room watch has been reduced from 13 to nine of which five man the combat system and four carry out platform management operations.

Operational status
The 'Agosta' design is in operational service with the French, Pakistan and Spanish navies, and an updated variant, the 'Agosta 90B', has been ordered by the Pakistan Navy to replace its ageing Daphne class and the first boat is now in service. The second indigenously built unit underwent initial depth trials on 10 October 2003. Agosta class units of the French Navy have paid off. Spanish Navy units are being modernised with new weapon fire-control systems, towed array sonars, new ESM and periscopes with IR imaging capability.

Contractor
DCN, Paris.

UPDATED

Barracuda

Type
Nuclear-powered attack submarine.

Development
Work has commenced on the design of a new class of six SSNs (the SMAF – Sous-Marin d'Attaque Future) under the Barracuda project.
2020 – Entire class planned to be in service.
2012 – First boat to enter service to start replacing Amethyste class.
2004 – Construction scheduled to commence.
2002 – Feasibility phase concluded at the start of the year.
1998 – Integrated Project Team formed by DGA.

The boats will be built at the rate of two per year.

Description
Technology
Much of the technology to be incorporated in the Barracuda design will emanate from the Le Triomphant design as well as new features developed for the Scorpene design. This will lead to reduction in acquisition costs and, in the case of the propulsion system, will reduce design time. The high level of automation planned for the boats will enable the crew to be limited to around 60 (the current SSNs are manned by a crew of 75). To maximise time at sea each boat will be provided with two crews.

Combat Management System
The command system, to be known as Systeme de Combat pour Barracuda et SNLE (SYCOBS), will be fully integrated with all the boat's sensors and is being developed by Thales Underwater Systems in association with DCN. This system will also equip the last unit of the Le Triomphant class SSBN *Le Terrible* which will act as a trials boat for the system.

Sensors
The sensor suite of the Barracuda will include bow sonar, wide aperture flank array and a reelable thin-line towed array for which QinetiQ in the UK is carrying out application studies. A spokesman from the Etat-Major de la Marine has said that the design will exhibit a lower radiated noise over current French SSNs.

Weapons
The boats will be armed with a new generation heavyweight wire-guided torpedo and the SCALP land-attack cruise missile fired from two of the four torpedo tubes using a water-ram discharge system, as well as anti-ship missiles of a new generation. The remaining two torpedo tubes will be fitted with a swim out discharge system. A total of 18 weapons will be carried. At present there is no requirement for the boats to integrate UUVs, but the final design may take account of future UUV operating requirements for which a possible UUV retrofit may be encompassed.

Propulsion
It is reported that a derivation of the K-15 150 MW reactor developed for the Le Triomphant class SSBN and the carrier *Charles de Gaulle* will be fitted. The propulsion system will be of hybrid configuration using electric propulsion for cruising and a turbo-mechanical system for high speed.

Operational status
Under development.
2013 - Entry into service.
2011 - Sea trials scheduled.
2005 - Construction of the lead unit may commence.
2004 - Orders for long-lead items due.

Specifications

	Barracuda
Displacement:	
surface:	4,100 t
Dimensions:	
length:	c 90 m
Electronics:	
combat management system:	SYCOBS
Weapons:	
torpedo tubes:	4 × 533 mm
torpedoes:	new generation
missile tubes:	none
missiles:	Scalp, Exocet SM 39
mines:	in lieu of torpedoes
payload	18 weapons
Machinery:	
diesels:	none
power output:	none
AIP:	none
power output:	none
nuclear plant:	1 × K-15 PWR
shafts:	1
Speed:	
submerged:	>25 kt
Range:	
autonomy:	70 days
operating depth:	>350 m
Personnel:	60 crew

Contractor
DCN, Paris.

VERIFIED

Germany

Dolphin class

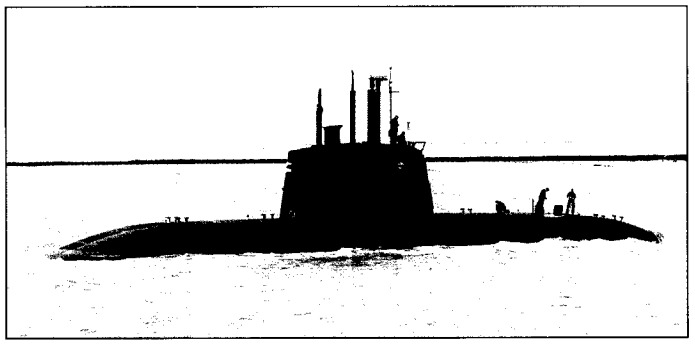
Type
Diesel-electric patrol submarine.

Description
The design developed for the Israeli Navy, the 1,550 tonne *Dolphin* features considerable stealth technology, with emphasis being laid on its interdiction capabilities. For this, the boats will be fitted with a wet and dry facility for special forces operations and an extensive payload of torpedoes and Sub-Harpoon missiles for the 4 × 533 mm and 2 × 650 mm bow torpedo tubes.

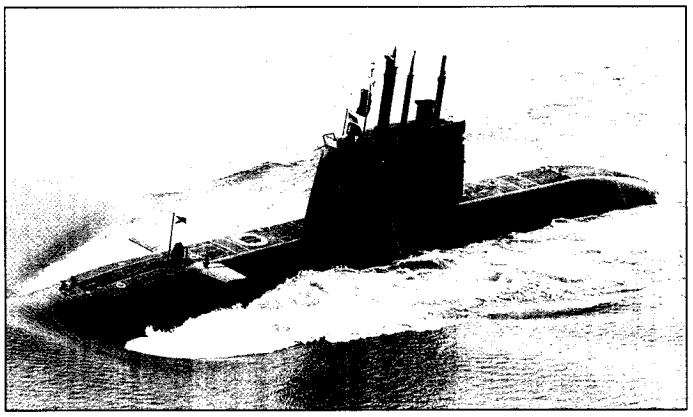
It has been reported that the Sub-Harpoon missiles may be modified to contain a land attack capability and possibly fit an Israeli designed nuclear warhead with a new guidance system. Thus modified, each boat will carry five Sub-Harpoon in addition to 16 DM2A4 S heavyweight torpedoes. The missiles may be deployed from the 650 mm tubes which may also be used for deploying SDVs.

Sensors include ATLAS Elektronik CSU-90 sonar which will be integrated with PRS 3 passive ranging and FAS 3 flank array sonars, all integrated with the ATLAS Elektronik ISUS 90-1 weapon control system. The ESM system is the Timnex 4CH (V)2. Periscopes comprise the Kollmorgen Model 90 attack and a Kollmorgen search type. The masts are mounted fore to aft and comprise in that order: communications, radar (an Elta system), electro-optic mast, attack periscope, snorkel and ESM. The operations room is sited on the upper deck immediately below the sail.

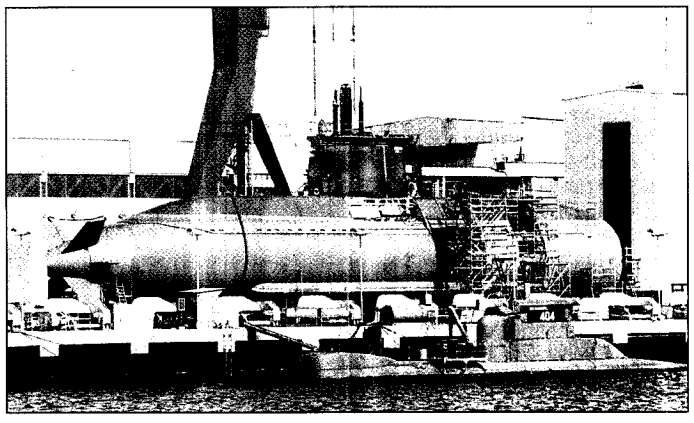
Propulsion will comprise three 3.12 MW (total) MTU turbocharged, intercooled diesel generators (16V 396 SE 84) mounted across the boat and each driving a single Piller 960 kVA synchronous inner pole design generator with an integrated exciter. The three diesels are individually mounted to the boat's structure, the entire machinery space being encapsulated to reduce airborne noise transmission to a minimum. The AC current is rectified to charge two 216-cell banks of Hagen batteries to drive the electronic motor. This is a Siemens 2.85 MW electric motor which drives a single 7-bladed skewed propeller. Control surfaces comprise an X-form rudder with hydroplanes on the forward casing, control being exercised through a GEC-Marconi control platform. Submerged speed will be about 20 kt, 12 kt while snorkelling.



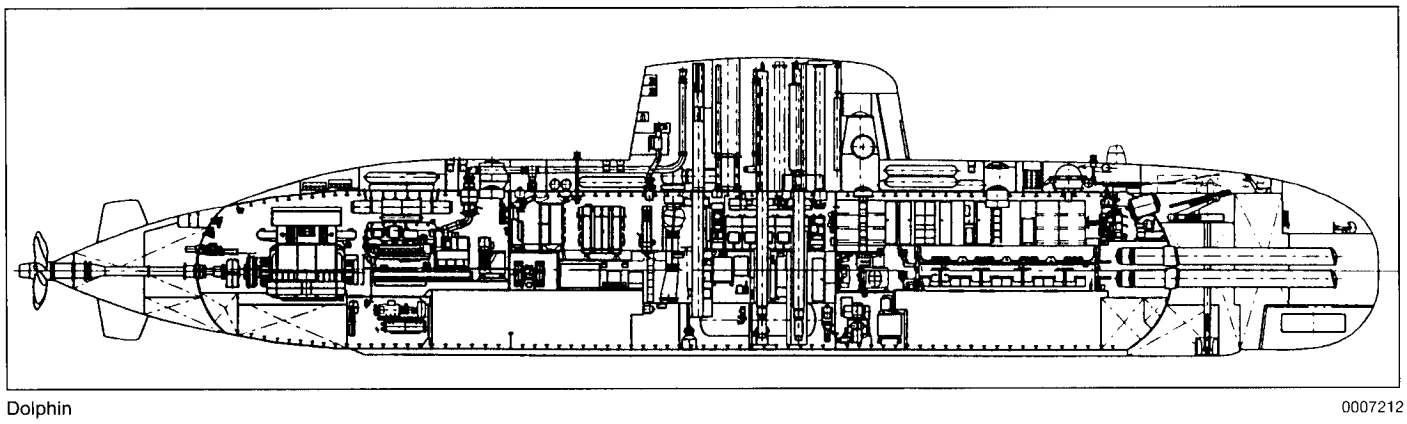
Tekuma, *third of the Dolphin class* (Courtesy Michael Nitz) 0059331



INS Dolphin *en route to Israel* (Courtesy Michael Nitz) 0059333



Second of the Dolphin class Leviathan *on the ship lift. Note the much smaller Type 206 in the water alongside. The picture reveals the full size of the hull, and the stern control plane arrangement* (Courtesy Michael Nitz) 0059332



Dolphin 0007212

Operational status
Three boats are in service with the Israeli Navy.

Specifications
Displacement:
- **surface:** 1,640 t
- **submerged:** 1,900 t

Dimensions:
- **length:** 57.3 m
- **beam:** 6.8 m
- **draft:** 6.2 m

Electronics:
- **combat management system:** ISUS 90-1
- **sonars:** CSU-90, PRS-3, FAS-3
- **periscopes:** Model 90
- **radar:** Elta
- **electronic warfare:** Timnex 4CH(V)2

Weapons:
- **torpedo tubes:** 4 × 650 mm, 6 × 533 mm
- **torpedoes:** 16 × DM2A4
- **missile tubes:** none
- **missiles:** 5 × Sub Harpoon or Israeli SLCM
- **mines:** (in lieu of torpedoes)

Machinery:
- **diesels:** 3 × MTU 16V 396 SE84
- **power output:** 3.12 MW
- **electric motor:** 1 × Siemens
- **power output:** 2.85 MW
- **shafts:** 1

Speed:
- **submerged:** 20 kt

Range:
- **surfaced:** 8,000 n miles @ 8 kt
- **submerged:** 420 n miles @ 8 kt
- **autonomy:** 30 days
- **operating depth:** 350 m

Personnel: 6 officers, 24 crew

Contractors
HDW, Kiel.
Thyssen Nordseewerke GmbH, Emden.

UPDATED

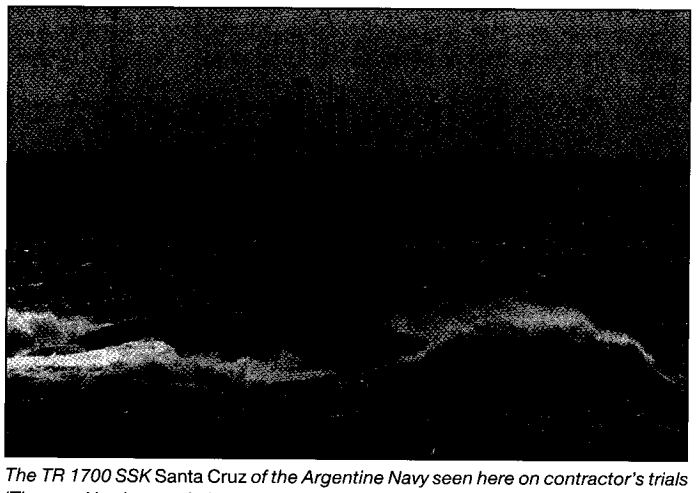
Santa Cruz

Type
Diesel electric patrol submarine.

Description
The Argentine Santa Cruz class (TR 1700 series) developed by Thyssen Nordseewerke features: high underwater sprint speed (in excess of 25 kt) but average transit speed; high submerged endurance and low indiscretion; and high survival capability combined with considerable offensive capacity. The electronics in the Argentine boats are a mixture of American, Dutch, French and German systems. The boats are fitted with six swimout discharge torpedo tubes, and the Dutch Sinbads fire-control system can control three torpedoes simultaneously and track up to five targets. The total number of torpedoes carried is 22.

Because of its great structural strength, the Santa Cruz class can dive to below depths of 300 m with safety. A pressuretight bulkhead adds considerably to survival capability and crew safety is further enhanced by the provision of facilities to handle a Deep Submersible Rescue Vehicle (DSRV). The boats are designed to operate with a small crew (about 30), and a very high standard of accommodation has been provided to enable long duration patrols (70 days) to be undertaken with some degree of comfort.

The propulsion arrangement comprises four MTU 16V 652 MB 81 diesels driving four 970 kW generators to charge the eight 120 cell batteries. These power the 6.6 MW Siemens electric motor, to give a submerged speed of around 25 kt. Cruising range is 12,000 n miles at 8 kt surfaced, and the diving depth is around 270 m.



The TR 1700 SSK Santa Cruz *of the Argentine Navy seen here on contractor's trials*
(Thyssen Nordseewerke)

Operational status
Two units in service with the Argentine Navy. Four other boats in various stages of construction are being used for spares. The *Santa Cruz* is currently undergoing a mid-life refit in Brazil during which the sonar is being upgraded and a new electric motor fitted. In addition the Mk 37 torpedoes are being replaced by Mk 48 weapons. On completion of the refit the *San Juan* will enter dock for a similar refit.

Specifications
Displacement:
- **surface:** 2,116 t
- **submerged:** 2,264 t

Dimensions:
- **length:** 66 m
- **beam:** 7.3 m
- **draft:** 6.5 m

Electronics:
- **combat management system:** Sinbads
- **sonars:** CSU-83, DUUX 5
- **radar:** MM/BPS-704
- **electronic warfare:** Sea Sentry III

Weapons:
- **torpedo tubes:** 6 × 533 mm
- **torpedoes:** 22 SST4/Mk 48
- **mines:** (in lieu of torpedoes)

Machinery:
- **diesels:** 4 × MTU 16V 652 MB81
- **power output:** 4.94 MW
- **electric motor:** 1 × Siemens 1HR4525
- **power output:** 6.6 MW
- **shafts:** 1

Speed:
- **surfaced:** 15 kt

submerged: 25 kt

Range:
- **surfaced:** 12,000 n miles @ 8 kt
- **submerged:** 460 n miles @ 6 kt
- **autonomy:** 70 days
- **operating depth:** 270 m

Personnel: 5 officers, 24 crew

Contractor
Thyssen Nordeseewerke GmbH, Emden.

UPDATED

Type 209

Type
Diesel-electric patrol submarine.

Description
German SSK design continues to dominate the world market, because it has been principally developed by one company, Ingenieur Kontor Lübeck (IKL) and with boats built by HDW. The principal design is the Type 209 which is offered and built in a number of versions ranging from 970 tonnes standard displacement up to 1,500 tonnes. Although the design was originally developed some years ago, HDW, together with other German companies, has now developed a series of modifications which, when retrofitted to existing boats, will enable them to extend their operational life to around 30 years.

The single-hull design incorporates two ballast tanks and fore and aft trim tanks. The 1500 series features a central bulkhead with an IKL-designed integrated escape sphere which can accommodate up to 40 of the crew. The sphere is supplied with 8 hours supply of oxygen and can withstand pressures down to the maximum diving depth of the boat.

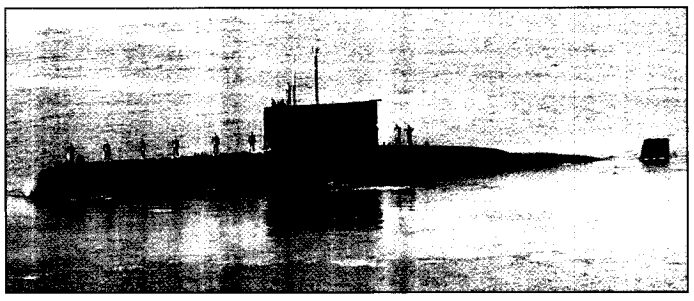
The boats have been fitted with a variety of combat systems, while acoustic sensors are usually of the STN Atlas Elektronik type. Sonars generally comprise a cylindrical bow-mounted passive array and an active array at the fore edge of the sail, together with three passive ranging arrays mounted along the port and starboard sides of the hull. The fitting of a flank array is also foreseen.

EW systems are generally of either French or American origin, although some units, notably the Turkish boats, have been fitted with British ESM systems. Eight swimout discharge torpedo tubes are fitted with accurately sited launch rails the position of which can be adjusted during construction to accommodate different types of weapon. Up to 14 torpedoes are carried. A recent development allows

Specifications

Class	1100 (Glavkos class)	1200 (Chang Bogo class)	1300 (Thomson class)	1400 (Tupi class)	1500 (Shishumar class)
Displacement:					
surface:	1,100 t	1,100 t	1,260 t	1,453 t	1,660 t
submerged:	1,285 t	1,285 t	1,390 t	1,590 t	1,850 t
Dimensions:					
length:	55.9 m	56.00 m	59.5 m	61.2 m*	64.4 m
beam:	6.2 m	6.2 m	6.2 m	6.2 m	6.5 m
draft:	5.5 m	5.5 m	5.5 m	5.5 m	6.0 m
Electronics:					
combat management system:	Kanaris	ISUS 83		KAFS*	SFCS Mk 1
sonars:	CSU 83-90, DUUX 2	CSU 83	CSU 3	CSU 83/1	CSU 83, DUUX 5
radar:	Calypso II	I-band	Calypso II	Scanter	Calypso
electronic warfare:	AR-700	AR-700, Ferret	DR 2000U	DR 4000 (MAGE)	AR-700, C 303 decoys
periscopes				Model 76	
Weapons:					
torpedo tubes:	8 × 533 mm	8 × 533 mm bow	8 × 533 mm bow	8 × 533 mm	8 × 533 mm
missile tubes:	None	None	None	None	None
torpedoes:	10 SUT Mod 0	14 × SUT Mod 2	14 × SUT Mod 1	16 × Tigerfish Mod 1/2*	14 × SUT Mod 1
missiles:	4 × Sub Harpoon	Can launch Sub Harpoon	None	None	Missiles in 2 units
mines:		28 (in lieu of torpedoes)			24 in strap-on container
Machinery:					
diesels:	4 × 12V 493 AZ80	4 × 12V 396 SE	4 × 12V 493 AZ80	4 × 12V 493 AZ80	4 × 12V 493 AZ80
power output:	1.76 MW	2.8 MW	1.76 MW	1.76 MW	1.76 MW
batteries:	4 × 120 cell	4 × 120 cell		4 × 120 cell	4 × 132 cells
electric motor:	1 × Siemens	1 × Siemens	1 × Siemens	1 × Siemens	1 × Siemens
power output:	3.38 MW	3.38 MW	3.38 MW	3.36 MW	3.38 MW
shafts:	1	1	1	1	1
Speed:					
surfaced:	11 kt	11 kt	11 kt	11 kt	11 kt
submerged:	21.5 kt	22 kt	21.5 kt	21.5 kt	22 kt
Range:					
surfaced:	7,500 n miles @ 8 kt	8,200 n miles @ 8 kt	8,200 n miles @ 8 kt	13,000 n miles @ 10 kt	
submerged:	8,600 n miles @ 4 kt snorting	11,300 n miles @ 4 schnorkel	400 n miles @ 4 kt	400 n miles @ 4 kt	524 n miles @ 4 kt
autonomy:	50 days	50 days	50 days	50 days	50 days
operating depth:	250 m	320 m		250 m	260 m
Personnel:	6 officers, 25 crew	6 officers, 27 crew	5 officers, 27 crew	7 officers, 29 crew*	8 officers, 32 crew

*62 m, ISUS 83-13, Torpedo 2000 and 8 officers and 34 crew in *Tikuna*

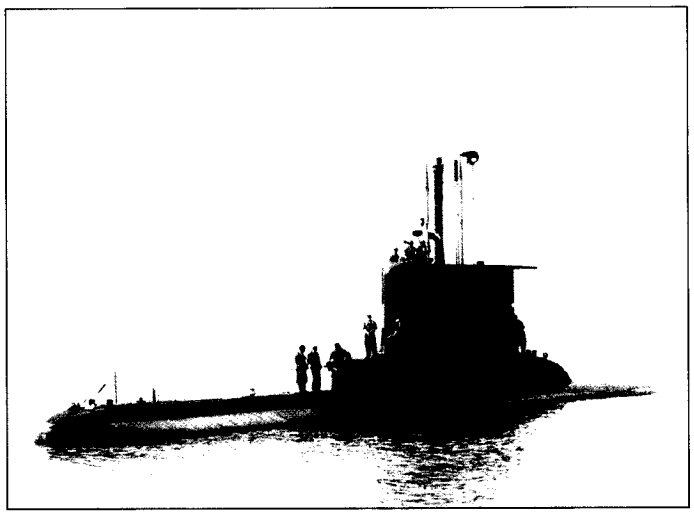


A number of countries operating Type 209 submarines may consider modernising their fleet with AIP. Typical of these boats is Lee Jongmu *(South Korea) shown here* (van Ginderen Collection) 0118046

boats to carry out a submerged launch of anti-ship missiles such as Sub-Harpoon and Triton.

Machinery almost invariably comprises four MTU diesels driving four alternators. Submerged power is provided through a single Siemens electric motor developing around 3.7 MW and driving a single slow revolution propeller. Management is exercised through a remote machinery control system. The very high capacity GRP lead-acid cells incorporate a battery cooling system. All boats are fitted with snort masts. Submerged speed is around 21 to 22 kt with a speed of 11 kt maintained while snorting.

The Type 209s built for the Chilean Navy feature escape hatches in the engine room and the forward torpedo room, the latter being equipped to take a DSRV. An innovation in the design is a hatch aft of the sail providing a machinery exit route. This incorporates a pressure reactive hatch seal with watertight integrity which increases with greater external pressure, thus improving safety in the event of underwater explosion. The sail has been lengthened and longer masts fitted in the Chilean boats to cope with the exceptional wave heights experienced in that part of the world.



Type 209/1200 Tayrona *of the Colombian Navy* (Michael Nitz) 0143748

The latest variant to be ordered is the Type 209/1400MOD for the South African Navy. Of 1,594 tonnes displacement, they will be 62 m long and have a beam of 7.6 m. Armament will comprise eight 533 mm torpedo tubes with 14 torpedoes. There are no plans, at present, to acquire submarine launched missiles, but the boats will be capable of launching such weapons. If it is decided to acquire such weapons then it is likely that the SM 39 Exocet will be purchased to provide commonality of systems with the new frigates which will have the MM 40 Exocet. Combat system will be the ISUS 90 with CSU 90 sonar systems, both from STN ATLAS Elektronik. Periscopes will be from Zeiss and Grimtek will supply EW equipment and communications systems.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

HDW and Siemens of Germany have developed an AIP module which can be inserted into existing Type 209 submarines to considerably improve their effectiveness as underwater weapons platforms.

The proposal for installing AIP in an existing Type 209 submarine involves cutting the boat in half immediately aft of the control room and partially under the rear part of the sail. At this point a 6 m section is inserted containing the AIP system. This comprises an upper deck housing two fuel cell stacks developing 120 kW that are housed in a pressurised container. The stacks – which can be connected electrically either in series or parallel as required – are water cooled to absorb any heat given off during the chemical reaction in the cell.

Inserting the AIP section does not result in major disruption to the submarine's existing layout and could be easily undertaken during a major overhaul or refurbishment of the boat.

The potential for upgrading Type 209 boats around the world is considerable, and such an upgrade would considerably improve a boat's capabilities and extend its effective life (assuming that other systems on board are also brought up to date and the stress factors on the hull, due to the number and depth of dives it has undertaken, have not already adversely affected its life expectancy).

Operational status

Variants are in service with the navies of Argentina, Brazil, Chile, Colombia, Ecuador, Greece, India, Indonesia, South Korea, Peru, Turkey and Venezuela.

In mid-1999 the Indian government gave the Navy approval to build two more Type 209/1500 boats to a modified design. These boats will be capable of firing missiles.

Contractor

HDW, Kiel.

UPDATED

Type 212A

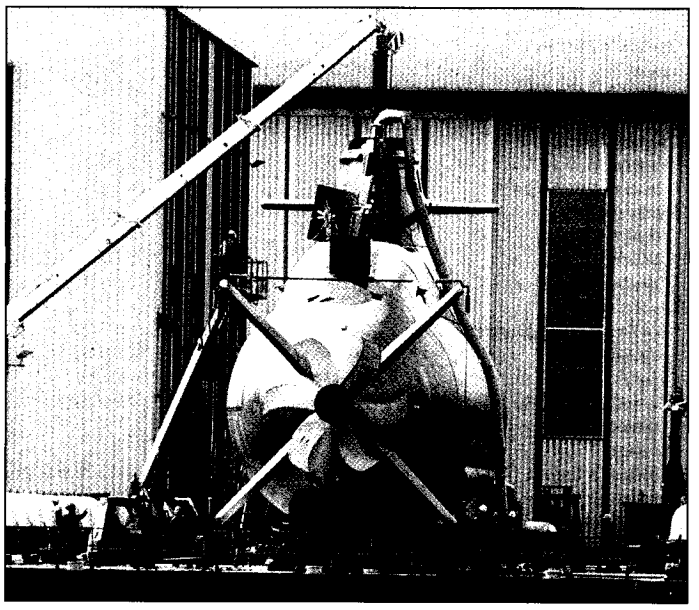
Type

Hybrid diesel-electric/AIP (fuel cell) submarines.

Description

The Type 212A forms part of Germany's new fleet programme for the next century. The first batch of four units has been authorised and will enter service beginning early within the next decade. Construction of the first boat started on 1 July 1998 at HDW.

The Type 212A is about three times the size of the Type 206. This enables it to develop a much larger radius of action and increased endurance, which will be considerably enhanced with the use of a hybrid diesel/fuel cell AIP system based on the liquid electrolyte system successfully tested in the submarine *U1*. Power is being considerably increased over the system tested in *U1*, by replacing the liquid electrolyte with a solid polymer technology. Siemens KWU in Erlangen has developed the polymer electrolyte fuel cell (PEM-FC) AIP system. The H_2 metal hydride storage cylinders as well as the O_2 tanks for the fuel cell system will be mounted outside the pressure hull and inside the outer casing, allowing the size of the pressure hull to be reduced. The fuel cell works at an operating temperature of 70 to 80°C, which makes the submarine difficult to detect using external heat sensors. With the extended range and endurance, the boats will be suitable for operations in the whole operating area of the German fleet with emphasis on European waters and the North Atlantic. The Type 212A will be fitted with nine PEM fuel cell modules.

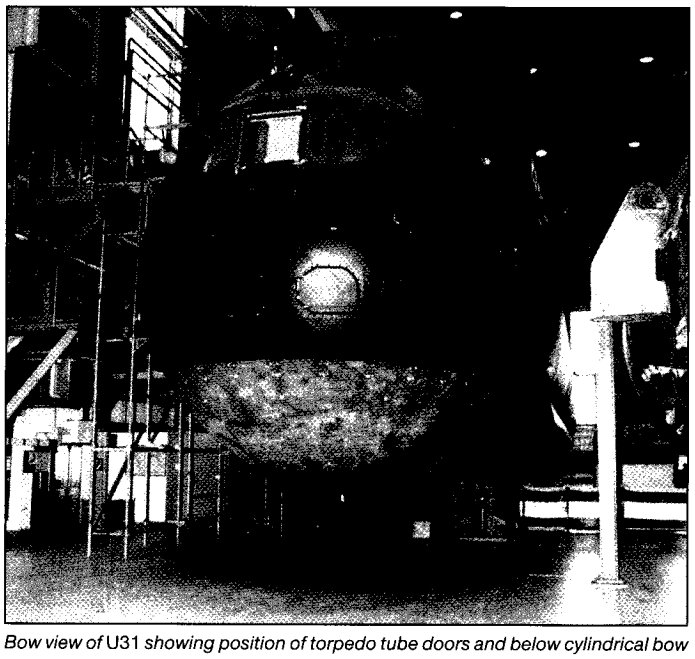


U31 *on shiplift before being placed in the water. The picture shows the propeller and rudder arrangement* (Michael Nitz) 0137205

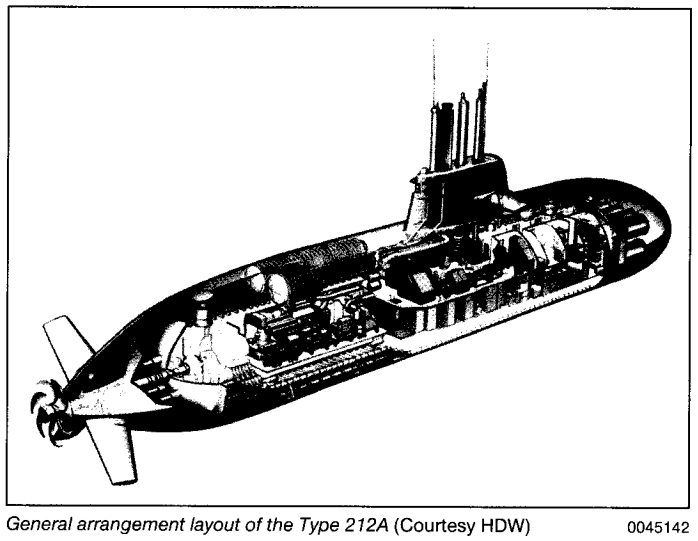
In addition to the fuel cell battery, the boats will be fitted with a modular sodium sulphide high-energy battery system driving a Siemens permanent magnet excited electric motor of the new Permasyn type, which is much smaller in size and weight than present motors. A single MTU 16V 396 exhaust-gas turbocharged-diesel generator is mounted in a new acoustically treated motor room. The motive power will drive a 7-bladed skewed propeller.

Considerable effort has been devoted to incorporating the latest stealth technology. The sophisticated hydrodynamic design has resulted in a carefully shaped hull and sail with no straight lines giving rise to a very low target echo strength. Sensors will be fitted for the detection and analysis of self-generated noise. The use of amagnetic steel in the construction gives a very low magnetic signature and heat emission will be considerably reduced resulting in a much reduced infra-red wake signature. The boats will be equipped with an integrated ship control and monitoring system, steering being exercised through a single-operator console with two engineering consoles manned by a single crewmember sited alongside.

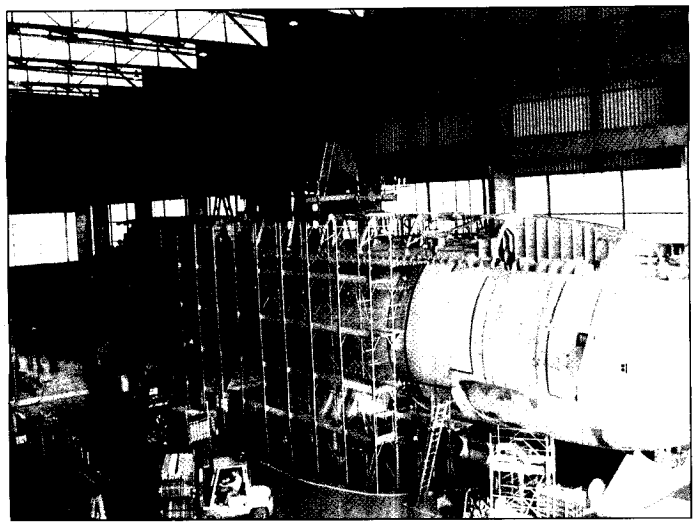
The first batch of boats will be fitted with ATLAS Elektronik DBQS 40 integrated sonar system. This will include a cylindrical, medium-frequency bow array operating in the 0.3 to 12 kHz band, a passive flank array (FAS-3), a Passive Ranging Sonar (PRS), an intercept sonar and a low-frequency, passive towed array sonar (TAS-3) and the active HF MOA 3070 obstacle avoidance sonar from ATLAS Elektronik. Electro-optic sensors will be the Zeiss SERO 15 (with laser range-finder) and SERO 14 (with GPS antenna). The EW capability will be provided by an EADS FL 1800U system, for which Thales of the UK will provide key processing and MMI components. In addition, the boats will be fitted with own-noise monitoring equipment and the TAU 2000 torpedo countermeasures system. Control of the sensors is exercised through a Kongsberg MSI-90U command system. Navigation equipment includes a Kelvin Hughes Type 1007 radar while the integrated communications suite will comprise HF, VHF, UHF, VLF, Inmarsat-C, UHF SATCOM and GMDSS. Other systems include inertial platform, attitude and heading reference equipment, EM-log, echo-sounder and GPS. The control room will be mounted on a frame elastically connected to the hull, while the electronics will hang from a frame above.



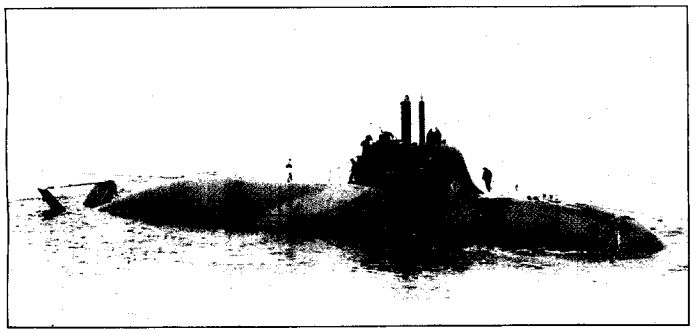
Bow view of U31 *showing position of torpedo tube doors and below cylindrical bow sonar array, and above the obstacle avoidance sonar window* (Michael Nitz) 0129216



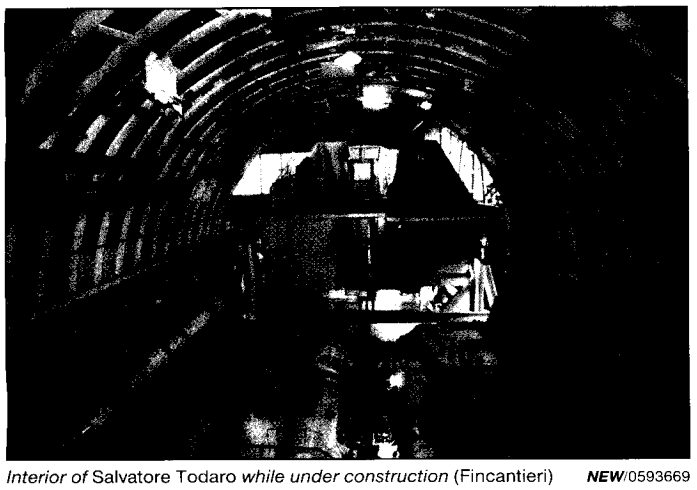
General arrangement layout of the Type 212A (Courtesy HDW) 0045142



Salvatore Todaro *under construction* (Fincantieri) ***NEW***/0593670



U 31 *on harbour trials* (Michael Nitz) ***NEW***/0526845



Interior of Salvatore Todaro *while under construction* (Fincantieri) ***NEW***/0593669

Torpedoes will be discharged through six bow tubes using an HDW water ram discharge system for launching the DM2 A4 heavyweight torpedo. A total of 12 weapons will be carried. In addition, the boats will be provided with fittings for carrying a minelaying belt.

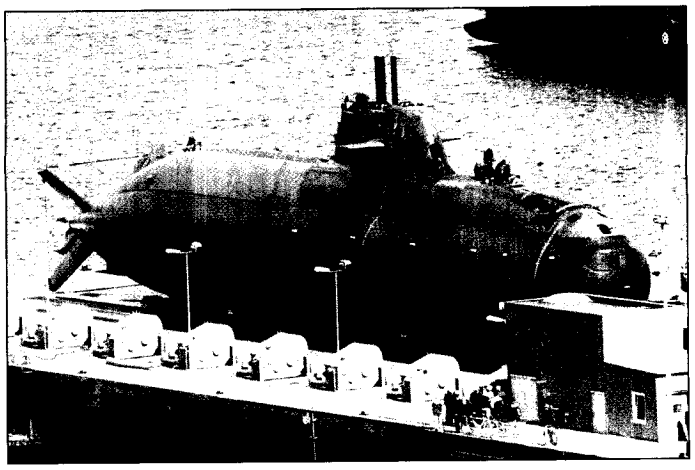
Forward, the hull features a two-deck arrangement that results in considerably improved living standards.

Italy joined the Type 212a Programme under an MoU signed between the governments of Germany and Italy in April 1996. Fincantieri was awarded a contract in August 1997 to build, test and deliver two boats to the Italian Navy, with an option on a further two boats.

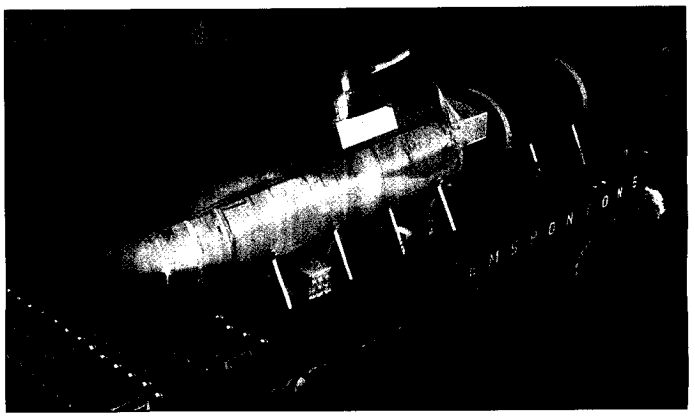
The two Italian boats will be of the same configuration as the German ones, apart from some national variations as defined by the Italian Navy. In particular for the Italian boats, the rescue capability, (that is a mating platform for a DSRV, emergency inlet/outlet fresh air blowing system) the operational capability, (frogmen can exit and enter via the sail) and two alternative weapon load capabilities (which will be the Italian A184 Mod 3 torpedo as well as the German DM2A4) and their integration into the command and weapon control system.

Operational status

On order for the German and Italian navies. Steel for *U31* was cut at HDW on 1 July 1998 and she was named on 20 March 2002. She commenced sea trials on 7 April 2003. The forepart of *U32*, the second unit, was delivered to Nordsweewerke GmbH by HDW on 17 March 2003. The submarines are due to enter service between March 2004 and 2006. The official start date for the first Italian boat (the *Salvatore Todaro*) was 3 July 1999 and the boat was launched on 6 November 2003.



U31 *on the shiplift showing hull form and hydrodynamically shaped sail* (Michael Nitz) 0137204



The forepart of U32, *the second Type 212A submarine of the German Navy* (Michael Nitz) 0547547

Specifications

Displacement:	
surface:	1,450 t
submerged:	1,830 t
Dimensions:	
length:	56 m
beam:	7 m
draft:	5.8 m
Electronics:	
combat management system:	MSI-90U
sonars:	DBQS-40, FAS-3, TAS-3, MOA 3070
periscopes:	SERO 14, SERO 15
radar:	Type 1007
electronic warfare:	FL 1800U
Weapons:	
torpedo tubes:	6 × 533 mm
torpedoes:	12 × DM 2A4, Black Shark
missile tubes:	none
mines:	24
other:	C 303 countermeasures
Machinery:	
diesels:	1 × MTU 16V 396
power output:	3.12 MW
AIP:	9 Siemens/HDW PEM fuel cell modules
power output:	306 kW
batteries:	sodium-sulphide
electric motor:	Siemens Permasyn
power output:	2.85 MW
nuclear plant:	none
shafts:	1
Speed:	
surfaced:	12 kt
submerged:	20 kt
Range:	
surfaced:	8,000 n miles @ 8 kt
submerged:	420 n miles @ 8 kt
autonomy:	30 days
Personnel:	8 officers, 19 crew

Contractors

HDW, Kiel.
Nordseewerke GmbH, Emden (for Germany).
Fincantieri, Genoa (for Italy).

UPDATED

Type 214

Type
Ocean-going patrol submarine.

Description
The Type 214 developed by HDW integrates features of the Type 209 together with technological advances derived from the Type 212A programme and some of the latest technology incorporated in the Dolphin design. Thus, the hull design and its hydrodynamic form emphasise stealth capabilities, offering good low signature features including both self-generated noise and flow noise and magnetic signature. The design is characterised by low displacement and high weapon and sensor payload. The high degree of automation results in low crew numbers, which enables the weapons payload to be optimised. Built of austenitic steel the buoyancy reserve is in excess of 10 per cent and diving depth is in excess of 400 m.

The modular design of the Type 214 will enable future developments in propulsion, weapons and sensor systems to be easily integrated. In the current design, propulsion is provided by two MTU 16V 396 engines (2,000 kW) serving a 600-900 V propulsion battery with a fully integrated auxiliary AIP system based on two PEM 120 kW fuel cell modules. The propulsion motor is a Siemens Permasyn low-speed permanently excited electric motor driving a low-noise, skewback propeller.

Using the AIP system on submerged patrol and intercept missions enables the boat to remain submerged for up to 13 days at a speed of 4 kt. Submerged sprint speeds of between 16 and 20+ kt are possible for periods of a few hours several times during a 50 day mission. At a speed of 6 kt the mission range is almost 12,000 n miles. Endurance will be 50 days.

The command, sensor and weapon control outfit comprises the STN ATLAS Elektronik ISUS 90 system upgraded to provide increased low frequency detection range. The sonar suite includes five types of sonar:

- cylindrical array for medium frequency passive detection
- flank array to cover transition from medium to low frequency
- thin line towed array for low frequencies in a medium self-noise environment
- passive ranging sonar for calculation of target data
- active sonar, for determination of target range and bearing.

Other sensors include: an attack periscope, an electro-optic mast (both manufactured by Zeiss) and an integrated torpedo countermeasure system. All sensors and weapons are controlled via multipurpose consoles.

The Type 214 boats of the Greek Navy are being equipped with the Thales Naval GmbH FOCON (Fibre Optic COmmunication Network) communication network.

The weapons system comprises eight 533 mm swim-out torpedo tubes fitted through the forward bulkhead and which permit the discharge of all kinds of torpedoes. Four of the tubes are also equipped with a Weapon Expulsion System (WES) for launching encapsulated anti-ship missiles. Optionally, all weapon tubes can be equipped with a positive weapon discharge system. With eight torpedoes positioned ready for instant fast reload, the Type 214 has an overall heavyweight torpedo payload of 16.

Operational status
Four boats ordered for the Greek Navy (Katsonis class) in February 2000 and three boats for South Korea. The first Greek boat *Papanikolis* was launched on 22 April 2004 at the Kiel yard of HDW, and is the first fuel cell submarine built for export. Subsequent Greek boats will be built at the HDW subsidiary company Hellenic Shipyards in Greece.

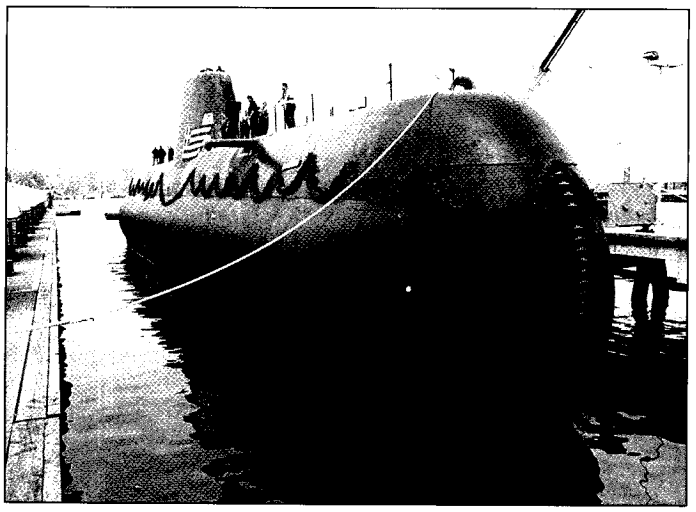
Specifications

	Greece	South Korea
Displacement:		
surface:	1,700 t	1,700 t
submerged:	1,980 t	1,860 t
Dimensions:		
length:	65 m	65 m
beam:	6.3 m	6.3 m
draft:	6 m	6 m
Electronics:		
combat management system:	ISUS 90 or Kanaris	ISUS 90
radar:	Sphynx	I-band
electronic warfare:	Elbit Timnex 2, Circe	
Weapons:		
torpedo tubes:	8 × 533 mm	8 × 533 mm
torpedoes:	16 × DM2A4	16 weapons
missiles:	Sub Harpoon*	
torpedo countermeasures:	Circe	
Machinery:		
diesels:	2 × MTU 16V 396	1 × MTU 16V 396
power output:	6.24 MW	3.12 MW
AIP:	2 × HDW PEM	9 × HDW PEM
power output:	240 kW	306 kW
batteries:	Sodium sulphide high energy	Sodium sulphide high energy
electric motor:	1 Siemens Permasyn	1 Siemens Permasyn
power output:	2.85 MW	2.85 MW
shafts:	1	1
Speed:		
surfaced:	12 kt	12 kt
submerged:	20 kt	20 kt
on fuel cell:	2-6 kt	2-6 kt
Range:		
surfaced:	12,000 n miles @	12,000 n miles @
submerged:	420 n miles @ 8 kt	420 n miles @ 8 kt
on fuel cell:	1,248 n miles @ 4 kt on fuel cells	1,248 n miles @ 4 kt on fuel cells
autonomy:	50 days	50 days
operating depth:	400 m	400 m
Personnel:	5 officers, 22 crew	5 officers, 22 crew

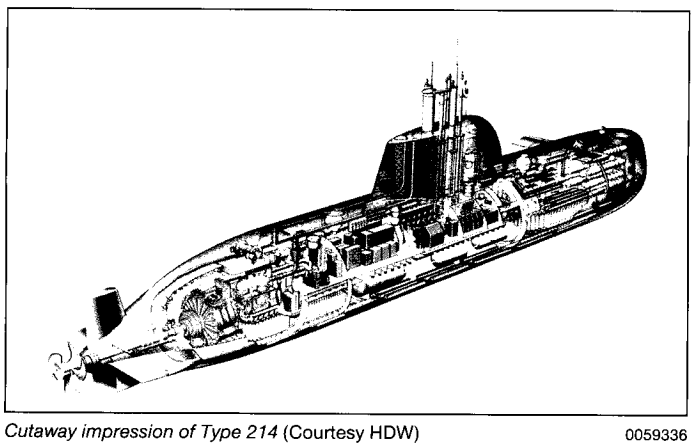
* four torpedo tubes are fitted for Sub Harpoon discharge, the remaining four tubes are swim out tubes

Contractor
HDW, Kiel.

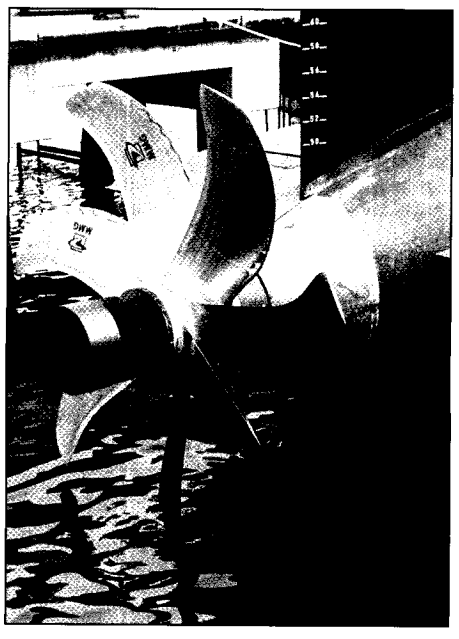
UPDATED



Launching of the Greek Type 214 boat Papanikolis *on 22 April 2004* (M Nitz)
NEW/0583217



Cutaway impression of Type 214 (Courtesy HDW) 0059336



The highly skewed 7-bladed propeller of the Papanikolis (M Nitz)
NEW/0583216

Ula class

Type
Diesel-electric patrol submarine.

Description
Design work on the Norwegian Ula class (Type 201) submarines began under a Memorandum of Understanding (MoU) signed between Germany and Norway in March 1979. Under the terms of the MoU, Norway was to purchase ATLAS Elektronik (formerly STN Atlas Elektronik) sonars, Carl Zeiss periscopes and ATLAS Elektronik torpedoes. In return, Germany was to purchase the Kongsberg Gruppen AS (formerly NFT) MSI-90U command system for the German Type 211 submarines (subsequently cancelled and replaced by the Type 212A design). The MSI-90U underwent extensive acceptance trials in 1989-90, including firing the new DM2A3 torpedo with which the Norwegian submarines are armed. The combat system is designed to engage multiple targets in quick succession. Sensors feeding the combat system include the ATLAS Elektronik DBQS-21DN (CSU-83) sonar, Carl Zeiss type SERO 14 and SERO 15 attack and search periscopes mounted in non-penetrating masts. The boats are armed with 14 × DM2A3 torpedoes discharged from eight torpedo tubes. Propulsion is provided by two MTU 16V 396 SB83 diesels and two NEBB electric generators. The main electric propulsion motor is a 4.5 MW Siemens model with power supplied by Anker batteries. The navigation radar is the Kelvin Hughes Type 1007.

The Ula class will undergo a progressive modernisation to enable them to remain effective until around 2020-2025. The initial part of this initiative will see the boats retrofitted with towed array sonar and associated winch handling system and signal processing and interface to the MSI-90U combat management system.

EDO Corporation was awarded a contract in January 2004 to upgrade the communications and datalink systems on the Ula class. Under the contract EDO will provide engineering, manufacturing and integration services to deliver open systems architecture tactical datalink systems. EDO will also upgrade the existing submarine communications systems to provide new LOS, OTH and satellite data communications capabilities, allowing interoperability with all NATO forces. Information from EDO's datalink system will be fully integrated with the submarine's on board command and control system to give the crew a common operational picture that will be distributed throughout the submarine.

Operational status
Six boats in service with the Norwegian Navy.

Specifications
Displacement:
- **surface:** 1,040 t
- **submerged:** 1,150 t

Dimensions:
- **length:** 59 m
- **beam:** 5.4 m
- **draft:** 4.6 m

Electronics:
- **combat management system:** MSI-90U
- **sonars:** CSU-83
- **periscopes** SERO 40, SERO 14, SERO 15
- **radar:** Type 1007
- **electronic warfare:** Sealion

Weapons:
- **torpedo tubes:** 8 × 533 mm
- **torpedoes:** 14 × DM 2A3
- **missile tubes:** none
- **missiles:** none
- **mines:** in lieu of torpedoes

Machinery:
- **diesels:** 2 × MTU 16V 396 SB83
- **power output:** 1.98 MW
- **AIP:** none
- **batteries:** Anker
- **electric motor:** 1 × Siemens
- **power output:** 4.41 MW
- **nuclear plant:** none
- **auxiliary system:** none
- **shafts:** 1
- **propellers:** 1

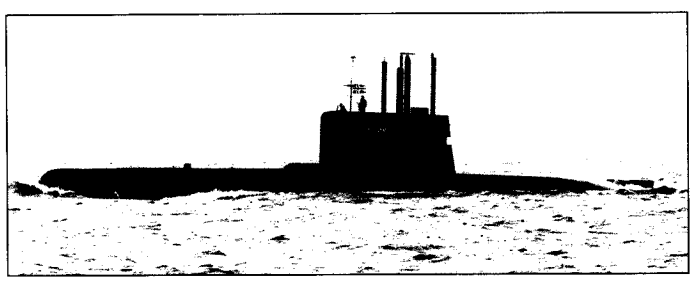
Speed:
- **surfaced:** 11 kt
- **submerged:** 23 kt

Range:
- **surfaced:** 5,000 n miles @ 8 kt
- **autonomy:** 40 days
- **operating depth:** 250 m

Personnel: 5 officers, 16 crew

Contractor
Thyssen Nordseewerke GmbH, Emden.

UPDATED



The Norwegian submarine Uredd *of the Type 201 Ula class* (Michael Nitz) 0143749

India

ATV

Type
Nuclear powered attack submarine.

Description
The Advanced Technology Vessel (ATV) nuclear-powered attack submarine is under development by the Defence Research and Development Organisation at Hyderabad and the Department of Atomic Energy at Kalpakkam. The boat will be around 105 m in length, with a diameter of about 15 m and it is claimed that it will be invisible to satellite detection. Fabrication has begun with launching due in 2006 and in service date of 2008. Construction will be undertaken at Mazagon Dockyard Ltd from parts fabricated at Vishakapatnam.

The boat may be armed with a short-range ballistic missile, and the Sagarika cruise missile. There have been reports that the boat will be fitted with vertical launch missile silos. Displacement will be around 6,000 t surface and 6,500 to 7,000 t submerged.

A single Pressurised Water Reactor (PWR) using enriched uranium and developing 40-55 MW will drive a steam turbine of 47,000 hp (34,590 kW) to power a single shaft with a seven-bladed propeller. The PWR will use enriched uranium fuel rods. The reactor is being developed at the Bhaba Atomic Research Centre near Mumbai. Speed will be in the region of 30 to 34 kt submerged. Maximum diving depth will be 300 m. The boat will be fitted with two 650 mm tubes for launching missiles and four 533 mm torpedo tubes. It is planned that a class of five will be built. One of the old Foxtrot class submarines is being used as a trials vessel for the command system, sonar (Pachendriya) and radar (Rani).

Construction of some hull modules may have already begun.

Operational status
Under development. A force of five boats is planned, with reports stating that the first boat may be ready to commission in 2008.

Specifications
Displacement:
- **surface:** 5,500/6,000 t
- **submerged:** 6,500/7,000 t

Dimensions:
- **length:** 95/105 m
- **beam:** 13/15 m
- **draft:** 7/9 m

Weapons:
- **missile tubes:** Vertical launch

Machinery:
- **nuclear plant:** PWR
- **power output:** 190 MW
- **shafts:** 1

Contractor
Mazagon Dockyard Limited, Mumbai.

UPDATED

International

Scorpene

Type
Diesel-electric patrol submarine.

Description
The partnership of DCN (France) and Izar (Spain) has developed for export the 'Scorpene' family of advanced submarines for open ocean and littoral warfare operations. The boats are designed around a common hull form based on DCN's experience with nuclear-powered submarines. The design features a

hydrodynamically efficient 'Albacore' hull form with fin-mounted hydroplanes and cross-configuration tailplane. The hull is constructed of HLES 80 steel.

Throughout the design, the emphasis has been to achieve maximum stealth capabilities. To this end the design features very low acoustic, magnetic, electromagnetic and infra-red signatures. All equipment is mounted on flexible couplings with double elastic mountings. Further noise reducing measures include the use of flexible cables and flexible couplings for joining pipes and so on and special low-noise emission components for rotating auxiliary machinery.

The single hull is divided by three main bulkheads with two decks. The forward compartment houses 6 × 533 mm positive discharge torpedo tubes and a battery section; the midship compartment contains accommodation, control room, header tanks and auxiliary systems; and the aft compartment houses the machinery and a second battery. The bow and stern sections are each fitted with two ballast tanks.

Certain equipment is common throughout the family (unless a different configuration is required by the customer) such as the SAGEM integrated navigation system, which is developed from the Minicin system; the external communications equipment; the integrated combat system incorporating passive/active sonars (cylindrical bow array, active array, ranging array, intercept array and flank array) from Thomson Marconi Sonar SAS; electro-optic sensor masts (types APS and SMS) from SAGEM; electromagnetic detection; data processing; tactical situation display; and weapon control. Tactical operations are controlled by a fully integrated combat management system using up to six multifunction common consoles. In the Chilean boats, the UDS SUBTICS combat system will be installed. Sonar sensors in the Chilean boats include the Thales TSM 2253 planar flank array; a cylindrical array (>800 Hz); an active array; a Thales Safare intercept array (2.5 to 100 kHz); a passive ranging distributed array (up to 20 kHz); two passive LF flank arrays (10 to 15 kHz).

The electric propulsion system is based on that used in the French nuclear-powered submarines and is a EPM Magtronic 2,800 kW AC permanent magnet synchronous motor developed by Jeumont-Schneider, powered by two banks of batteries, which are charged by two or four diesel alternators with rectifiers. Diesel power is provided by SEMT-Pielstick turbocharged diesels. Chile has specified four MTU 16V 396 SE84 diesels developing 2.2 MW for its version of the 'Scorpene'. The powerful lead-acid battery configuration is based around a 360-cell bank, Hagen units being fitted in the Chilean boats. The machinery and operations room are fitted as uncoupled blocks completely isolated from the hull by rubber mountings. This ensures that there is virtually no transfer of LF noise from these compartments through the pressure hull to the sea.

A major feature of the design is the provision for an AIP propulsion unit based on the French MESMA system. To allow for easy installation of the AIP system, the design features a cofferdam that is sited immediately forward of the machinery compartment and the MESMA AIP system would be inserted at this point. The boats under construction for Chile will not be fitted with the AIP system.

To ensure long submerged endurance, careful attention has been paid to management and quality control of the atmosphere. Equipment for oxygen regeneration and the removal of carbon dioxide, hydrogen and carbon monoxide to prevent the production of toxic gases from the batteries is installed. With the MESMA AIP system this is estimated at between 10 and 15 days at deep submerges.

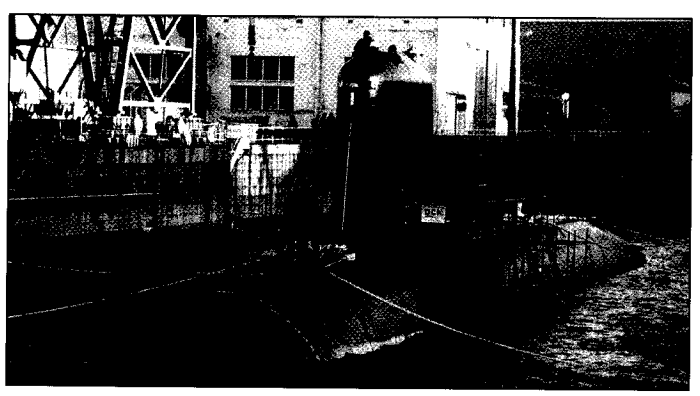
With its lead-acid batteries the Scorpene is therefore able to remain submerged for five days proceeding at a speed of 4 kt.

Platform control in the Chilean boats is exercised from a CAE Shipmaster IPMS (integrated platform management system) with a direct and/or back-up remote-control monitoring system. Management is exercised using four 18 in flat panel displays and a single 21 in large screen display for the supervising officer. The steering console from Alstom and DCN Ruelle is fitted with two 18 in flat panel displays.

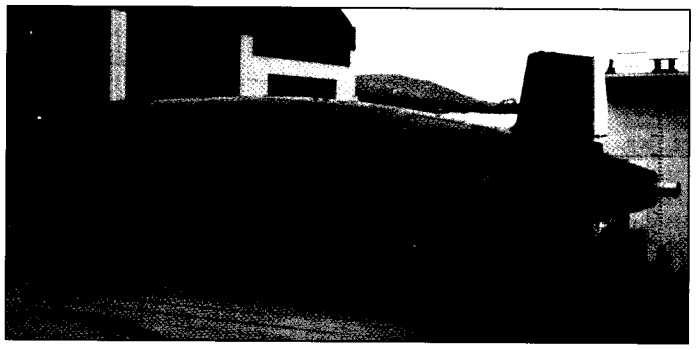
The design allows for the 18 weapons carried to be launched from six torpedo tubes using, in the Chilean boats, a swim-out system, with two tubes being fitted with a pneumatic ram system for the discharge of SM 39 Exocet missiles. The Chilean boats will also carry existing SUT torpedoes from the Chilean inventory as well as the newly acquired Black Shark torpedo.

Diving depth is in excess of 350 m. The crew totals about 30 to 32 and considerable emphasis has been placed on the crew environment, including a very high standard of comfort and accommodation to ensure they remain fit throughout the mission.

The boats are to be built in sections at different sites and brought together at the shipyard for final assembly.



The Chilean Scorpene boat O'Higgins preparing for harbour acceptance trials (DCN)
NEW/0563053



'Scorpene' aft section (Izar)
0593070



Aft section of O'Higgins *for the Chilean Navy* (Izar)
0593069

Specifications

	Chile	Malaysia
Displacement:		
surface	1,564 t	
submerged	1,711 t	
Dimensions:		
length	66.4 m	
beam	6.2 m	
draft	5.8 m	
Electronics:		
combat management system	SUBTICS	
sonars	TSM 2253	
periscopes	SAGEM SMS and APS	
radar	Type 1007	
electronic warfare	AR-900	
Weapons:		
torpedo tubes	6 × 533 mm	6 × 533 mm
torpedoes	18 x SUT or Black Shark	18
missile tubes	None	
missiles	SM 39 EXOCET	
mines	n/k	n/k
other		
Machinery		
diesels	4 × MTU/Izar 16V 396 SE84	4 × SEMT Piesltick 12 PA4 V 200 SMDS
power output	2.2 MW	
batteries	2 banks of 6 cells each of 180 elements	
electric motor	1 × Jeumont Schneider synchronous	
power output	3.5 MW	
power output		
shafts	1	1
Speed:	12 kt	
surfaced		
submerged	21 kt	
Range:	6,400 n miles @ 8 kt	
surfaced		
submerged	550 n miles @ 4 kt	
autonomy	>60 days	
operating depth	>300 m	
Personnel:	6 officers, 26 crew	



Fore section of Chilean Scorpene class boats under construction at DCN Cherbourg (DCN) 0111762

Operational status

Two units are on order for the Chilean Navy and two for the Malaysian Navy which are due to enter service in 2007-08. Harbour acceptance trials for the Chilean lead boat *O'Higgins* commenced in late 2003. It is very likely that Spain too will order the 'Scorpene' design to meet its requirement for a new class of submarine and it is also possible that India may order the design.

Contractors

Izar, Cartagena, Spain.
DCN International, Paris, France.

UPDATED

Viking class

Type

Diesel-electric patrol submarine.

Development

The Viking design is the outcome of the study and conceptual phase carried out by Kockums on assignment from the Viking Project Group representing Denmark, Norway and Sweden. Since its inception Norway has withdrawn from the project.

A study and concept phase was conducted between 1997 and 2000 and an agreement on Step 1 of the Project Definition Phase covering detailed design and costings was signed by Denmark, Norway and Sweden on 20 December 2000. The mission was to combine and integrate the requirements of the three nations into a concept which in the best possible way would meet their common requirement for a low-cost submarine.

The concept selected consisted of two variants – a long and short variant – in which the specific requirements of the nations involved were solved by a number of optional design alternatives. However, while the performance requirements were allowed to vary significantly, the design philosophy had to remain constant. The primary difference between the two variants involved the insertion of an additional energy section incorporating a second battery, additional diesel engines and fuel tanks to provide extended range and higher speed.

The submarine is characterised by substantial investments made in stealth technology and further development of Kockums advanced modular construction technique.

The RFT for Phase 1 of the PDP was issued to the Viking Submarine Corporation on 1 January 2001, but Norway subsequently withdrew on 13 June 2003 and became an observer only. Phase 1 was completed on 1 July 2003.

Description

The modular design of the Viking has been defined so that various sections of the boat can be changed to meet customer requirements. This led in the initial stages to two main concepts for the design:

- an AIP variant with a small diesel and
- an energy section with a power module.

As currently envisaged the design features six modules. These basic modules have now been more or less fixed. The bow section comprises the forward ballast tanks, weapon tubes, a conformal array, and a lower part housing the battery with weapon stowage on top and an upper part featuring accommodation. The next section features the forward auxiliary machinery space in the lower part and in the upper part, the control room. This section also incorporates the sail with forward control surfaces. The sail also houses the masts and a diver lockout chamber. Abaft the sail and control room section is a pressure-tight bulkhead, which divides the submarine into two pressure tight compartments. Behind this bulkhead is the section housing the ballast tank and main compensating tank. Above this is the escape hatch to which a DSRV flange is fixed allowing deep submergence rescue vehicles to mate. The escape hatch is so situated that it can be reached from either the forward or rear pressure tight compartments. In the longer variant the additional energy section is sited behind the tank section. Behind the tank section is the AIP section housing the Stirling engines, machinery control room and the upper part and LOX tanks and aft auxiliary machinery space in the lower part. The final section houses the propulsion motor, shaft line and propeller, control surfaces with actuators and aft ballast tanks.

Each section is completely modular in design, which allows the customer to have the various sections tailored to fulfil its requirements.

The open architecture combat management system integrated in the newly developed weapon system will co-ordinate all sensor functions, weapon functions, the navigation system and the communication system.

The boats' two-compartment single pressure hull will feature advanced hydrodynamic performance capabilities which will further improve its performance and capabilities together with the weapon load of multipurpose homing torpedoes, surface-to-surface and cruise missiles (possibly included at a future date), ASW torpedoes (including all current and future planned weapons to be acquired by the three nations), mines and countermeasures which the boat will be capable of carrying.

In addition the boats may carry offboard surveillance vehicles (UAV/UUV) which could be deployed from the torpedo tubes, and an unmanned underwater combat vehicle carrying surveillance equipment, small weapons or ECM decoys/jammers.

The sole form of propulsion for the boats will be the improved performance Stirling AIP system. This is one of the most significant developments that will enable the submarines to complete their mission submerged for extreme periods of time (100 per cent of mission times), making them invaluable both in peacetime and in all possible conflict situations.

The modular design also provides for the exclusion of certain specific options should economic considerations demand their omission. On the other hand items which are not part of the specified common design might be able to be added as an extra option, should they be a requirement for a specific customer.

The sonar suite will feature a large bow-mounted conformal array with a large aperture integrated planar flank array of similar height stretching for most of the straight part of the hull – that is all except the hydrodynamically shaped bow area and the aft section fairing back into the propeller. An optional LF towed array sensor could be installed if funds permitted and would almost certainly be a requirement for a Norwegian boat. Other sensors will include: an intercept array; an active HF sonar for navigation/mine avoidance/obstacle avoidance; ESM; and an optronic mast, although currently a standard non hull-penetrating periscope is envisaged.

A full range of self-defence measures will be incorporated and may possibly include an anti-helicopter missile system.

Operational status

The FMVs in Denmark and Sweden signed a contract for Phase 2 of the project definition phase on 6 October 2003, which will last until the end of 2004. Like Norway, Finland is involved in an observer status. The final decision to procure the submarines will be followed by an implementation period of 15 years. The project will involve the design and construction of six submarines: four for Denmark, and two for Sweden. Work on construction will commence in 2005 in Denmark, and in 2010 in Sweden. Plans for the Danish boat are now uncertain as the Danish forward defence plan has revealed that the submarine arm may be disbanded.

Specifications

Displacement: 1,100 to 1,700 tonnes
Length: 52 to 60 m
Diameter: 6.7 m
Crew: 22 to 28

Contractors

Kockums AB , Malmö, Sweden.
Odense Staalskipsvaerft A/S, Denmark.

UPDATED

Italy

Chariot CE2F/X100

Type

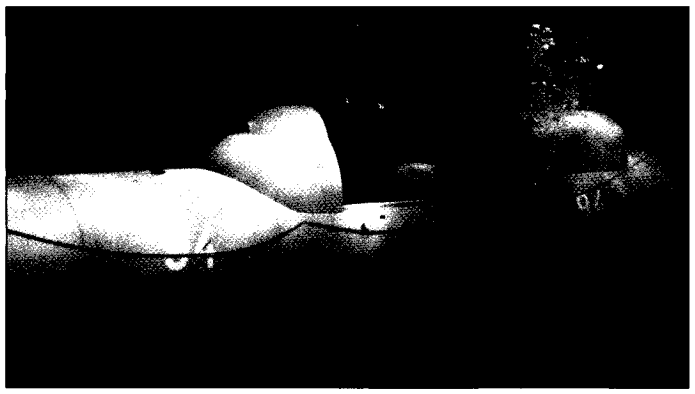
Small chariot.

Development

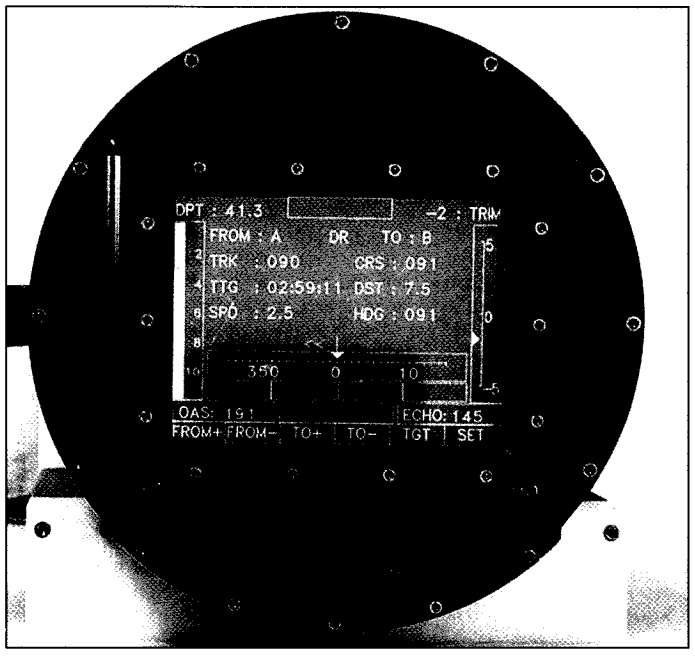
The Chariot or SDV (Swimmer Delivery Vehicle) as it is now referred to, is the result of an ongoing upgrading project of the famous Italian Maiali of World War II. Because of their endurance, chariots are normally transported to within their operating range by a parent ship such as a SWAT, patrol submarine, helicopter or even innocent-looking fishing vessel. The Chariot is designed to navigate undetected in hostile waters and carry two combat divers to their target (harbour, oil rig, coastal installation and so on) and then back to the parent ship after completion of the mission.

Description

The CE2F/X100 is a sturdy, two-man wet submersible vehicle designed for covert operations. The vehicle is characterised by its simplicity of construction, small dimensions and low weight, making it easy to handle and operate. Although new technologies are continuously developed and applied in order to improve the



Chariot underwater



Control module dial for Chariot

design, capabilities and maintenance of the Chariot, its fundamental operating principles remain the same.

Offensive capability includes limpet mines, which can be secured to targets such as ships' hulls or underwater structures and depth charges laid on the seabed near the target. Both weapons are fitted with electronic time fuzes, which in the case of limpet mines are provided with an anti-removal device.

The latest improvements include a digital Control Module where all navigation and platform parameters are displayed as well as a fully integrated autopilot.

Operational status
In service with a number of navies including Argentina, India (11 units) and Pakistan.

Specifications
Length: 7.00 m (overall)
Diameter: 0.80 m
Height: 1.50 m
Displacement: 2.10 t
Operational depth (max): 100 m
Speed: 5 kt (max); 4 kt (cruise)
Range: 50 n miles (at cruise speed)
Crew: 2
Armament: 1 × Mk 31 (230 kg explosive) or 2 × Mk 41 (105 kg explosive),12 × Mk 414 limpet mines (7 kg explosive each) or 10 × Mk 430 limpet mines (15 kg explosive each)

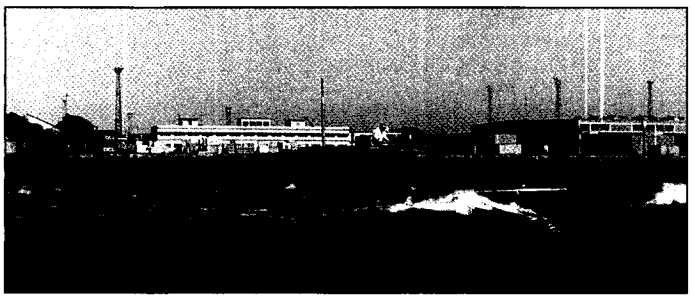
Contractor
Cosmos SpA, Livorno.

UPDATED

MG 120/ER

Type
Shallow Water Attack Submarine (SWATS).

Description
This MG 120/ER SWATS is designed to carry out both offensive and defensive operations in shallow waters where larger submarines are unable to fully exploit their potential capabilities.



An SWAT MG 120/ER submarine running on the surface 0007213

Because of its small size and low target echo strength, the submarine is extremely difficult to detect. The mission profile of the SWATS means that it operates in an environment characterised by strong surface and bottom reverberations where hostile active sonars are severely degraded in their capability to detect the small target. The submarine is also able to crawl along the seabed further enhancing its stealth capability.

The SWATS was initially conceived as a special craft for covert operations, a mission which it still retains. However, the design has been further developed featuring significant standoff capabilities and comprehensive attack and passive equipment which make it suitable for a wide range of tactical missions.

In peacetime the submarine can be used to train both submarine crews and commanding officers and also to train forces in ASW procedures and tactics.

Two of the outstanding characteristics of the MG 120/ER SWATS is its range, which exceeds 2,000 n miles surfaced, and its low indiscretion rate. The submarine is also fitted with an AIP system called the Underwater Auxiliary Propulsion Engine (UAPE) comprising a closed circuit diesel fuelled by liquid oxygen. This confers a submerged radius of 400 n miles.

Armament configurations can be varied according to the mission in hand and may comprise: up to four wire-guided torpedoes; two chariots; 16 mini-torpedoes; four remote-controlled Chariots; up to 12 ground influence (magnetic/acoustic) mines; 20 limpet mines; or commando gear containers.

The boat is manned by a crew of six and can carry up to 15 combat divers.

Operational status
Variants in service with several armed forces including Colombia, South Korea and Pakistan. Three variants are on order for Malaysia.

Specifications

	Malaysia	Pakistan
Displacement:		
surface:	134 t	110 t
submerged:	n/k	130 t
Dimensions:		
length:	29 m	27.8 m
beam:	n/k	2.02 m
draft:	n/k	5.6 m (height)
Electronics:		
Periscopes:		CK 39
radar:		n/k
Weapons:		
torpedo tubes:	2 × 533 mm	2 × 533 mm
torpedoes:	2	2 × SUT
mines:	n/k	8 × Mk 414 (in lieu of mines)
other	SDVs	SDVs
Machinery:		
diesels:	n/k	1
power output:	n/k	n/k
batteries:	n/k	n/k
electric motor:	n/k	1
power output:	n/k	n/k
shafts:	1	1
propellers:	1	1 × 3-bladed fp
Speed:		
surfaced:	n/k	9 kt
submerged:	n/k	7 kt
Range:		
surfaced:	n/k	1,600 n miles @ 7 kt
submerged:	n/k	60 n miles @ 4.5 kt
autonomy:	n/k	20 days
operating depth:	150 m	150 m
Personnel:	6 crew, 15 special forces	6 crew, 8 special forces

Contractor
Cosmos SpA, Livorno.

UPDATED

Sauro class

Type
Diesel-electric patrol submarine.

Description
The Sauro class submarines consist of four batches of two boats which commenced delivery in 1979 and completed in 1995. Due to enhancements in the design and machinery, the last two 'Improved Sauro' boats are regarded as the Longobardo class taking the name from the first of the last two boats to be built.

The boats have a single pressure hull with ballast tanks at bow and stern mounted outside the pressure hull, and an emergency tank in the sail. The pressure hull is constructed in circular sections of HY80 high-tensile steel and closed at bow and stern by spherical caps. The pressure hull incorporates a central bulkhead for emergency escape. The last two boats in the series are also fitted with anechoic tiles.

The propulsion system comprises three Fincantieri Diesel Engine Division A 210 16NM (SM in the 'Improved Sauro') diesels connected to three Marelli DC generators for battery charging or for feeding the electric motor or both. The electric motor is an ABB Italy (formerly Marelli) double armature DC motor with a continuous output of 2.4 MW at 225 rpm (for short periods the motor can develop 3.14 MW at 244 rpm), directly connected to the shaft. The batteries are sited in two compartments each of 148 cells. All diesel generators, auxiliaries and propulsion motor compartments are sound insulated and all systems are elastic mounted and flexibly connected in order to reduce structure-borne noise. Machinery control is extensively automated. The snort mast features a specially designed wave contour head with a very low radar profile. An AIP system is expected to be tested on the *Fecia di Cossato*.

The machinery in the 'Improved Sauros' is the Fincantieri Diesel engine Division A 210 16SM driving three alternators developing 2.16 MW. The electric motor is the same as in the earlier boats. General characteristics and hull configuration remain the same as in the earlier boats, but internal spaces have been redesigned to allow better location of equipment.

Six bow swimout torpedo tubes for guided weapons are fitted. Torpedo tubes are loaded through a hydraulically powered loading hatch in the torpedo room and weapons are fired hydropneumatically. Studies have been undertaken to adapt the B512 swimout torpedo discharge tube to launch encapsulated sub-launched anti-ship missiles. The last two boats in the improved series have been lengthened to accommodate missiles and normal weapon payload is 12 × Type 184 torpedoes.

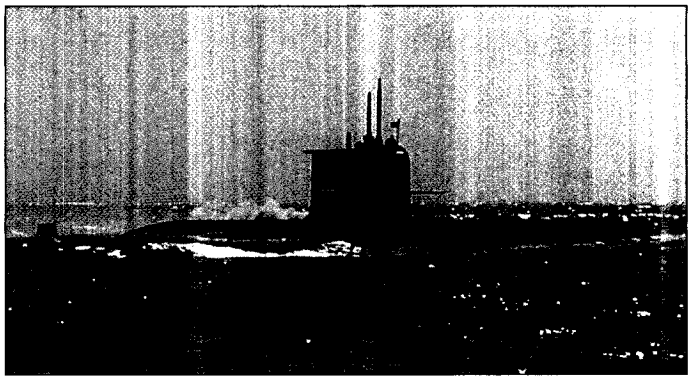
An extensive programme of upgrading is currently underway at Fincantieri's Muggiano shipyard and is relevant to each of the two boats in the 3rd and 4th batch. The first boat to have been modernised was the *Gazzana Priaroggia*, whose refit commenced in October 1999 and was completed in August 2001. The *Longobardo* completed her refit in December 2002. The programme was completed with the *Prini* in 2003.

The modifications relate primarily to the combat system in which the existing equipment (IPD-70S sonar, SACTIS command system and FCS Mk 3 fire-control system) has been replaced by the STN ATLAS Elektronik ISUS 90-20, modified to handle the A184 Mod 3. New acoustic sensors to be fitted include chin-mounted passive conformal array; bow-mounted HF cylindrical active array; passive cylindrical intercept array; eight self-noise monitoring transducers to monitor the level and frequency spectrum of on-board generated noise. The Batch 3 boats will additionally have their platform management and propulsion systems overhauled with new steering system upgrading of hydraulic, damage control, refrigeration and air purification to bring them up to the same standard as the Longobardo class. The Ferranti autopilot is being replaced by the SEPA 8518 system already installed in Batch 4 boats. Improved silencing and platform control enhancements will include elastomeric mounts for main machinery and hydraulic components, the replacement of a number of pumps and auxiliary systems with quieter equipment and a more efficient and quiet propeller. A new upper casing and noise absorbing coating will also be fitted.

Operational status
In service with the Italian Navy.

Specifications

	'Sauro'	'Improved Sauro'
Displacement:		
surface:	1,456 t	1,476-1,653 t
submerged:	1,631 t	1,662-1,862 t
Dimensions:		
length:	63.9 m	64.4-66.5 m
beam:	6.8 m	6.8 m
draft:	5.7 m	5.6 m
Electronics:		
combat management system:	ISUS 90-20	ISUS 90-20
sonars:	CSU 90	CSU 90
periscopes	CK 31, CH 81	Model 76
radar:	BPS 704	BPS 704
electronic warfare:	BLD 727	BLD 727
Weapons:		
torpedo tubes:	6 × 533 mm B512	6 × 533 mm B512
torpedoes:	12 × 184	12 × 184
missile tubes:	None	None
missiles:	None	None
mines:	n/k	n/k



Gazzana Priaroggia following refit with new combat management system (Fincantieri) ***NEW***/0567687

Machinery:		
diesels:	3 × A 210 16NM	3 × 210 16SM
power output:	2.4 MW	2.7 MW
batteries:		
electric motor:	1	1
power output:	2.36 kW	2.16 kW
shafts:	1	1
Speed:		
surfaced:	11 kt	11 kt
submerged:	19 kt	19 kt
Range:		
surfaced:	11,000 n miles @ 11 kt	11,000 n miles @ 11 kt
submerged:	250 n miles @ 4 kt	250 n miles @ 4 kt
autonomy:	35 days	45 days
operating depth:	300 m	300 m
Personnel:	49	50

Contractor
Monfalcone, Italy.

UPDATED

SWATS X 201

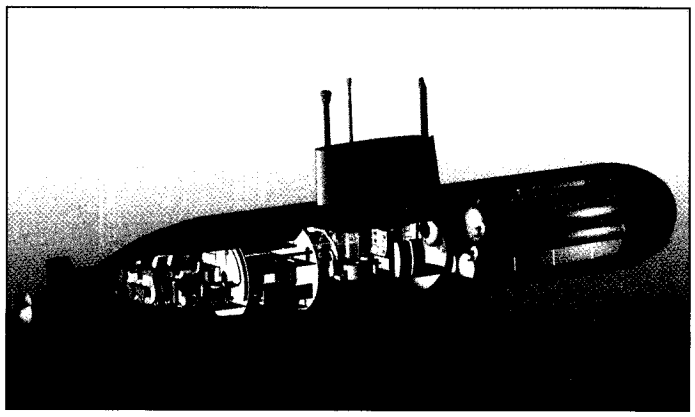
Type
Midget submarine.

Description
The latest generation of SWATS (Shallow Water Attack Submarine) designed by COSMOS is the SWATS X 201 which exceeds in performance and armament the previous MG-120/ER class.

The design is based on the traditional and well proven COSMOS concept of midget submarine design. This consists of battery compartments, torpedo launching tubes, mine launching system and other ancillary equipment being located outside the main pressure resistant hull in order to maximise safety.

The shape of the new generation SWATS X 201 has been changed according to the latest hydrodynamic data available to increase speed. The increase size of the vessel allows it to carry increased armament and personnel and for endurance to be improved. The new SWATS concept retains the good manoeuvrability, capability to navigate in very shallow water and to crawl on the seabed of the previous design.

Specifications
Displacement:
submerged: 200 t
Dimensions:
length: 30.5 m
beam: 3.6 m (diameter)
draft: 6.52 m (height)
Electronics:
combat management system: none
sonars: none
radar: none
electronic warfare: none
Weapons:
torpedoes: 6 × wire guided or 2 × wire guided
missile tubes: none
missiles: none
mines: 10 seabed
other: 2 × CE4/6F SDV or 2 with mines and 2 torpedoes
Machinery:
AIP: none
power output: none
nuclear plant: none
power output: none
shafts: 1



Schematic of SWATS X 201 (COSMOS) 0522428

Speed:
submerged: 15 kt
Range:
surfaced: =2,500 n miles
operating depth: 200 m
Personnel: 6/10 plus 12 divers/commandos

Contractor
Cosmos SpA, Livorno.

UPDATED

Japan

Harushio class

Type
Diesel-electric patrol submarine.

Description
The 'Harushio' design was first approved in the 1986 estimates. The design is a natural evolution from the preceding Yuushio class from which it differs in having slightly increased dimensions. Improved stealth technology has been incorporated into the design including a greater degree of noise control, mainly affecting propeller cavitation and machinery silencing, as well as the fitting of anechoic tiles. Other new features include a towed array sonar and improved communications system. The last boat of the class has a slightly larger displacement and a small reduction in crew numbers resulting from greater system automation.

Much of the equipment is of indigenous design, based on American systems. The sonar suite is the ZQQ-5B manufactured by the Oki Corporation using technology supplied by the Hughes Corporation and the passive towed array is the ZQR-1. The ESM system is the ZLA-7. The boats deploy the American Sub-Harpoon missile together with Japanese designed and manufactured Type 89 wire-guided torpedoes. The propulsion system consists of two Kawasaki 12V25/25S diesels developing 4.1 MW driving two Kawasaki alternators developing 3.7 MW. Two Fuji electric motors develop a maximum of 5.3 MW to drive a single shaft.

The training boat *Asashio* was lengthened by the addition of a 9 m plug equipped with four Stirling Mk 2 4-275R AIP systems in 2001. Trials were completing in March 2003.

Operational status
Seven boats in service with the Japanese Maritime Self-Defense Force.

Specifications
Displacement:
surface: 2,450 t standard
submerged: 2,750 t
Dimensions:
length: 77 m
beam: 10 m
draft: 7.7 m
Electronics combat management system: n/k
sonars: ZQQ-5B, ZQR-1
periscopes: n/k
radar: ZPS-6
electronic warfare: ZLR-3/6
Weapons torpedo tubes: 6 × 533 mm
torpedoes: Type 89
missiles: Sub-Harpoon
payload: 20 weapons
mines: n/k
other: n/k
Machinery diesels: 2 × Kawasaki 12V25/25S
power output: 4.1 MW
batteries: 2 × 480 cell Yuasa sets
electric motor: 2 × Fuji
power output: 5.3 MW
shafts: 1
speed
surfaced: 12 kt
submerged: 20 kt
range
surfaced: n/k
submerged: n/k
autonomy: n/k
operating depth: 350 m
Personnel: 10 officers, 65 crew

Contractors
Kawasaki, Kobe.
Mitsubishi, Kobe.

UPDATED

Oyashio class

Type
Diesel electric patrol submarine.

Description
The Oyashio class features a higher degree of machinery automation than the 'Harushio', with a further reduction in manning requirement. Length has been increased by about 4 m. The submarines are equipped with a large flank array sonar (ZQQ-6), which is said to be the reason for the increase in displacement over the Harushio class.

The design features double hull sections forward and aft, and is treated with anechoic tiles on the fin, which is faired. The design also features a new type of deck casing.

Two Kawasaki 12V25S diesels provide a total output of 5,520 bhp while the two Fuji electric motors have a combined output of 7,750 hp.

Under the terms of an agreement concluded with Kockums in Sweden, Kawasaki Heavy Industries has carried out experiments with an 800 hp Stirling AIP engine. Kawasaki has also investigated the fuel cell method of energy production and, on a commercial basis, a super conducting propulsion system. However, it is unlikely that a new system of propulsion will be fitted in the improved Harushio class, and the early boats of this class. However, next-generation submarines will undoubtedly be equipped with some form of AIP system.

Operational status
Six boats are in service with the Japanese Maritime Self-Defense Force, and construction is continuing.

Specifications
Displacement:
surface: 2,750 t standard
submerged: 3,000 t
Dimensions:
length: 81.7 m
beam: 8.9 m
draft: 7.4 m
Electronics combat management system: ZYQ-3
sonars: ZQQ-5B/6, ZQR-1
periscopes: n/k
radar: ZPS-6
electronic warfare: ZLR-7
Weapons torpedo tubes: 6 × 533 mm
torpedoes: Type 89
missiles: Sub-Harpoon
payload: 20 weapons
mines: n/k
other: n/k
Machinery diesels: 2 × Kawasaki 12V25S
power output: 4.1 MW
electric motor: 2 × Toshiba
power output: 5.7 MW
shafts: 1
speed
surfaced: 12 kt
submerged: 20 kt
range
surfaced: n/k
submerged: n/k
autonomy: n/k
operating depth: n/k
Personnel: 10 officers, 60 crew

Contractors
Kawasaki, Kobe.
Mitsubishi, Kobe.

UPDATED

Korea, North

Yugo class

Type
Midget submarine.

Description
The 'Yugo' midget submarine is designed for covert operations transporting infiltration teams into hostile territory.

The design is based on midget submarines imported from Yugoslavia during the 1960s and 1970s incorporating updated technology developed by North Korea. From the sparse details available it appears that a number of distinct variants of this type are in existence in which displacement, dimensions, power plant and weapons fit vary.

The description given here is based on information gleaned from the capture of the 'Yugo' off the coast of South Korea on 22 June 1998. In the case of this vessel the length is in the region of 22 m, and displacement around 70 tonnes. The power plant, said to be an MTU type diesel, drives an advanced, single-shaft twin propeller. The main propeller consists of seven specially designed highly skewed blades measuring approximately 130 cm in diameter, while the second auxiliary five-bladed freewheeling propeller measures some 30 cm in diameter. The use of highly skewed blades in this midget submarine would considerably reduce the radiated noise signature while cruising and the auxiliary propeller is probably used during the silent, slow run in phase to the hostile beach area as it exhibits an even lower noise signature. In addition stealth is further aided by the dark camouflage colouring (green/dark green mottled pattern) and fibre resin plastic (FRP) materials which are used to coat the conning tower. The casing and conning tower are of GRP.

The small conning tower houses the periscope and radio antennas, and also serves as a diver lockout chamber with a hand operated outer hatch and an inner hatch that is controlled by a hydraulic arm that can only be operated from inside the midget. Between the two hatches there is sufficient room to allow the infiltration team to put on or remove their scuba diving equipment.

A pivoted snorkel device is mounted on the stern deck which, when not in use, lays flush with the deck. Two small torpedo tubes are also fitted in some units.

The interior of the boat is divided into 10 watertight compartments. The vessel was manned by a crew of two and carried an infiltration team of six men.

Operational status
About 36 midgets are believed to be operational in North Korea and two are in service with the Vietnamese People's Navy. It is also believed that one of these craft has been exported to Iran.

Specifications
Displacement:
- **surface:** 76 to 90 t
- **submerged:** 90 to 110 t

Dimensions:
- **length:** 20 m
- **beam:** 2.0 to 3.1 m
- **draft:** 1.6 to 4.6 m

Electronics:
- **radar:** I-band

Weapons:
- **torpedo tubes:** 2 × 406 mm (only in some units)
- **torpedoes:** 2
- **mines:**

Machinery:
- **diesels:** 2 × MTU
- **power output:** 236 kW
- **batteries:** n/k
- **electric motor:** 1
- **power output:** n/k
- **shafts:** 1
- **propeller:** 1 × 7-bladed fp

Speed:
- **surfaced:** 12 kt
- **submerged:** 8 kt

Range:
- **surfaced:** 550 n miles @ 10 kt
- **submerged:** 50 n miles @ 4 kt
- **autonomy:** n/k
- **operating depth:** n/k

Personnel: 4 crew, 6-7 special forces

Contractor
Yukdaeso-ri Shipyard.

UPDATED

Netherlands

Walrus class

Type
Diesel-electric patrol submarine.

Description
The Walrus class SSK, built for the Royal Netherlands Navy by RDM Submarines bv and designed in close co-operation with the naval architects of the RNLN and the design office of NEVESBU, features improved manoeuvrability and higher speed compared to the previous Zwaardvis class. Diving depth has been increased by more than 50 per cent, resulting from the use of HY100 high-yield tensile steel for hull construction. The centre section of the hull is of the single-body type, while the fore and aft sections are of double-hull design.

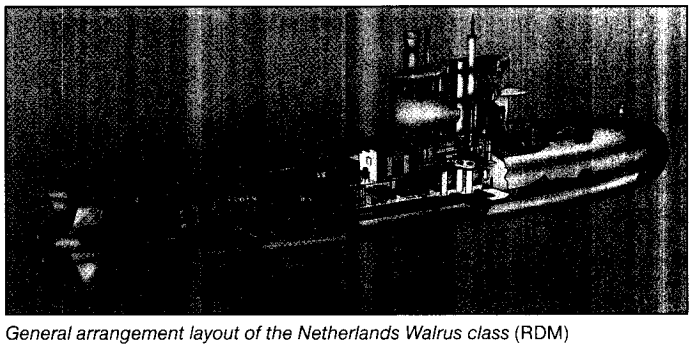
The design features a high degree of automation and monitoring which results in a considerable reduction in personnel requirement. Two escape hatches are provided, one forward with a single hatch and an aft unit with a double hatch to which a DSRV can mate allowing crew to transfer dry to the rescue vehicle. The advanced integrated platform monitoring and control system embodies the complete integration of platform data information and display, with the possibility of operating and supervising platform systems from one or several positions. The central control room also houses the computer-based steering control system. The boats are fitted with the Signaal SEWACO VIII command system, the Thomson Marconi Type 2026 low-frequency towed array sonar which is secured to an attachment fitted to the upper tip of the X-rudder blade, and the DUUX-5 (Fenelon) passive ranging sonar. The weapons system comprises four, positive ejection torpedo tubes for launching American NT.37C/E or Mk 48 Mod 4 torpedoes and Sub Harpoon missiles, although no missiles have been procured. Twenty weapons are carried or 40 mines may be carried in lieu of the torpedoes. The boats are powered by three SEMT-Pielstick 12-cylinder PA4 diesels driving three alternators to power a 4.1 MW two-stage electric motor driving a five-bladed propeller.

Operational status
Four boats in service with the Royal Netherlands Navy.

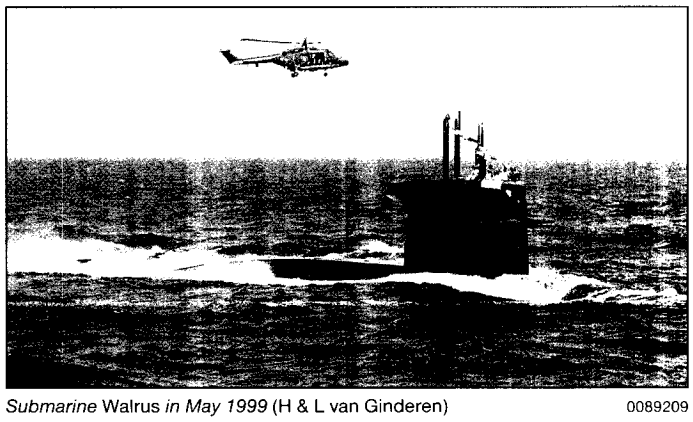
Specifications
Displacement:
- **surface:** 2,465 t
- **submerged:** 2,800 t

Dimensions:
- **length:** 67.7 m
- **beam:** 8.4 m
- **draft:** 7.0 m

Electronics:
- **combat management system:** Sewaco VIII, Gipsy
- **sonars:** TSM 2272, Type 2026, DUUX 5
- **periscopes:** CK24, CH74
- **radar:** ZW 07
- **electronic warfare:** AR-700



General arrangement layout of the Netherlands Walrus class (RDM)



Submarine Walrus *in May 1999* (H & L van Ginderen) 0089209

Weapons:
torpedo tubes: 4 × 533 mm
torpedoes: 20 × Mk 48 Mod 4 or NT-37D
missiles: Sub Harpoon (not carried)
mines: 40 (in lieu of torpedoes)
Machinery:
diesels: 3 × SEMT Pielstick 12 PA4 200VG
power output: 4.63 MW
batteries: 3 × 140 cells
electric motor: 1 × Holec
power output: 5.1 MW
shafts: 1
propeller: 1 × 5-bladed
Speed:
surfaced: 12 kt
submerged: 20 kt
Range:
submerged: 10,000 n miles @ 9 kt schnorkelling
autonomy: 60 days
operating depth: 300 m
Personnel: 7 officers, 45 crew

Contractor
RDM Submarines bv, Rotterdam. ***UPDATED***

Pakistan

MG 110

Type
Midget submarine.

Description
The MG 110 boats were built under supervision by, and with materials supplied by, Cosmos of Italy at the Pakistan Navy's Karachi dockyard. Delivery of the boats began in 1988 and in 1995 they were upgraded with improved sensors and weapons. In 1995 one of the boats was reported as having been lost, and was presumably replaced, although other reports indicate that construction ceased in 1995. However, the Karachi shipyard has recently begun promoting the design. The design is an enlarged version of the Cosmos SX 756 midget submarine.

The boats are designed to undertake a variety of roles including: attacking enemy targets in harbour or at sea with torpedoes, carrying out covert missions with Special Forces, conducting ISR operations, minelaying and so on.

The boats are powered by a standard diesel-electric propulsion system driving a single three-bladed propeller, and are said to have an active/passive HF hull-mounted sonar. A Thales Optronics CK 039 periscope is fitted in the boats. Two SDVs or up to 12 mines can be carried in lieu of torpedoes.

Operational status
Three boats are in service with the Pakistan Navy and others may possibly have been built for other navies.

Specifications
Displacement:
surface: 102 t
submerged: 110 t
Dimensions:
length: 27.28 m
beam: 5.59 m
Electronics:
sonars: Active/passive HF
periscopes: CK 039
Weapons:
torpedo tubes: 2 × 533 mm
torpedoes: 2 × SUT
mines: 12 × Mk 414 in lieu of torpedoes
other: 2 × CF2 FX 60 SDVs in lieu of torpedoes
Machinery:
diesels: 1 × n/k
electric motor: 1 × n/k
shafts: 1
Speed:
surfaced: 9 kt
submerged: 6 kt
Range:
surfaced: 1,600 n miles @ 7 kt
submerged: 60 n miles @ 4.5 kt
autonomy: 20 days
operating depth: 150 m
Personnel: 6 crew, 8 special forces

Contractor
Karachi Shipyard, Karachi. ***NEW ENTRY***

Russian Federation

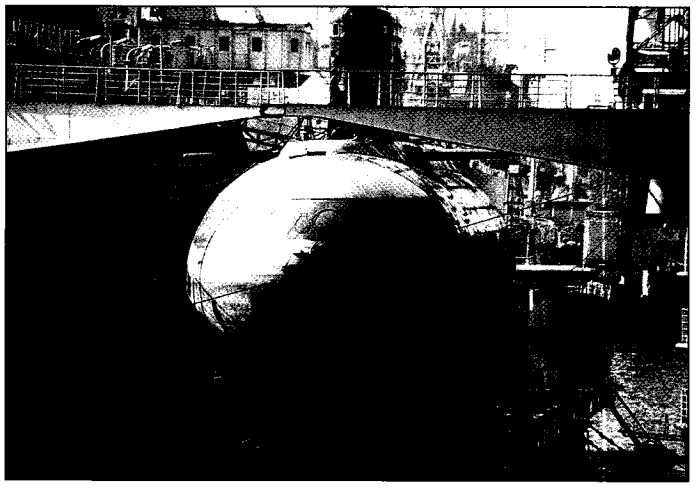
Kilo class

Type
Diesel-electric patrol submarine.

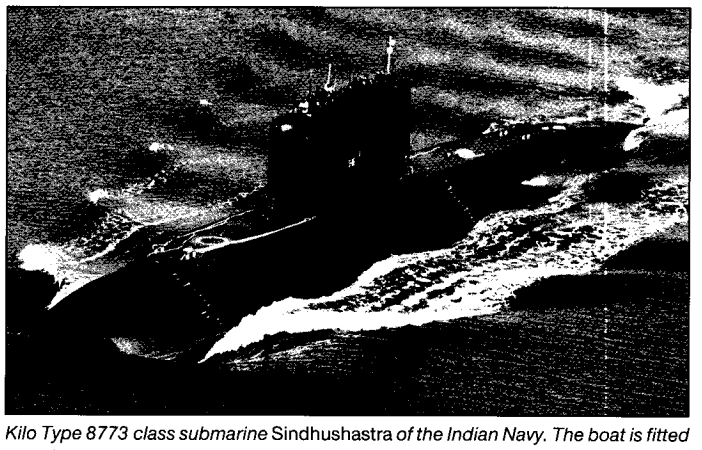
Description
The Kilo class design dates back to the early 1970s and the first vessel, for the then Soviet Navy, was launched in 1979. Since then it has undergone continual improvements. The Kilo has been developed from the previous Foxtrot and Tango designs, but shows an improved hull form. However, it is still fairly basic compared to its modern Western counterparts. The layout of the Kilo is almost identical to the Canadian Victoria class with similar endurance and performance. However, it does not exhibit the same noise isolation and shock resistance capabilities as those incorporated in the Victoria. The basic variant is the Project 877. The Project 877K has an improved fire-control system, while the Project 877M is fitted to fire wire-guided torpedoes from two tubes. The latest variant is the Project 636, which is available for export. This model is 1.2 m longer than previous variants and features improved stealth technology (including unique multilayer anechoic tiles) with a redesigned propulsion system, claimed to generate half the noise of its earlier variants. In total, the Project 636 variant is an exceptionally quiet boat, which is proving very difficult to detect. Capability has been improved with an automated combat information system (MVU-110EM) that can track up to six targets simultaneously and provide concurrent fire-control data on two targets while carrying out TMA on three others. The forward hydroplanes are mounted on the hull just forward of the fin. The pressure hull is divided into six watertight compartments separated by pressure bulkheads, has a reserve of buoyancy of 32 per cent at normal load and is heavily compartmented, the boat remaining buoyant with any one compartment flooded. Normal diving depth is 240 m and maximum depth is 350 m.

Acoustic discretion has been improved by removing the flooding ports from its forebody and treating the hull with rubber tiles. These have been specially treated with an outer layer to combat the effects of the sun in tropical climates. The bow planes are positioned close to the midship point to improve sonar performance.

The electronic equipment is of Russian manufacture, with the sonar suite comprising the hull-mounted, low-/medium-frequency passive search and attack Shark Teeth (MGK-400EM); and the hull-mounted, high-frequency active search/attack sonar Mouse Roar (MG-519). The Shark Teeth, although primarily a passive search and attack sonar, also has some active capability. The Indian boats are additionally fitted with the low-/medium-frequency, passive search Whale series. The bow sonar features a surface array of 6.4 m² enabling it to detect a submarine



Kilo at St Petersburg (H M Steele)



Kilo Type 8773 class submarine Sindhushastra *of the Indian Navy. The boat is fitted with the Alfa Klub SS-N-27 (3M-54E1)* (Michael Nitz) ***NEW***/0526847

Specifications

	Project 877E (Algeria, Romania)	Project 877EM (India, Poland)	Project 877EKM (Iran, China)	Project 636 (Russia, China)
Displacement:				
surface:	2,325 t	2,457 t	2,356 t	2,325 t
submerged:	3,076 t	3,076 t	3,076 t	3,076 t
Dimensions:				
length:	72.6 m	74.3 m	72.6 m	73.8 m
beam:	10.00 m	10.00 m	9.9 m	9.9 m
draft:	6.6 m	6.6 m	6.6 m	6.6 m
Electronics:				
combat management system:	MVU-110EM	MVU-119EM	MVU-119EM	MVU-119EM
sonars:	MGK 400, MG 519	MGK 400, MG 519	MGK 400, MG 519	MGK 400, MG 519
periscopes:	2 × PZKG	2 × PZKG	2 × PZKG	2 × PZKG
radar:	MRK-50	MRK-50	MRK-50E	MRK-50
electronic warfare:	MRP 25, 6701E	MRP 25, 6701E	MRM-25EM, 6701E	MRP 25 or MRM-25EM, 6701E
Weapons:				
torpedo tubes:	6 × 533 mm	6 × 533 mm	6 × 533 mm	6 × 533 mm
torpedoes:	18 × 53-65 and Test-711	18 × 53-65 and Test 71 or 53-56 WA and SET 53 M	18 × 53-65 and TEST 71/96	18 × TEST 71ME, 53-65KE
missile tubes:	none	none	none	none
missiles:	8 × SA-N-5/8	8 × SA-N-5/8, 3M-54E (in Indian boats only)	uncertain	18 × SS-N-16, SA-N-5/8
mines:	24 in lieu of torpedoes	24 × MDT in lieu of torpedoes	24 × MDT in lieu of torpedoes	24 × AM in lieu of torpedoes
Machinery:				
diesels:	2 × Type 4-2DL-42M	2 × Type 4-2DL-42M	2 × Type 2D-42	2 × Type 4-2AA-42M
power output:	2.68 MW	2.68 MW	2 68 MW	2.68 MW
AIP:	none	none	none	none
power output:	none	none	none	none
batteries:	2 × Type 446 120-cell	2 × Type 446 120-cell (2 × Indian 120 cell in Indian boats)	2 × Type 446 120-cell	2 × Type 446 120-cell
electric motor:	1 × PG 141	1 × PG 141	1 ×	2 × PG 141M
power output:	4.34 MW	4.34 MW	4.05 MW	4.34.MW
nuclear plant:	none	none	none	none
power output:	none	none	none	none
auxiliary system:	1 × PG 142	1 × PG 142	1 × PG 142	1 × MT-140
power output:	150 kW	150 kW	150 kW	150 kW
low speed manoeuvring:	2 × PG 140 electric	2 × electric	2 × electric	2 × MT-168
power output:	204 shp on 2 ducted propellers	204 shp on 2 ducted propellers	204 shp on 2 ducted propellers	204 shp on 2 ducted propellers
shafts:	1	1	1	1
propeller:	1 × 6-bladed	1 × 6-bladed	1 × 6-bladed	1 × 7-bladed
Speed:				
surfaced:	10 kt	10 kt	10 kt	10 kt
submerged:	17 kt	17 kt	17 kt	17 kt
Range:				
surfaced:	6,000 n miles @ 7 kt (schnorkel)	6,000 n miles @ 7 kt (schnorkel)	6,000 n miles @ 7 kt (schnorkel)	6,000 n miles @ 7 kt (schnorkel)
submerged:	400 n miles @ 3 kt	400 n miles @ 3 kt	400 n miles @ 3 kt	400 n miles @ 3 kt
autonomy:	45 days	45 days	45 days	45 days
operating depth:	240 m	240 m	240 m	240 m
Personnel:	12 officers, 40 crew	16 officers, 44 crew	12 officers, 41 crew	13 officers, 39 crew

Notes:
1 - torpedoes carried can include E-53, E-53-60, E-53-85, E-53-67
2 - mines carried can include KMD-500, KMD-1000, KMD-II-500, KMD-II-1000, UMD

target at 10.75+ n miles, a surface vessel at 43 n miles and a task force at around 80 to 105 n miles, depending on environmental conditions and the generated noise of the task force. The electronic warfare suite consists of either the Brick Group, Stop Light or Squid Head radar warning system and Quad Loop D/F. For navigation the ships are fitted with the I-band Snoop Tray radar.

Standard armament comprises six torpedo tubes firing a mixture of TEST-71ME/TEST 71/96 wire-guided ASW active/passive homing and Type E53-65 and SET-53M ASV passive wake homing torpedoes and the E53-56B acoustic homing torpedo, with a total of 18 weapons being carried. Only the outboard lower torpedo tubes are equipped to fire wire-guided torpedoes. The boats can also launch anti-submarine SS-N-15 Starfish missiles from the torpedo tubes. As with most submarines, mines can be carried in lieu of the torpedoes, up to a total of 24. In addition, some vessels are fitted to carry an SA-N-5/8/10 shoulder-held SAM launcher with 6-8 missiles. The containerised portable missile launcher is carried in a well between the snort and communications masts. The Project 877MKE boats of the Indian Navy are being adapted to launch the 3M54E Klub antiship cruise missile. Four of the missiles are carried in place of four torpedoes and are deployed from tow of the torpedo tubes.

Propulsion is provided by two 4-2AA-42M diesels (in the export variants and the latest variant, the Type 636, in service with the Russian Navy) developing 2.68 MW powering two generators and carried on a suspended platform for stealth. The single shaft is driven by a single electric motor developing 4.34 MW and powering a slow-turning (500 rpm in the Project 877 EKM, and only 250 rpm in the Project 636) seven-bladed propeller. In addition, two small MT-168 auxiliary motors developing 150 kW are fitted and a low-powered electric motor of 95 kW for economic running and slow speed operations (6 kt) in ultra quiet mode. Two 120 cell storage batteries are accommodated in the first and third compartments. Battery capacity is 9,700 kW h. Fuel reserves total 51.6 tonnes normal and 172 tonnes maximum.

The Indians suffered problems with the batteries which, having been designed for operation in cold water regions, suffered from overheating in the warm waters around India. These were eventually overcome by re-equipping the boats with German-designed, Indian-built batteries. This change has also improved battery cooling. The Iranians experienced similar difficulties with their batteries in the Gulf. From their experience the Indians have assisted the Iranians to overcome their difficulties with modifications to the battery cooling system. The Indians are also said to be considering changing the diesels in their boats. The Indian boats may receive new engines while undergoing refit in Russia.

Operational status

In service with the Russian Navy. The first country to receive an export Kilo was India and since then the design has been exported to Algeria, China, Iran, Poland and Romania. The latest variant of the Kilo to be exported is the Type 636 which is being delivered to China and India. This variant features improved weapons system management and fire control, together with a basic combat information suite. Accommodation has been improved compared to earlier boats in the series. Export variants have been distinguished by the letter E after the type or project designator but this has not been applied to the 636 variant. Export construction is now said to be running at about three boats a year.

Contractors

Admiralty Yard, St Petersburg.
Sudomekh, St Petersburg.
Krasnoje, Gorki.
Gorki, Nizhny Novgorod.
Komsomolsk, Komsomolsk.

UPDATED

Lada class (Project 677)/Amur class (Project 1650)

Type
Family of patrol submarine designs.

Development
The latest design to be developed by the Central Design Bureau Marine Engineering (Rubin) is the Lada (Project 677)/Amur (Project 1650) export variant. The design has been developed for introduction as a gradual replacement for the Kilo class. The Amur offers a family of six different designs ranging from 550 to 2,000 tonnes surface displacement.

The 'Lada' is apparently intended for use as a 'shop window' and is to be armed with 16 missiles (86R and Alfa or Oniks) and torpedoes (SET-80 or Shkval).

Description
Design

This fourth-generation SSK incorporates all new design technology and weapons. Compared to the Kilo, the Amur has reduced the noise factor still further by as much as 10 per cent of the Kilo. This has been achieved by stringent control of acoustic emission from equipment, double elastic mounting of all equipment and the use of anechoic cladding on the outer hull. The single hull design is divided into five watertight compartments: torpedo, missile storage and batteries; control room complex; accommodation, storage and batteries; diesel generator; and electric motor.

The design features fin-mounted hydroplanes and cruciform control surfaces aft. The hull is constructed of AB-2 steel which allows the boat a maximum diving depth of 250 m.

The design is fully tropicalised for operation in any part of the world.

Increased automation will result in a significant reduction in manning compared to the Kilo with a total of 34 working on a 2-shift watch or 41 on a 3-shift watch.

Weapons

The weapons payload of 18 weapons includes the latest types of Russian torpedo (SET-80 UGST), anti-submarine rocket torpedo (SS-N-15 Starfish), cruise missile (SS-N-27 Club S) and mines (PM-1, RM-2G). Torpedoes can be fired both singly and in salvoes of up to six weapons. An automatic torpedo loading system permits prompt reloading of torpedo tubes for subsequent firing within less than 20 seconds.

Sensors

Sensors include extremely sensitive passive transducer arrays that are much more effective as a result of the boat's very low noise signature. In addition to the hull-mounted sonars the boat can deploy a towed array streamed through the sail, as well as the usual intercept, obstacle avoidance, underwater telephones, noise monitoring sensors and velocity and range measurement systems that combine to make up the Lira multi-array sonar suite. The usual array of ESM, radar, non-hull-penetrating electro-optic search sensor and hull-penetrating attack periscope is fitted and the commander's periscope features, in addition to the normal viewing system, a night vision facility and a laser range-finder.

The main control room houses all the combat and platform management systems which interface through a common databus. The combat management system will be capable of tracking multiple targets simultaneously, providing concurrent fire-control data on a number while continuing to carry out TMA on others. The dual workstations of the combat management system interface to the weapon and countermeasures discharge systems on a separate weapons control bus.

Propulsion

Propulsion comprises a full electric propulsion system consisting of two diesel (2D-42 series) powered generators of a brushless type and a single permanent magnet electric motor developing 2,000 kW together with storage battery, driving a single shaft and skewed 7-bladed propeller. The batteries are incorporated in two main groups. The electric motor and diesels can be used simultaneously to achieve maximum propulsion speed. Power supply is in AC configuration. Provision has been made in the design to fit a 12 m section with fuel cell AIP system, should a customer require this. The vessel is managed through an integrated automation system controlling both propulsion and boat manoeuvring capabilities.

All machinery control and submarine attitude, together with damage control and general boat system management, is controlled either from a central console in the main control room or other control stations around the boat. Submarine attitude is controlled by sail-mounted hydroplanes and cruciform stern control surfaces.

Operational status
April 2004 - *St Petersburg*, a Lada for the Russian Navy, due to commence sea trials.

December 1997 - Work on two boats commenced.

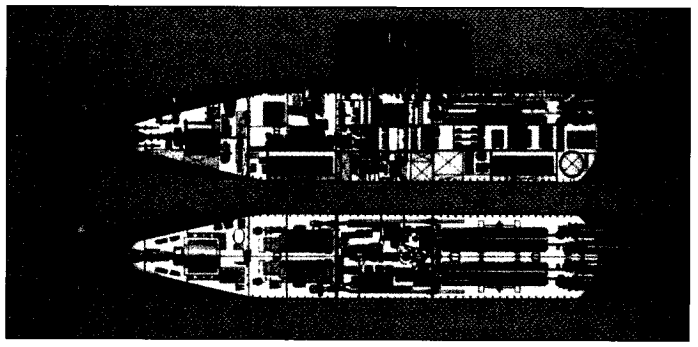
Work on the second Amur export version has been halted as no export customer has been forthcoming, but both India and China have shown interest in the design.

Specifications

	Lada
Displacement:	
surface:	1,765 t
submerged:	2,650 t
Dimensions:	
length:	68 m
beam:	7.2 m
draft:	4.4 m
Electronics:	
sonars:	Lira integrated suite
radar:	I-band
Weapons:	
torpedo tubes:	6 × 533 mm
torpedoes:	18 × SET 80 UGST
missile tubes:	none
missiles:	3M-54E1 Club S, SS-N-15 Starfish, SS-N-27
mines:	22 × PM-1/RM-2G in lieu of torpedoes
Machinery:	
diesels:	2 × 2D-42
power output:	2.5 MW
AIP:	Optional Kristal system
batteries:	2 groups
electric motor:	1
power output:	4.1 MW
shafts:	1
Speed:	
surfaced:	10 kt
submerged:	21 kt
Range:	
surfaced:	6,700 n miles @ 7 kt (schnorkel)
submerged:	650 n miles @ 3 kt
autonomy:	50 days
operating depth:	>250 m
Personnel:	34

Contractor
Admiralty Yard, St Petersburg.

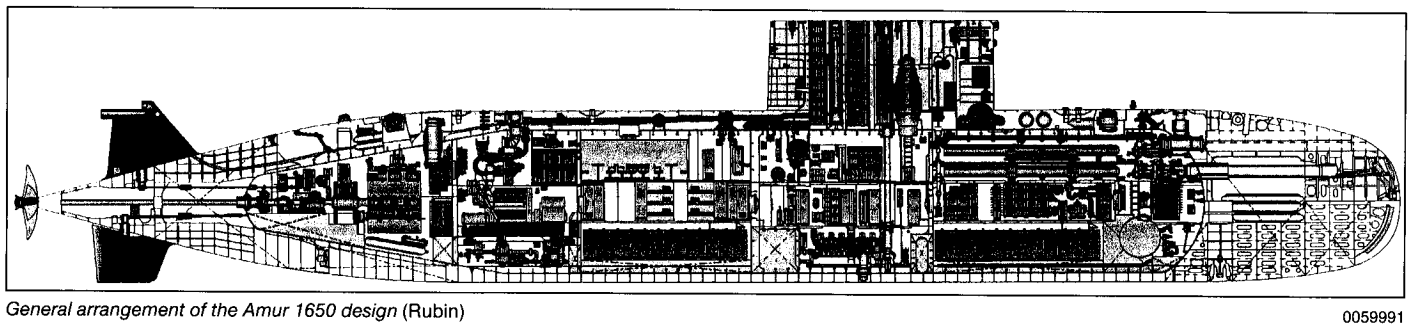
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General arrangement drawing of the Amur class (Anchor Consultancy) 0024688



A cutaway model of the Amur class Model 1650 variant seen at LIMA 99 at Langkawi, Malaysia (Josh Corless/Jane's) 0103962



General arrangement of the Amur 1650 design (Rubin) 0059991

Serbia and Montenegro

R-1

Type
Swimmer Delivery Vehicle (SDV).

Description
The R-1 is a single-seat underwater SDV designed for covert tasks such as reconnaissance, harbour protection, minefield surveillance and so on.

The monohull vehicle is built of aluminium alloy and comprises light bow and stern sections that can be flooded. The vehicle can be transported in a submarine torpedo tube and used in both freshwater and seas of specific gravity of 1.000 to 1.030 t/m³ without reserve updrift.

Navigation instruments are housed in a watertight container and comprise a gyromagnetic compass, sonar, echo-sounder, electric clock and other measuring systems.

Operational status
Four units are believed to remain in service with Yugoslav forces and one unit is operational in Croatia.

Specifications
Displacement:
- **surface:** 145 kg
- **submerged:** n/k

Dimensions:
- **length:** 3.72 m (oa)
- **beam:** 1.05 m (max)
- **height:** 0.76 m (max)
- **diameter:** 0.52 m (max)

Weapons:
- **payload:** 40 kg

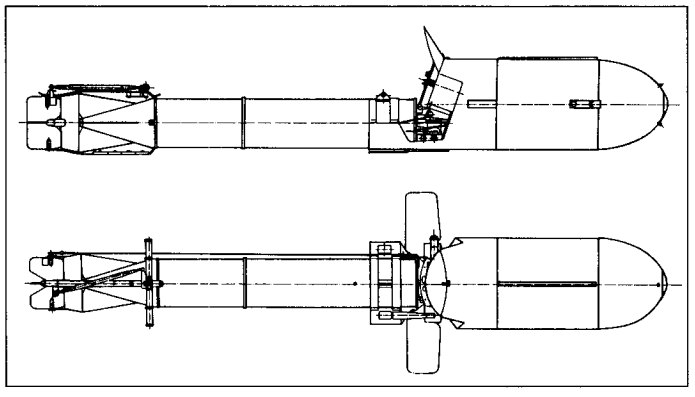
Machinery:
- **batteries:** 24 V silver-zinc
- **electric motor:** 1 × DC motor
- **power output:** 1 kW
- **shafts:** 1

Speed:
- **surfaced:** 3 kt (max), 2.5 kt (cruise)

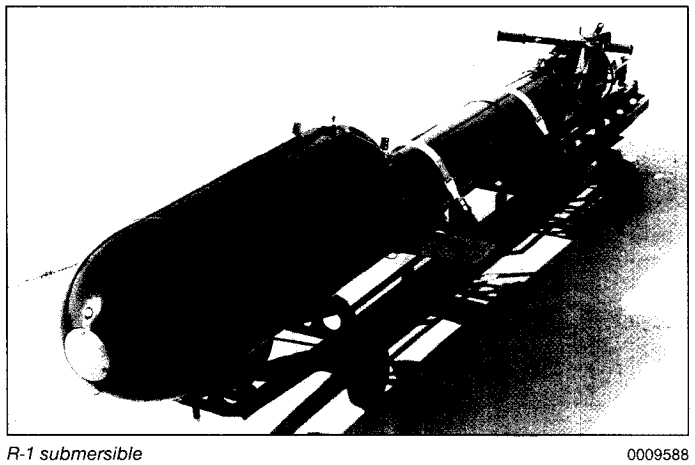
Range:
- **surfaced:** 6 n miles @ 3 kt, 8 n miles @ 2.5 kt
- **autonomy:** n/k
- **operating depth:** 60 m

Personnel: 1

Contractor
Brodosplit, Split. ***UPDATED***



Frogman submersible R-1



R-1 submersible 0009588

Sweden

Challenger class

Type
Diesel electric submarine.

Description
The Challenger class (the former Swedish Sjoormen (Sea Serpent) class) boats entered service with the Royal Swedish Navy in the 1960s. The single pressure hull design is subdivided into two watertight compartments on two decks. With this design (the first new generation design to follow on the existing Second World War designs) Kockums introduced a number of new technologies including a new hydrodynamic teardrop hull shape (based on the US Albacore hull), single operator manoeuvring system and the X-rudder configuration which allowed the submarine to perform very high speed evasive manoeuvres. With their teardrop hull (length: beam ratio 8:1), schnorkel system and X-rudder and stern planes and fore planes mounted on the sail, with new control system, these boats offered a totally new capability for manoeuvring and operating from a mainly submerged position rather than previous boats which operated mainly on the surface and merely dived to carry out an attack.

Another feature of these boats is the high degree of automation incorporated in the design that enabled the crew to be reduced to 28. However, this was at the expense of the displacement, resulting from the increased equipment required for automation.

The boats are powered by four Hedemora/Pielstick V12A diesels (2,200 hp) and an ASEA electric motor (1,500 hp) driving a single shaft with a five-bladed propeller for a submerged speed slightly in excess of 14 kt. Power for the electric motor is provided by a four-compartment battery section.

Armament comprises four 533 mm torpedo tubes for launching a maximum load of 10 wire-guided heavyweight torpedoes and two 400 mm torpedo tubes designed to launch four lightweight anti-submarine torpedoes. All tubes are fitted with a positive discharge or swim-out launch system.

The combat system features STN Atlas Elektronik CSU-83 sonar suite with a Thomson Marconi Sonar Hydra flank array and the UDS SUBTICS combat management system.

For operation with the Singapore Navy the boats are being tropicalised with air conditioning in place of the heating system and battery cooling, and with valves and piping replaced to allow them to operate in waters of high salinity and high levels of marine growth which collect on the hull of the submarine and accelerate corrosion.

The first boat, *Sjöbjörnen*, was acquired in 1996 and refitted to train submariners of the Singapore Navy. Renamed *Challenger*, she remains in Swedish waters to continue training. Another three boats were acquired in July 1997, with the fifth boat of the class, *Sjohasten*, being purchased for spares.

Operational status
All five boats have been withdrawn from service with the Swedish Navy, modernised and sold to Singapore the first being ordered in 1995 and extended to the entire class in 1997, the entire project being named Riken. The *Sjöbjörnen* (renamed *Challenger* for service in the Singapore Navy) was re-launched on 26 September 1997 following her refit. The *Sjoormen* and *Sjolejonet* were transferred in May 1999 and commenced refurbishment being renamed *Centurion* and *Conqueror*. The fourth boat commenced refurbishment in late 1999 and was launched and renamed RSS *Chieftain* on 22 May 2001 and commissioned on August 24 2002. The fifth boat *Sjohasten* is being used to provide spares for the other four boats. The Programme has been managed by the Singapore Defence Science and Technology Agency (DSTA).

Specifications

Displacement:	
surface:	1,130 t
submerged:	1,210 t
Dimensions:	
length:	51 m
beam:	6.1 m
draft:	5.8 m
Electronics:	
combat management system:	SUBTICS
sonars:	Hydra
radar:	Terma
Weapons:	
torpedo tubes:	4 × 533 mm bow, 2 × 400 mm
torpedoes:	10 × Type 613, 4 × Type 431
missile tubes:	None
missiles:	None
mines:	In lieu of torpedoes
Machinery:	
diesels:	2 × Hedemora-Pielstick V12A/A2/15
power output:	1.62 MW
AIP:	None
electric motor:	1 × ASEA
power output:	1.1 MW
nuclear plant:	None
auxiliary system:	None
shafts:	1

Speed:
surfaced: 12 kt
submerged: 20 kt
Range:
operating depth: 150 m
Personnel: 7 officers, 15 crew

Contractor
Kockums AB, Malmö.

UPDATED

Collins class

Type
Diesel-electric long-range patrol submarine.

Development
The Australian Navy initiated a replacement programme for the ageing Oberon class boats in 1981. Through an extensive tender review process encompassing the numerous available options, the Type 471 (later named Collins class) design was selected from Kockums Submarine Systems AB of Sweden. The Australian Submarine Corporation was formed in 1985 with Kockums being a major shareholder, and in June 1987 was awarded the contract to design and build six new Collins class.

The first of class, HMAS *Collins*, was launched on 28 August 1993, and after an extensive programme of Tests and Trials, was accepted and commissioned into the RAN on 27 July 1996.

Description
These large SSKs are designed for ocean patrol with an extended submerged (using snorkel) radius of action of 9,000 n miles at 10 kt.

One of the most important design areas in a submarine is noise and in particular the prevention of cavitation in the area of the propeller and around the hull. SSPA of Sweden has carried out detailed studies on the design to ensure that it features an extremely low noise signature. To ensure noise is maintained at a minimum level, all equipment is double-elastic mounted, which also provides for excellent shock absorption. In addition, to minimise detection by hostile sonars, the hull is coated with Australian designed and manufactured anechoic tiles. The propulsion system comprises three Hedemora VB210 18-cylinder 4-stroke turbocharged 1,475 kW diesel generators with a combined output of 4.425 MW, each diesel driving a Jeumont-Schneider 1,440 kW, 440 V DC generator. The main electric motor is a Jeumont-Schneider 5.4 MW water-cooled, double-armature 440 V DC shunt motor rated at 5,250 kW powering a single shaft with flexible coupling arrangement to drive a 4.2 m skew-back 7-bladed propeller. In an emergency the diesel generators can power the electric motor. The main storage batteries are essentially lead-acid cells manufactured and supplied by Pacific Marine Batteries at Osborne, South Australia. The batteries are contained within four main storage battery compartments of the submarine.

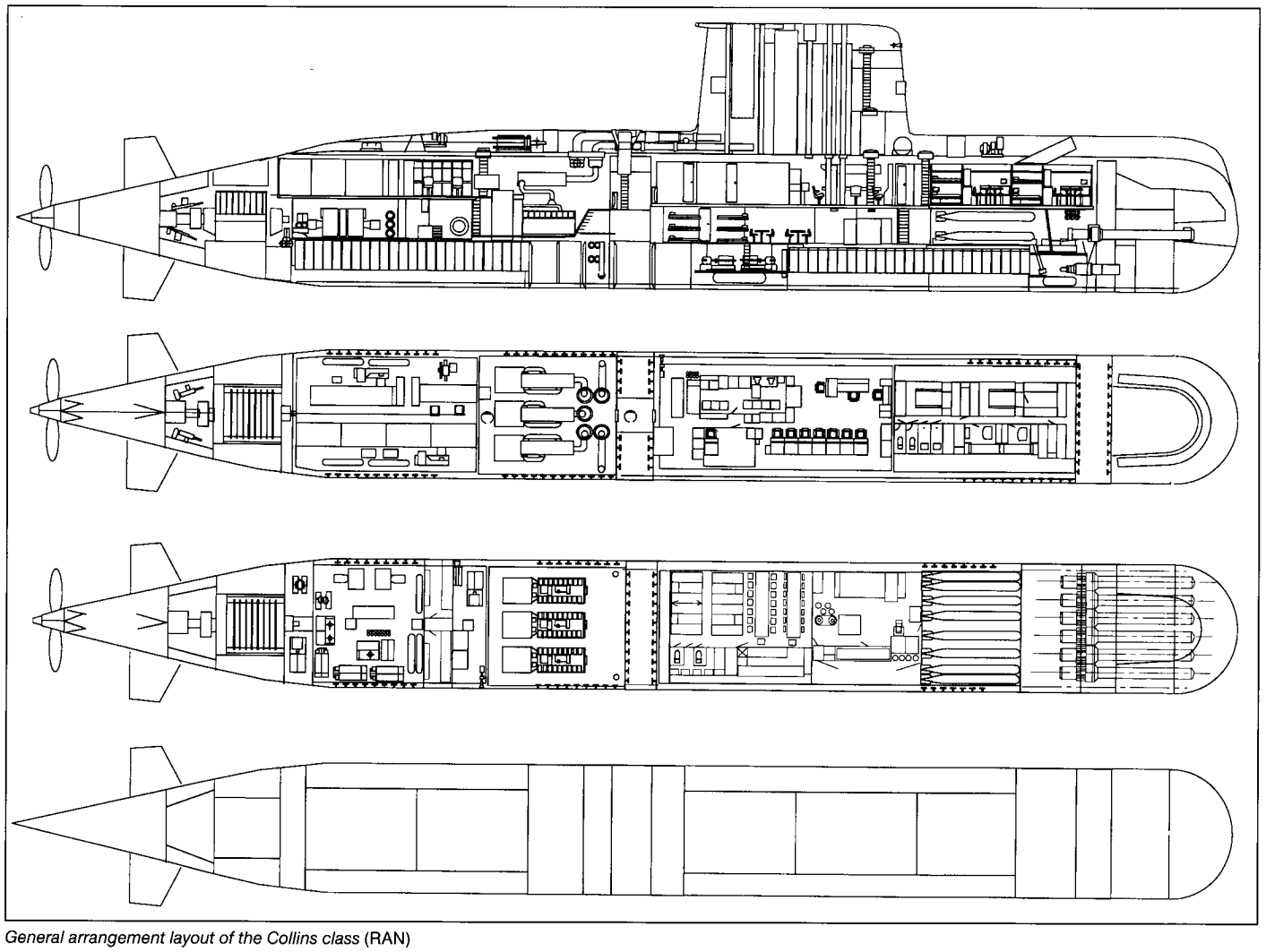
Maximum submerged speed is in excess of 20 kt. In addition, a McTaggart Scott DM 43006 retractable hydraulic motor is fitted for emergency propulsion. Later boats may be fitted with a Stirling AIP system but no definite decision has been made by the Australian government on the acquisition of such a system for the Collins class.

The tear drop single hull is built of BIS 690 high-tensile micro-alloy steel developed specially for the class. The hull consists of two continuous decks, while the fin houses attack and search periscopes, communications, radar and ESM masts, and the 'snort' induction mast.

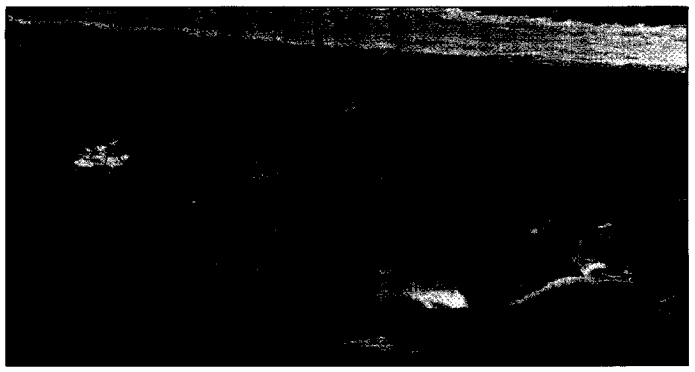
Armament comprises six bow torpedo tubes firing Mk 48 torpedoes or Sub-Harpoon missiles. A total of 22 weapons can be carried by each submarine. The torpedo tubes are arranged into three banks to port and three to starboard. Each bank of tubes is capable of independent operation in all respects because all discharge, control and operating equipment is duplicated. The discharge system, designed by Strachan & Henshaw (part of the Weir Group), uses the Air Turbine Pump (ATP) as its prime mover for the weapons. Strachan & Henshaw has also designed and built the Submarine Signal and Decoy Ejector (SSDE) for the Collins class, two of which are fitted. The SSDEs are capable of discharging a wide range of pyrotechnics, decoys, countermeasures and communications buoys over the full speed and depth range of the submarine. Other stores which can be ejected from the SSDE are expendable communication buoys, intelligence gathering probes, emergency signalling devices, flares and grenades. The SSDE is integrated within the submarine's combat system.

Fire control is exercised through a Loral Librascope weapons control system, with data derived from Thomson Marconi Scylla integrated sonar system (developed from the Eledone sonar system) and the Australian GEC-Marconi Systems Pty Ltd Kariwara retractable thin-line towed array for which McTaggart Scott of the UK is providing the towed array handling equipment. Later boats in the class may be fitted with the Thomson Marconi Narama retractable thin-line passive towed array. Other sonar sensors comprise the TSM 2253 LF passive flank array, TSM 2225 passive ranging array, intercept array and active and passive mine avoidance arrays.

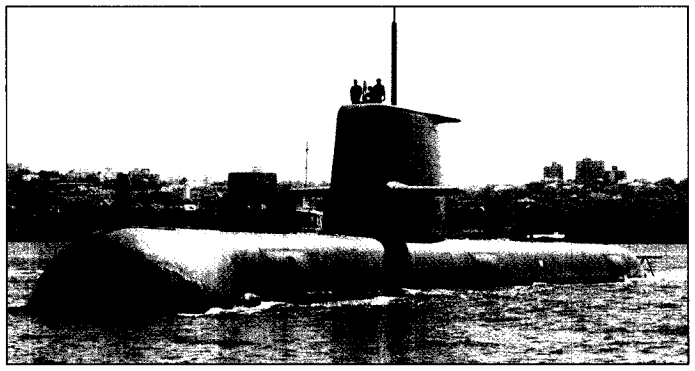
Rockwell Systems (now Raytheon Australia Pty Ltd) is responsible for the Combat System design, assembly, test, integration and support activities; while



General arrangement layout of the Collins class (RAN)



The leadship of the Collins class. The long tube at the stern is for dispensing the towed array (Australian Submarine Corporation)



HMAS Farncomb *will soon undergo refit to rectify some of the problems experienced with the Collins class* (van Ginderen Collection) 0079555

Computer Sciences of Australia is responsible for the design, development and integration of the system software.

The non-hull penetrating masts are being supplied by Riva Calzoni of Italy. The first search (CK 43) and attack (CH 93) periscopes were built in the UK by Pilkington Optronics, the remaining sets being manufactured in Australia. US EDO and British Aerospace Australia, together with Watkins Johnson of the USA and the Australian company Stanlite, are responsible for the development and manufacture of the EW system which will include the EDO AR 740 radar warning ESM system. The CH 93 periscope is to be replaced by a Pilkington CM010 optronic non-hull penetrating periscope.

The Integrated Ship Control, Management and Monitoring System (ISCMMS) is designed by Saab Instruments of Sweden and is based upon its SCC-200 steering control system. The system uses special and general purpose processors linked by a dual-redundant Ethernet databus. Manoeuvrability is exercised through four aft control surfaces arranged in an X-configuration, each individually actuated. Fin-mounted hydroplanes confer accurate depth keeping.

UK GEC-Marconi Radar & Control Systems, in conjunction with GEC-Marconi Australia, is supplying the degaussing system. Accommodation is to a high standard with each cabin having a maximum of six bunks for ratings, each with its own air conditioning and six-channel audio outlet. A single galley is centrally located to provide food service to the ratings, senior rates and officers' messes. Meals are forwarded to the respective messes via a food service lift.

In December 1997, an enhancement upgrade was approved which would enable the boats to support special forces missions. Under the enhancement, the boats' sails would be modified to provide improved storage and deployment facilities for insertion teams and provide an interface for SDVs which it is planned to acquire.

Following the discovery of a number of deficiencies with the lead ship *Collins* during acceptance trials and evaluation, the Australian government commissioned a report to investigate the project. The resulting Report presented in June 1999 recommended that a number of improvements be undertaken to remedy the deficiencies found.

The major challenge related to the US-designed SCCS Mk 2 combat system. An interim fix equipment allowed the system to effectively bypass deficient processing software areas allowing the sonar system to operate effectively as an independent system from the combat system as a whole. In September 2002, the Australian Government responded to the problem by indicating that it intended to adopt a variant of the US Raytheon CCS Mk 2 command and control system as the core of the replacement combat system for the Collins class. The system is being acquired through the US FMS system and an acceptance to this effect was signed on 19 June 2003, with a parallel contract award made to Raytheon to support the system installation.

Following from the Report, the Australian government in June 1999 approved a fast track upgrade for four of the Collins class *(Dechainaux, Sheean, Farncomb* and *Rankin)* to remedy a number of the deficiencies. These included enduring platform improvements and a critical augmentation of the existing combat system. The $266 m programme has resulted in significant improvements to the noise signature, diesel reliability and fixes, including a quieter propeller (which also addresses the fatigue problem), modified casing to reduce radiated and flow noise, improved platform systems, improved hydraulic components and replaced ESM. Further improvements have been made to the Scylla sonar system, with Thales Underwater Systems Pty providing Scylla Sonar Interface (SSI) and a new suite of data processors and sonar displays. The SSI displays and data processing are being integrated with the existing Scylla sonar array and processing suite. The whole system will be integrated with the CCS Mk 2 combat management system. The sonar will also be improved with a new high bandwidth data port functionality based on technology developed by the DSTO.

The modifications are so extensive that they can only be incorporated during build or scheduled refits.

The lead ship *Collins* had already received certain modifications before returning to service in July 2000. These included modifications to improve hydrodynamic performance and stealth capability. Anechoic coating was added to the hull and the sail configuration has been completely remodelled. New engine mountings were fitted to reduce vibration.

Apart from the modifications noted above, the Collins class will also receive the Mk 48 ADCAPa Mod 6 torpedo which will begin to enter operational service in the Australian Navy in December 2006.

To support the submarines the Australian Submarine Corporation has provided a Submarine Escape and Rescue Service (SERS) which is on call 24 hours a day throughout the entire year. The SERS comprises a remotely operated rescue vehicle which is fully integrated with transportable hyperbaric transfer and treatment chambers.

Operational status

All six boats have now been commissioned into service with the RAN.

Specifications

Displacement:	
surface:	3,051 t
submerged:	3,353 t
Dimensions:	
length:	77.8 m
beam:	7.8 m
draft:	7 m
Electronics:	
combat management system:	CCS Mk 2
sonars:	Scylla, Kariwara/Narama/TB23
periscopes	CK 043, CH 093
radar:	Type 1002
electronic warfare:	AR 740
Weapons:	
torpedo tubes:	6 × 533 mm
torpedoes:	22 × Mk 48 ADCAP
missile tubes:	none
missiles:	none
mines:	44 (in lieu of torpedoes)
Machinery:	
diesels:	3 × Hedemora/Garden Island V18B/14
power output:	4.42 MW
AIP:	none
electric motor:	1 × Jeumont Schneider
power output:	5.4 MW
nuclear plant:	none
auxiliary system:	1 × McTaggart Scott DM 43006 hydraulic motor
shafts:	1
Speed:	
surfaced:	10 kt
submerged:	20 kt
Range:	
surfaced:	11,500 n miles @ 10 kt
submerged:	400 n miles @ 4 kt
autonomy:	70 days
Personnel:	6 officers, 36 crew

Contractors

Australian Submarine Corporation, Outer Harbor, South Australia (manufacturers and prime contractor).
Kockums
Malmo (design authority).

UPDATED

Gotland class

Type

Diesel-electric patrol submarine with AIP.

Description

In 1997 Kockums completed building three Type A-19 Gotland class 1,400 tonne boats to replace the Sjoormen class boats built in the 1960s. The main roles envisaged for the Gotland boats are attack, surveillance, minelaying and ASW. Externally the single-hull Gotland is very similar to the Type A-17, but has improved performance in submerged endurance, and with increased stealth capability afforded by anechoic tiles that are fitted to the hull. All equipment is resiliently mounted and major platform decks and all equipment are carried on rubber

mountings to isolate them from the hull. The hull is divided into two watertight compartments separated by a tank section, which incorporates a one-man escape chamber accessible from both compartments. A DSRV or a rescue bell can be mated to the chamber. The forward compartment is divided into two decks, the lower deck housing the four 533 mm and two 400 mm bow torpedo tubes and associated weapon handling gear and reload racks. Beneath this compartment is the battery space and auxiliary machinery. The upper deckhouses the control room, accommodation and other equipment rooms associated with the sensors and communications. The aft compartment houses the diesel generator sets and more battery space, as well as auxiliary machinery and propulsion control equipment. This aft section also contains the AIP machinery and electric motor.

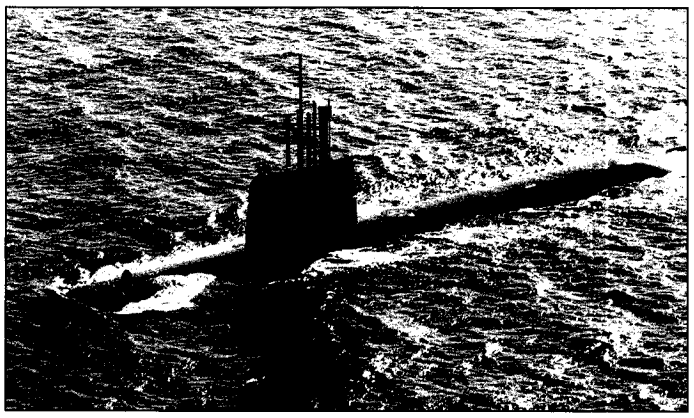
In the aft section are installed two Stirling V4-275R AIP Mk 2 systems developed by Kockums using LOX and diesel. The engines together develop about 150 kW under continuous run conditions. This enables the boats to carry out extended periods of submerged patrol, independent of snorkelling and to transit at slow to moderate speeds. Space is available for the addition of more Stirling engines at a future date should it be proved necessary that a high AIP transit speed is required. The liquid oxygen for the Stirling motors is stored in two double-skinned cylindrical tanks mounted to the bottom of the hull on rubber shock-absorbers and sited underneath the compartment housing the AIP machinery. Behind the Stirling engines is the electrical centre for controlling the batteries, and the boat's electrical requirements. The standard propulsion system comprises two MTU 16V 396 turbocharged diesels driving two Jeumont-Schneider alternators, with a 2MW Jeumont-Schneider electric motor. Battery power is provided by Varta lead-acid batteries. All machinery is controlled by two persons, a machinist and a motorman.

The aft control surfaces are arranged in an X-configuration, being individually and independently controlled. The forward control surfaces are mounted on a common shaft on the sail. Steering control is supervised and exercised through a Van Rietschoten & Houwens system single console system operating in automatic or manual mode.

Sensor capability is also improved compared to earlier classes, and comprises an ATLAS Elektronik CSU-90 integrated sonar system incorporating hull-mounted, cylindrical bow, LF flank, and intercept arrays and passive search and attack, and a Thales MANTA ESM system. Only one periscope is mounted. The periscope is the only mast that penetrates the hull. The Sesub 940 combat system is a derivative of the CelsiusTech 9LV Mk 3 based on a LAN configuration and using a series of intelligent nodes which provide access for various subsystems into the databus. The navigation radar is supplied by Terma.

The operations room is manned by a crew of six or seven with the integrated control and management system forward on the port side opposite the navigation console. Along the starboard side of the compartment are the consoles for the combat system and the sonars and fire-control system. The ESM console is aft on the port side with the periscopes centrally mounted.

The Gotland is designed to deploy the new Torpedo 2000, although pending entry into service of this weapon the boats will be able to deploy the Type 613. With its dual-torpedo capability, the Gotland class can deploy the 400 mm 43X2 torpedo from either the 400 mm tubes or the 533 mm tubes, the latter being able to house two 43X2 weapons in lieu of one Torpedo 2000. The tubes may also be used to lay mines, although Kockums has developed a mine pannier which can be strapped on to the side of the hull in a matter of hours. These panniers are capable of carrying up to 25 mines each.



Gotland *showing array of masts* 0024689

The Gotland class, originally designed to operate in cool Scandinavian waters, has been tropicalised with the fitting of a cooling arrangement comprising an inner closed system using cooling compressors fitted in series and an outer arrangement incorporating a heat exchanger to further dissipate the heat experienced in warm waters. The tropicalisation also involved re-ballasting the boats to enable them to operate safely in more salty waters such as the Mediterranean. Further modification involved increasing the amount of fuel carried to enable the boats to undertake much longer passages.

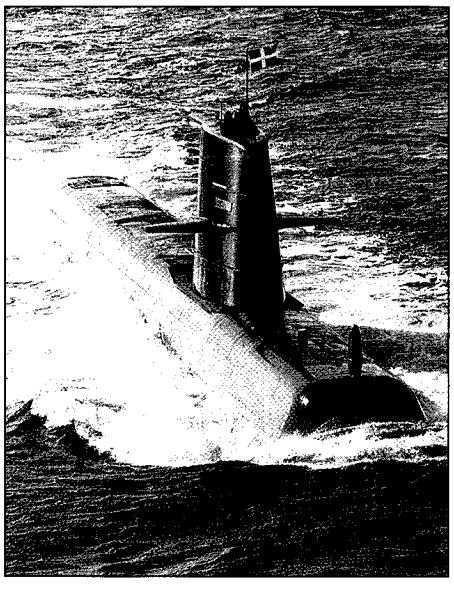
The class is to be fitted with new active sonars for mine detection and localisation, bottom navigation and localisation of subsurface and surface targets. The sonars will be capable of operating in both Mediterranean and Baltic waters.

Operational status

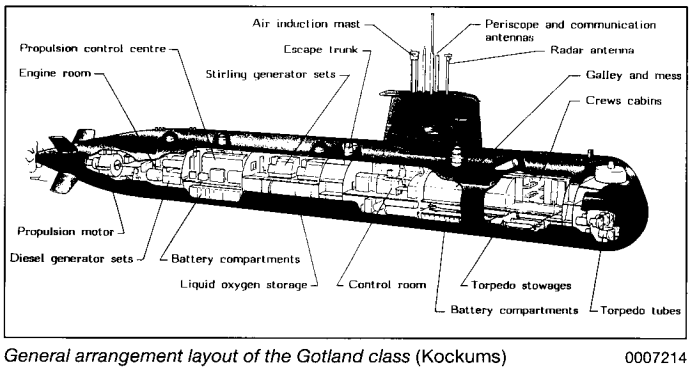
Three boats in service with the Swedish Navy.

Specifications

Class	**Gotland**
Displacement:	
surface:	1,384 t
submerged:	1,494 t
Dimensions	
length:	60.4 m
beam:	6.2 m
draft:	5.6 m
Electronics:	
combat management system:	IPS-19 (Sesub 940A)
sonars:	CSU 90-2 suite, PRS 3-15, FAS 3
periscopes	CKO38, Model 76
radar:	Scanter
electronic warfare:	Manta S ESM
Weapons:	
torpedo tubes:	4 × 533 mm, 2 × 400 mm
torpedoes:	12 × Type 613 or Type 62. 6 × Type 432
missile tubes:	none
missiles:	none
mines:	48 in girdle attached to outer hull, 12 swim-out type 47 in lieu of torpedoes
Machinery:	
diesels:	2 × MTU
AIP:	2 × V4-275R Stirling
power output:	150 kW
batteries:	Varta lead acid
electric motor:	1 × Jeumont-Schneider
nuclear plant:	None
auxiliary system:	None
propellers:	1 × LIPS 7-bladed
Speed:	
surfaced:	11 kt
submerged:	20 kt
Range:	
autonomy:	14 days
Personnel:	5 officers, 20 crew



Gotland at sea
(Kockums)
NEW/1107975



General arrangement layout of the Gotland class (Kockums) 0007214

Contractor

Kockums AB, Malmö.

UPDATED

Västergötland class

Type
Diesel-electric patrol submarine.

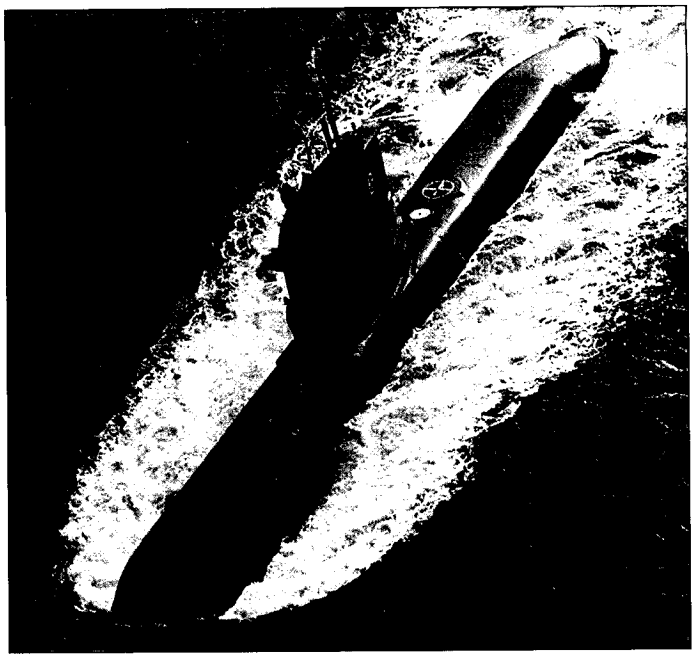
Description
The four Västergötland A-17 boats built by Kockums for the Swedish Navy have been designed to carry out a variety of roles to provide defence against invasion. Among the missions envisaged for the boats are attack, mining, surveillance, anti-submarine and interjection of Special Forces.

The two-deck single-hull design features two watertight compartments divided by a centre watertight bulkhead. The pressure hull is of circular cross-section ending in truncated cones. Fore and aft the hull extends into ballast tanks. The forward compartment houses accommodation, stores, communications room and control room on the upper level, with weapons handling and nine torpedo tubes (six conventional 533 mm with 12 torpedoes and three 400 mm tubes with six weapons), forward battery section and auxiliary machinery on the lower deck. Immediately aft of the watertight bulkhead is a cylindrical tank section with a passage aft and an escape lock, which connects to a rescue vehicle or bell. The after section houses the electrical control centre with the aft battery section, diesel generators and propulsion motor on the deck below. Manoeuvrability is exercised through an X-configuration rudder/after hydroplane design.

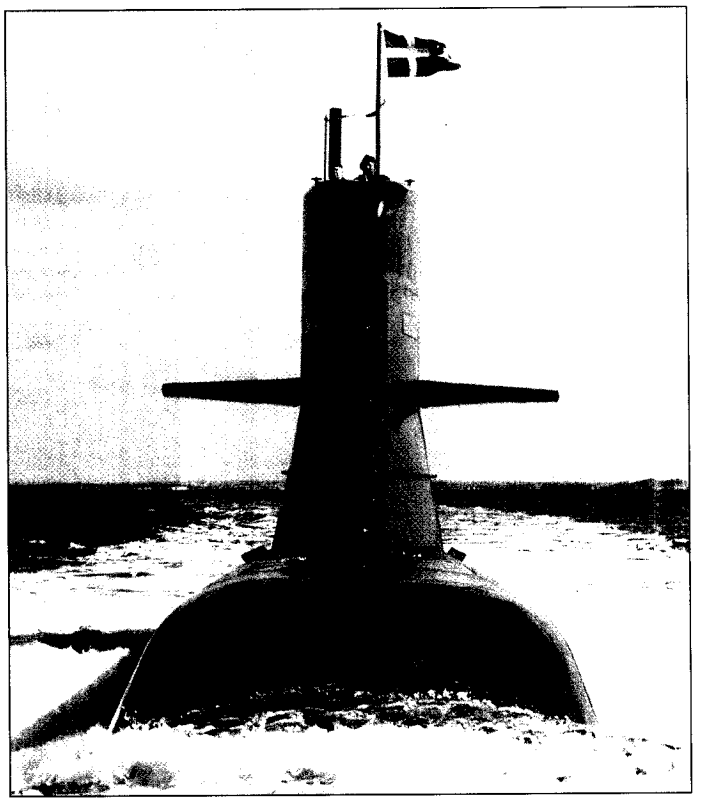
The boat carries a comprehensive range of sensors including periscopes, Terma radar, the American Condor Systems AR-700-S5 ESM, and a wide range of ATLAS Elektronik sonars, including the CSU-83. Sonar arrays are mounted on and under the casing. The boats are equipped with an Ericsson IPS-17 weapons control system developed from the NIBS system fitted in the Näcken class.

The resiliently mounted propulsion motor is a Jeumont-Schneider water-cooled, single-armature 1.32 MW DC motor. Lead-acid storage batteries developed by Tudor provide electrical power, charging being accomplished with Jeumont-Schneider alternators with built-in rectifiers. The alternators are powered by two Hedemora V12A/15 turbocharged diesels. All equipment is resiliently mounted on steel springs or rubber mounts, and the complete control room is placed on rubber mounts permitting a simple mounting of units directly on to the platform.

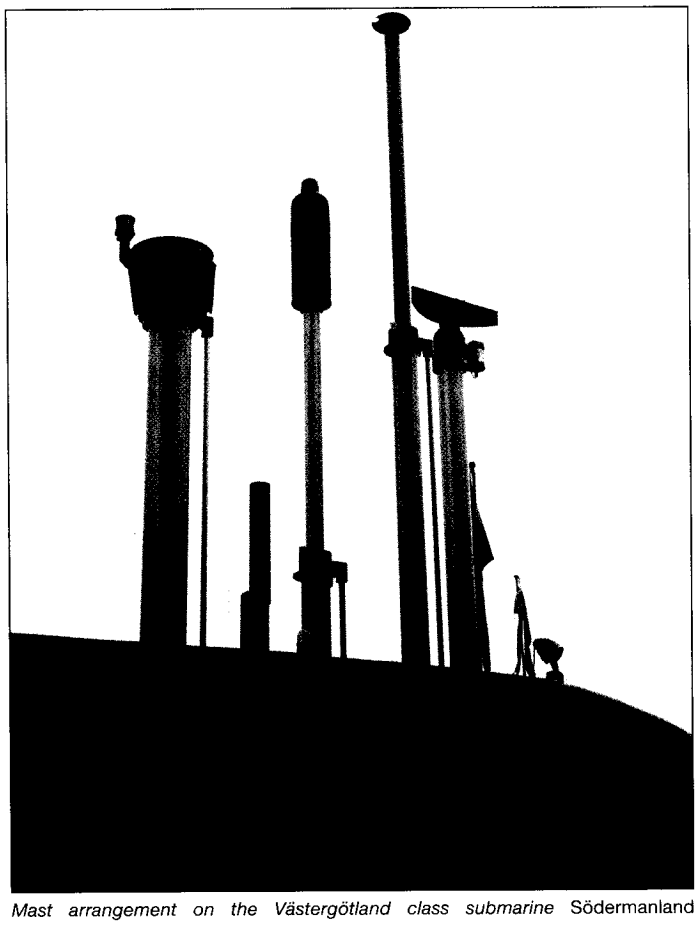
In 1997 Kockums received an order from the Swedish FMV (Defense Materiel Administration) for the modernisation of two Västergötland class submarines. The order comprised the fitting of a Mk 3 Stirling AIP system which would considerably extend the submerged radius of the submarines. The installation of the system will significantly increase the operational and tactical capability of the two boats. The upgrade is also designed to increase the boats' operational efficiency in warmer waters, thus improving the Swedish Navy's capability to participate in international peacekeeping missions. For this the boats have been fitted with a climate control section incorporating cooling equipment featuring freon compressors. The boats to be modified are the *Östergötland* and *Södermanland*. The general layout of the AIP section is similar to that in the Gotland class. The compact arrangement of the Mk III Stirling allows the modules to mounted athwartships in the submarine. This offers improved access for onboard maintenance as the module is accessible from



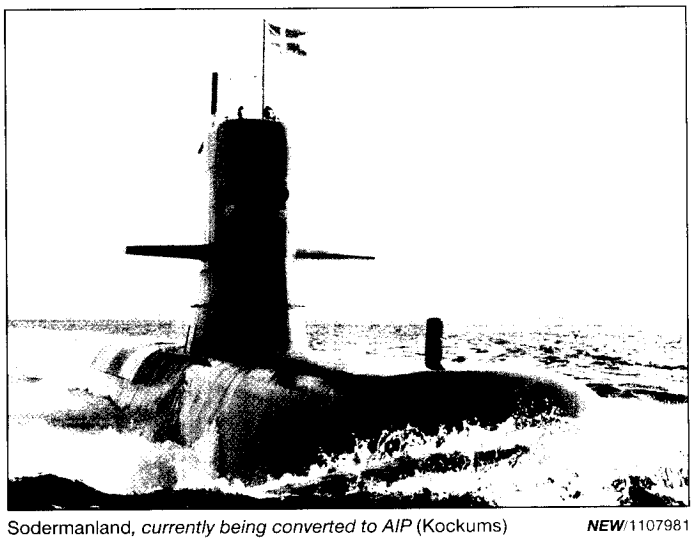
The Östergötland, *fourth unit of the Västergötland class* (H&L van Ginderen)



Bow view of Västergötland *showing sail-mounted hydroplanes and intercept sonar array housing* (Courtesy of Kockums) 0024690



Mast arrangement on the Västergötland class submarine Södermanland *September 1999* (Anchor Consultancy) 0064615



Sodermanland, *currently being converted to AIP* (Kockums) ***NEW***/1107981

three sides. The two Stirling modules are mounted on a floating platform on the upper level and provide an output power of 25 to 140 kW. The LOX tanks are housed in the lower level with two tanks – a fuel tank and a compensating tank. Production of the engines began in the Summer of 2000 and delivery was completed in 2004. To fit the Stirling system the boats have been divided in the middle and the new machinery section inserted increasing their length by about 12 m. Displacement will be increased by about 400 t.

The two AIP modified boats will also receive new active sonars for mine detection and localisation, bottom navigation and localisation of subsurface and surface targets. The sonars will be capable of operating in both Mediterranean and Baltic waters.

The Thales Optronics CK038 periscope, which equips the Västergötland class, is being upgraded with a thermal imaging camera and an improved image intensifier.

Operational status
Four boats in service with the Swedish Navy. The modernised *Södermanland* was re-launched in November 2003.

Specifications

	Västergötland	AIP boats
Displacement:		
surface:	1,070 t	
submerged:	1,143 t	
Dimensions:		
length:	48.5 m	58.5 m
beam:	6.1 m	6.1 m
draft:	5.6 m	5.6 m
Electronics:		
combat management system:	IPS-17 (Sesub 900A)	IPS-17 (Sesub 900A)
sonars:	CSU-83, FAS-3	CSU-83, FAS-3
periscopes	CK 038	CK 038
radar:	Terma	Terma
electronic warfare:	EDO 700-S5/900A	EDO CS 3701
Weapons:		
torpedo tubes:	6 × 533 mm, 3 × 400 mm	6 × 533 mm, 3 × 400 mm
torpedoes:	12 × Tp 613, 6 × Type 431/451	12 × Tp 613, 6 × Type 431/451
mines:	12 × Type 47 (in lieu of torpedoes)	12 × Type 47 (in lieu of torpedoes)
Machinery:		
diesels:	2 × Hedemora V12A/15	2 × Hedemora V12A/15
power output:	1.62 MW	1.62 MW
AIP:	None	2 × Stirling Mk III
power output:		140 kW
batteries:	2 × Tudor 84 cell	2 × Tudor 84 cell
electric motor:	1 × Jeumont Schneider	1 × Jeumont Schneider
power output:	1.32 MW	1.32 MW
shafts:	1	1
Speed:		
surfaced:	10 kt	10 kt
submerged:	20 kt	20 kt
Range:		
autonomy:	45 days	
operating depth:	300 m	300 m
Personnel:	5 officers, 22 crew	5 officers, 22 crew

Contractor
Kockums AB, Malmö.

UPDATED

United Arab Emirates

Class 4/5

Type
Swimmer delivery vehicles.

Development
Originally designed in 1994 by Eurotec Industries under a research and development contract from the UAE MoD, the prototypes were first trialled in 1996 and first entered service about 1998. Eurotec now forms the manufacturing arm of United Emirates Technologies.

Description
Referred to as LRSC (Long-Range Submersible Carriers), these vehicles are constructed of nine layers of GRP and carbon composite some 80 mm thick. Acoustic and magnetic signatures have been reduced to a minimum.

The craft are extensively outfitted with sensors and navigation systems including a 150 m range sonar, 30 m range echo-sounder, GPS, electronic compass and electronic mapping facility, and an onboard computer. In addition, the Class 5 craft is fitted with an autopilot. The craft are powered by an 8 kW Alstom/Parvex electric motor powered by silver zinc (Class 4) and nickel cadmium (Class 5) batteries to give a cruising speed of 6 kt and a maximum speed of 7 kt. The batteries are mounted externally in containers on either side of the lower hull to provide stability and a quick change round capability. At cruising speed the craft have a range of 60 n miles and can dive to a depth of 50 m. The craft are manned by a crew of two, the pilot in a forward position and the navigator behind in separate cockpits with quick release canopies. With an endurance of 6 hours, the craft are equipped with two BIBS (Built-In Breathing System) with variable rate mixtures of oxygen and nitrogen stored in two 6.8 litre capacity cylinders. A permanent pressure reading system and manual connection allows the divers to configure the breathing circuits according to their requirements, alternating between their individual rebreather sets and the onboard system.

Operational status
Some 10 Class 4 vehicles have been in service with the UAE Special Forces since 1998, and two other GCC nations are said to have entered into contracts for an unknown number of similar systems. The craft were first seen in public at the IDEX Exhibition at Abu Dhabi in March 2001.

Specifications

	Class 4	Class 5
Displacement:		
surface:	3 t	8 t
submerged:	n/k	n/k
Dimensions:		
length:	7.35 m	9.1 m
beam:	0.95 m	1.15 m
draft:	n/k	n/k
Weapons:		
payload:	200 kg	450 kg
Machinery:		
batteries:	n/k	n/k
electric motor:	1 × n/k	1 × n/k
power output:	n/k	n/k
shafts:	1	1
Speed:		
surfaced:	6 kt (cruise), 7 kt (max)	6 kt (cruise), 7 kt (max)
submerged:	n/k	n/k
Range:		
surfaced:	60 n miles @ 6 kt	60 n miles @ 6 kt
submerged:	n/k	n/k
autonomy:	6 h	6 h
operating depth:	50 m	50 m

Contractor
Emirates Marine Technologies, Abu Dhabi.

UPDATED

United Kingdom

Astute class

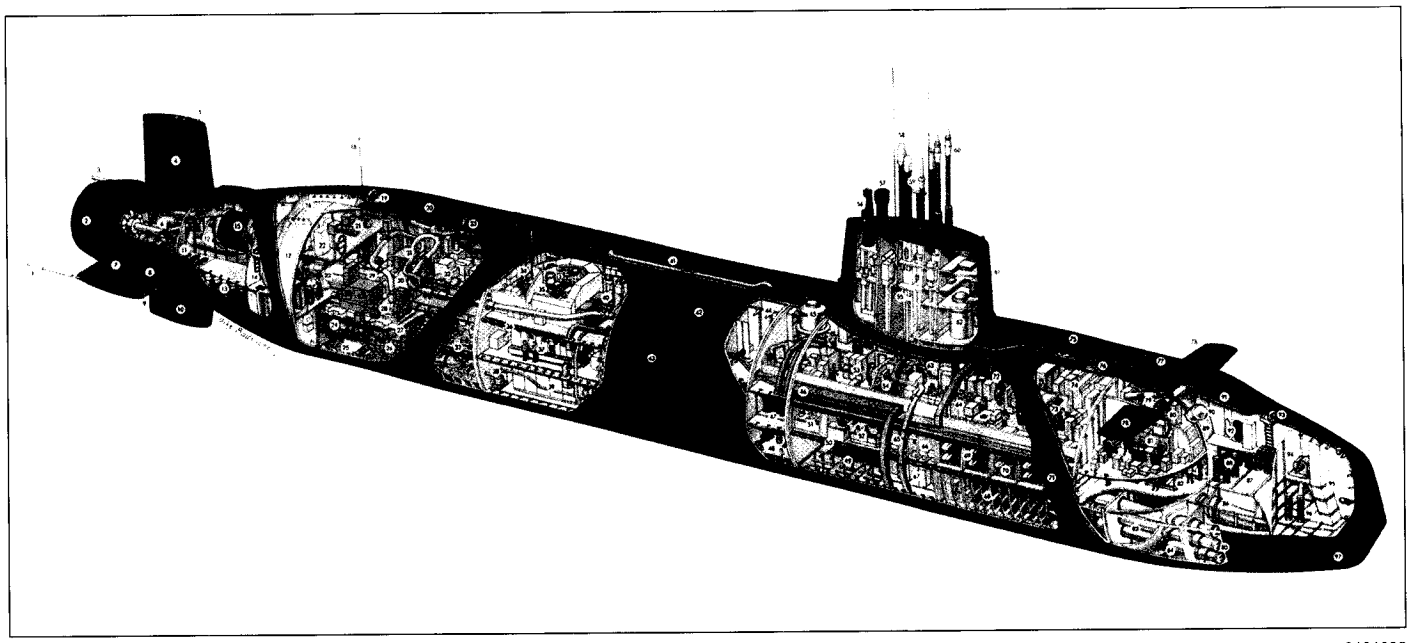
Type
Nuclear powered attack submarine.

Development
The Astute class for the Royal Navy is being developed to replace the Swiftsure class SSNs which, in spite of a major update programme, will reach the end of their life around 2005-2010.

The original Target Cost Incentive Fee (TCIF) contract for the Astute class was awarded in 1997 to BAE Systems as prime contractor and design authority. However, in July 2002 BAE Systems revealed an 18-month slippage in the programme as a result of design, engineering and programme management problems leading to substantial cost and schedule overruns. Work on *Astute* and *Ambush* was then suspended pending a review of the transition phase from design to production. However, on examination, the extent of the problems was seen to be more serious than at first thought. BAE Systems and the UK Defence Procurement Agency entered into extensive discussions to resolve the problems, which resulted in a revision of the original TCIF with anticipated increase in cost to completion and a delay in entry into service of first of class *Astute* until 2008. BAE Systems and the MoD finally agreed to share any overruns above the target cost up to a maximum ceiling level established from the discussions.

Description
The basic design, with similar dimensions will be an evolution of the existing 'Trafalgar' class, but with modified forward part of the hull, will offer an enhanced performance with increased weapon payload and reduced radiated noise signature. The fin will be slightly longer, housing non-hull penetrating masts while the hull diameter will be increased to provide space for the new nuclear reactor system.

The interior will be redesigned to provide crew accommodation to the latest standards. In parallel with the construction of the Astute class the MoD is also



Artist's cutaway of the 'Astute' class SSN (Courtesy Navy News/Mike Badrocke 2001)

0131092

(1) Clip-on TAS outlet
(2) Shrouded propulsor
(3) Installed TAS outlet
(4) Upper rudder segment
(5) Aft rudder light
(6) Rudder and hydroplane hydraulic actuators
(7) Starboard hydroplane
(8) Horizontal stabiliser
(9) Circulating water inlet, condenser cooling
(10) Lower rudder segment
(11) No 4 main ballast tank
(12) Propeller shaft
(13) High pressure air bottles
(14) No 3 main ballast tank
(15) TAS cable drum and winch
(16) Main ballast vent system
(17) Aft pressure dome
(18) Ensign staff
(19) Hinged fairlead
(20) Hinged bollards
(21) Air treatment units
(22) Naval stores
(23) Propeller shaft thrust block and bearing
(24) Circulating water transfer pipes
(25) Lubricating oil tank
(26) Starboard condenser
(27) Main machinery mounting raft
(28) Turbo generators, port and starboard
(29) Combining gearbox
(30) Main turbines
(31) Steam delivery ducting
(32) Aft equipment compartment
(33) Aft capstan
(34) Typical watertight bulkhead
(35) Manoeuvring room citadel
(36) Manoeuvring room isolated deck mounting
(37) Switch room
(38) Diesel generator room
(39) Static converters
(40) Main steam valve
(41) Hinged bollards
(42) Part of pressure hull
(43) Reactor section
(44) Forward airlock
(45) Control room hatch
(46) Conditioned air ducting
(47) Air handling compartment
(48) Waste management equipment
(49) Batteries
(50) Forward section isolated deck mountings
(51) Galley
(52) Junior ratings' mess
(53) Office
(54) Commanding Officer's cabin
(55) Mast hydraulic actuators
(56) Diesel exhaust
(57) Snort induction mast
(58) Communications masts
(59) Radar antenna
(60) Optronic masts
(61) Sonar panel
(62) Conning tower access
(63) Port side communications office
(64) Control room consoles
(65) Junior ratings' bathroom
(66) Senior ratings' bathroom
(67) Battery switchroom
(68) Weapons stowage and handling compartment
(69) Senior ratings' bunks
(70) Medical berth
(71) Flank array sonar
(72) Sonar operators' consoles
(73) Maintenance workshop
(74) Sonar equipment room
(75) Intercept sonar
(76) Forward hinged capstan
(77) Hinged bollards
(78) Forward hydroplanes
(79) Hydroplane hydraulic actuator
(80) Hydroplane hinge mounting
(81) Ship's office
(82) Junior ratings' berths
(83) Torpedo tubes
(84) Water transfer tank
(85) Torpedo tube bow caps
(86) Air turbine pump
(87) No 2 main ballast tank
(88) High pressure air bottles
(89) Forward pressure dome
(90) Weapons embarkation hatch
(91) Hinged casing plates
(92) Gemini craft stowage
(93) Hinged fairlead
(94) Anchor windlass
(95) No 1 main ballast tank
(96) Anchor cable locker
(97) Bow sonar

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procuring the Astute Class Training Service (ACTS) with the preferred bidder being the FAST Consortium a 50:50 owned group comprising CAE of Canada and Alenia Marconi Systems. The simulators and classrooms will be housed in a new complex to be built in Scotland.

Propulsion

The boats will be powered by a larger PWR 2 pressurised water-cooled reactor equipped with the new Core H powering two Alsthom turbines driving a single shaft with a pump-jet propulsor supplied by Rolls Royce. The reactor was originally developed for the 'Vanguard' class SSBNs and also equips the Batch II boats of the 'Trafalgar' class. It is planned that the new reactor core will last the lifetime of the boat. In addition the boats will be fitted with two diesel alternators, an emergency drive motor and an auxiliary, retractable propeller.

The boats will be fitted with an emergency propulsion system supplied by Ultra Electronics' subsidiary Power Magnetics and Electronics Systems Ltd. This system, which replaces the DC motor drive system installed in previous SSNs, is an AC variable speed induction motor drive system using insulated gate bipolar transistor technology to provide a back-up to the steam-driven, geared, turbine propulsion system. Rolls-Royce will supply three sets of turbo-generators for each vessel to provide the boats' electrical power for sensors, services and weapons systems. The design will enhance the features of the current systems in service aboard the Vanguard class SSBNs. The main coolant pumps for the propulsion system are being supplied by ALSTEC Ltd.

The boats will be driven by a new generation pump-jet propulsor designed and developed by an industrial team led by Rolls-Royce. The new pump-jet is designed to achieve improved efficiency and significant signature reduction compared to the previous pump-jet propulsors used by the Royal Navy. In addition the new propulsor is designed to achieve a major improvement in corrosion resistance offering a 25-year life compared to the current two years, a weight reduction of 11 tonnes, and major improvement in shock capability. The new propulsor is being delivered fully assembled to the shipbuilder. The propulsor is of a completely new composite duct designed as a single unit with full longitudinal ribs for shock strength and manoeuvring rigidity with the outer skin of sandwich construction to meet stringent signature requirements.

Power Magnetics and Electronics Systems Ltd are also supplying the centralised control console and starting platform console. The centralised control console remotely controls the boats' electrical generation and distribution, propulsion and reactor systems in normal, abnormal and emergency situations. The starting platform console provides indication and control of the propulsion systems. Power Magnetics and Electronics Systems are supplying the consoles to CAE Electronics Ltd of Canada who are providing the controls and instrumentation.

Electronics

The combat information and weapon control system will be AMS Ltd Integrated Systems Division ACMS tactical data handling system using Ultra Electronics combat management system operator consoles with flat panel display technology that is currently being back fitted to the Trafalgar class boats.

The sensor suite will include two optronic non-hull penetrating CM010 systems from Thales Optronics rather than conventional periscope systems and I-band navigation radar. The optronic systems will present information on flat panel display consoles to be supplied by Ultra Electronics Information and Sea Systems Division. Initial delivery began in late 2001. The sonar suite will be the Type 2076 developed for the Trafalgar class Update programme. Indal Technologies of Canada will supply the towed array handling and recovery system, the first unit of which is due for delivery in 2006. Northrop Grumman Corporation's Sperry Marine unit will supply the inertial navigation systems for the boats. Each submarine will be fitted with dual enhanced NATO SINS based on Sperry's ring laser gyro technology. Initial units started to be delivered in late 2002. The core of the navigation system is the Own Ship Data Distribution System (OSDDS) featuring a dual redundant architecture and embracing the functionality of the system currently operational in the Swiftsure and Trafalgar classes. The analogue retransmission units of the synchro/resolver systems is being replaced by digital units.

L-3 Communications of the US is to supply the Internal Communications Systems (ICS), which will be similar to one that is being provided for the Virginia class SSN. The ICS will be built around a distributed switching network and audio-user terminals to provide all internal communications: intercom, broadcast, alarms, sound-powered telephone network, and wireless communications. The system will also provide the interfaces required to network with shore-based communications system, sonar communications and the boats' entertainment system.

Weapons

Weapons will include the Tomahawk Block III missile (which does not require a vertical launch tube system) and Sub Harpoon (although the latter is scheduled to be retired from service by the end of 2005) in addition to a mix of Spearfish and Tigerfish torpedoes. Weapons will be launched from six 533 mm torpedo tubes using an air turbine pump system from Strachan & Henshaw instead of a torpedo water ram discharge system, and a total of 38 weapons will be carried. The weapon handling system is being developed from the system fitted in the Vanguard class SSBNs. Countermeasures will include decoys (both active and passive) as well as the UAP 4 ESM system. The boats will also be fitted with a Dry Dock Shelter for Special Forces' operations.

Operational status

2008 – Final revised *Astute* in-service date
December 2006 – *Astute* revised in-service date.
June 2005 – original in-service date for *Astute*.
22 October 2003 – keel for second boat, *Ambush*, laid
June 2003 – Deliveries of propulsor scheduled to commence.
September 1999 – First steel cut for forward dome of the pressure hull.
17 March 1997 – BAE Systems wins £1.9 billion contract for 3 boats.

Manufacture of the gearbox and elements of the nuclear steam raising plant have begun. To date, five three-deck high sections forming the reactor area have been completed and are being joined together. The first three boats will be named *Astute*, *Ambush* and *Artful* and an option on two more boats has recently been confirmed.

The government is now studying the possibility of extending the two boat option to three boats to capitalise on the factor of whole life cost savings instead of the cost of refuelling a Trafalgar class boat.

Specifications

Displacement:	
surface:	6,500 t
submerged:	7,200 t
Dimensions:	
length:	97 m
beam:	10.7 m
draft:	10 m
Electronics:	
combat management system:	SMCS
sonars:	Type 2076
periscopes	2 × CM 010
radar:	I-band
electronic warfare:	UAP 4
Weapons:	
torpedo tubes:	6 × 533 mm
torpedoes:	38 Spearfish
missile tubes:	None
missiles:	Sub-Harpoon, Tomahawk
mines:	in lieu of torpedoes
other	DDS
Machinery:	
diesels:	None
AIP:	None
batteries:	None
electric motor:	None
nuclear plant:	1 × Rolls Royce PWR-2
turbines	2 × Alsthom
auxiliary system:	2 × electric motors
shafts:	1
Speed:	
submerged:	29 kt
Range:	
operating depth:	>300 m
Personnel:	12 officers, 86 crew plus 12 spare positions

Contractor

BAE Systems Marine Ltd, Barrow-in-Furness, Cumbria.

UPDATED

Maritime Underwater Future Capability (MUFC)

Type

Range of concepts for underwater sea control and denial, including submarines.

Development

The total MUFC project will look at a range of future capabilities required by the UK for the control and denial of the underwater battlespace in the third and fourth decades of the century. A range of concepts involving innovative solutions will be studied which will combine UUVs, surface and airborne platforms, land systems as well as submarines.

Conceptual studies are already under way to define the outline specification for the Royal Navy's future attack submarine designed to replace the Trafalgar class SSNs when they begin to be phased out of service around the time scale 2015-2020.

A range of concepts involving advanced new technologies is under investigation for this new class which it is intended will follow on from the five planned Astute class boats, the first of which is scheduled to enter service around 2005.

Under the concept studies, 10 separate options are under investigation, seven of which relate to nuclear-powered vessels ranging in size from 5,000 to 8,000 t submerged displacement.

These nuclear-powered concepts will be centred on the existing PWR2 reactor and the new Core H that is designed to power the submarine for its entire life without the need for refuelling. Currently, nuclear-powered boats need to have their reactor cores replaced during lengthy refuellings carried out during refit.

The remaining three concepts cover conventionally powered submarines, the studies of which are designed to monitor the progress of developing non-nuclear technologies and capabilities, including AIP systems.

All ten concepts will be assessed against the staff requirement before the next step in the development phase is undertaken by the Navy.

Part of the requirement is to contain and force down the cost of building, running and supporting any future submarine, while refocusing the capabilities of the vessel to meet the new operational environment laid out in the Strategic Defence Review.

Among the new technologies being studied for a future submarine are:

- A nuclear-powered integrated full electric propulsion (IFEP) plant
- New vertical launch systems for cruise missiles
- 'Fly-by-wire' control via an integrated platform management system
- The capability to carry and deploy unmanned underwater vehicles (UUVs) equipped with their own sonars for reconnaissance
- A novel pentaform or X-form stern control surface to enhance manoeuvrability.

The IFEP technology involves using the nuclear steam generating plant to drive generators to power electric motors to propel the submarine, rather than the existing system in which geared steam turbines are used to turn the propeller shaft. IFEP would offer a much quieter and stealthier capability than the geared steam turbine arrangement.

The submarine will also feature advanced multirole capabilities that will be developed with the requirements of littoral warfare in mind.

Operational status

Development commenced in 1999 and conceptual studies are in hand. Scheduled to enter service from around 2017.

Contractor

Defence Procurement Agency.

VERIFIED

SSGT

Type

Gas turbine powered submarine.

Development

Technology

The SSGT has been designed by British Maritime Technology (BMT) in consultation with Rolls-Royce in the UK to provide a submarine with the mobility of the SSN whilst retaining all the advantages of the SSK, but with greatly improved characteristics such as higher speed and longer range (the SSK is energy limited and exhibits a characteristic low transit speed as a result). The revolutionary design is based on a composite propulsion system incorporating gas turbine technology, which would offer speeds in excess of 30 kt for short sprint tasks, combined with a range of 6,000 n miles at speeds of 20 kt. It is claimed that such a design would offer a much better acoustic discretion (stealth) rate than a nuclear powered boat, which is forced to use pump machinery continuously for cooling for the reactor.

The concept design was based on the need for current submarines to operate out of area in littoral regions in the face of modern high-tech threats which demands the deployment of superior sensors to the enemy, combined with very low signatures and be capable of undertaking long duration operations in theatre. Such ideas lead to the conclusion that in many cases long transit will be required to be made in waters where the boat will not be subject to serious or continued threats. In this case it would be feasible to compromise on stealth to achieve the optimum air breathing capability combined with the most cost and energy effective fuel and to exploit this potential by using the most compact air breathing power generation solution for partial offset of the large fuel load that would be required together with the air independent plant. Flexibility in speed and endurance between transit and operations on stations leads to the adoption of common fuels and equipments for power generation and propulsion in all modes of operation.

The boat is highly automated with an all-electric architecture and all systems are fully integrated making the concept a highly capable, cost effective and environmentally sound project.

The pressure hull is conventional in construction and rated to a depth in excess of 250 m. The fore and aft sections are finely tapered occupying some 85 per cent of the total length of the boat. The pressure hull is divided into three main compartments:

- The forward compartment housing the weapons stowage and discharge systems
- The main compartment arranged on three decks and housing the command and control, accommodation and services
- and the aft compartment housing LOX stowage, power generation and conversion and propulsion systems.

The hull form is a modified saddle tank arrangement with a very narrow casing on top and a tall wave piercing fin (about 140 m^3 in volume most of which is filled with syntactic foam of which around 15 m^3 is filled with water). This arrangement has been adopted to reduce surface wave making, particularly in the semi-submerged, high-speed transit mode, without compromising performance when fully submerged. The fin carrying the gas turbine alternators and all the main surface sensors and the induction mast are built of carbon fibre to produce the right strength and stiffness and low weight as the fin and is a key element in determining the surface stability of the boat.

Control of the boat is exercised through large forward hydroplanes and relatively high aspect ratio after hydroplanes mounted in the water flow of the pumpjet. These features are intended to provide good manoeuvrability. A dorsal rudder is mounted to counteract snap roll arising from the large fin and to improve slow speed manoeuvrability.

The design is considered to offer very good operational characteristics in the Atlantic in up to around Sea State 6. It can follow waveforms because of the wavelength crest to crest. This will result in around 80 to 85 per cent operating time in transit mode. Operating in this mode would be much more of a problem where short wavelengths such as are experienced in the Mediterranean are to be found – but a conventional snorting SSK experiences the same limitation. The design would therefore exhibit a high degree of habitability in the Atlantic.

Through life costing of the design will be very much reduced compared to a nuclear boat, as it would not require the same infrastructure. The design would therefore make a very good alternative to the SSN for navies where costing is a problem but who require boats with long-range capability to cover very large transit distances, for example India and Australia.

Propulsion

The SSGT is fully electrically powered and propelled using different power generating plants (gas turbine, fuel cell and advanced battery) depending on operational requirements.

The design is based on twin independent gas turbine alternator sets mounted in a 'bulb' on top of the fin and designed to develop around 2.7 MW. This arrangement allows for the inclusion of a substantial air independent installation using the space and weight freed up by the adoption of compact gas turbine alternators.

For high-speed transit operations the boat operates as a semi-submersible with the 'bulb' piercing the surface. The gas turbines would burn kerosene (AVTUR/AVCAT) mixed with air inducted through an extendable induction mast to reduce water ingestion.

For slower transit speeds the boat would rely on fuel cell stacks to provide propulsion power and hotel services. The fuel stacks take in atmospheric air from above the surface using a snort mast. This would then be used to react with hydrogen obtained from reformed kerosene carried in fuel bags mounted external to the pressure hull and under the casing. It is envisaged that individual fuel stacks of up to 300 kW will deliver a continuous output of 1.1 MW and will feature PEM type units supported by a catalytic/thermal reformer system with separators and heat recovery arrangements.

For conventional covert operations the SSGT would operate fully submerged using the fuel cells in a fully AIP mode for up to 25 days. In this mode the fuel stacks would be fed with LOX stored on board and offering fully submerged speeds up to 10 kt.

For 30 kt submerged sprint speed, the SSGT would derive its power from large advanced Zebra battery cells (a total of 520 providing in excess of 14.5 MW at peak power) carried in two compartments. The battery could also be used to help maintain a constant power supply during fuel stack operation or gas turbine operation.

The main propulsion motor may be a high temperature, superconducting unit or a permanent magnet motor. The power is used to drive a large diameter slow turning pumpjet propulsor. This achieved minimum cavitation when running semi-submerged at high speed and minimises radiated noise.

Weapons

The design has been so configured that it can offer a flexible mix of vertical and horizontal weapon discharge tubes and UUV stowage sufficient to satisfy a range of mission profiles. Six standard 533 mm torpedo tubes are mounted axially forward and served by a pair of conventional air turbine discharge pumps. Six reload torpedoes are carried in the weapons stowage compartment and a further eight encapsulated weapons, four each side of the pressure hull beneath the casing. Both the inboard and outboard weapon stowage can be increased without incurring a major impact on platform size or arrangement. In addition four large UUVs can be carried in an external recess, allowing for the recovery of the vehicles on completion of their mission. A detachment of 12 SOF and up to 40 tonnes of SOF stores can be supported, together with a suitably developed UUV to provide SDV capability. Self defence is assured through 16 expendable acoustic countermeasures carried under the after casing. A lock-in/lock-out chamber is provided for the SOF.

Sensors

The platform can accommodate high capability communications and combat management systems together with advanced signature management features. The communications suite would include a night-bandwidth EHF capability and buoyant wire aerial. Acoustic systems incorporate a very large flank and conformal bow arrays, and fin arrays. A towed array could be carried, if required. All masts are of the non-penetrating type. The navigation radar and electro-optic sensor are carried on the air induction mast and in addition there is an attack tactical mast, ESM mast, main tactical ESM and optical search mast, snort head and return, EHF communications mast and buoyant wire aerial.

Operational status

Proposed in service date – 2016-18
Design matured – 2010-12
Detailed design – 2007-09
Selection of core/enabling technologies – 2005-06

Contractor

BMT Defence Services Ltd, Bath, Somerset.

NEW ENTRY

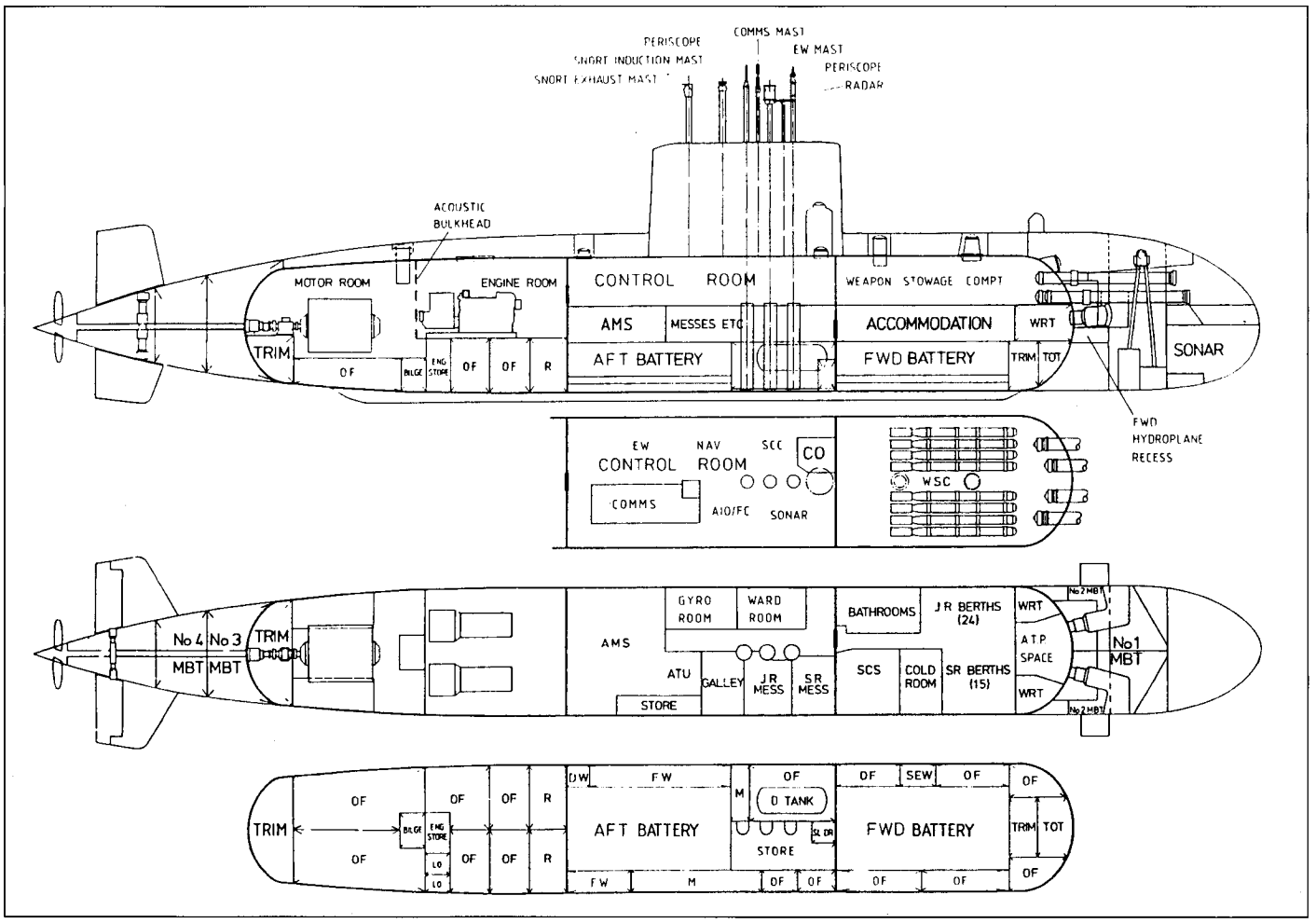
Victoria class

Type

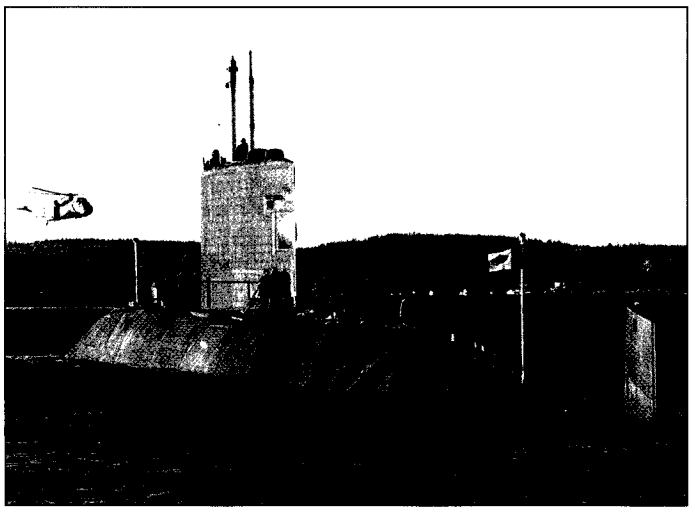
Diesel-electric submarine.

Development

The decision to prepare an outline requirement for Upholder class was taken in the mid-1970s. Two of the most important factors to be considered in the new design were the need to optimise noise reduction and the need to reduce snorting time



General arrangement layout of Upholder 0024691



HMCS Victoria*, the first of the ex-RN Upholder class seen in Canadian waters flying the Canadian flag after delivery* (Canadian DND) 0105320

required to recharge the batteries. By reducing these factors to an absolute minimum, the possibility of the boat being detected would be considerably reduced and its discretion improved.

The original Staff Target for the new design outlined a displacement of 2,250 tonnes submerged, later increased to 2,400 tonnes, which was endorsed in late 1977.

Discussions between MoD and the shipbuilder (VSEL) resulted in agreed characteristics that were the basis of the Naval Staff Requirement (NSR) submission that was finally approved in 1980. Among the specific characteristics laid down for the design were a displacement of 2,400 tonnes (hence the Type 2400 designation), a maximum diving depth well in excess of 200 m, a long patrol radius with a time on patrol of 28 days and a 49 day stores endurance. Maximum underwater speed was to be over 20 kt with a maximum snort speed of over 10 kt and surface speed of over 12 kt. Taking into account the normal underwater cruising speed together with the snort speed and the frequency and period of the snort operation, the designers calculated that the boat could achieve an average speed of advance of 8 kt with a very low indiscretion rate. The detailed design and full contract definition were completed between 1981 and 1982.

To carry out its intended role, it was deemed necessary that the new SSK should embark the most advanced combat system available. The combat system covered not only the boat's combat system and weapons (which included torpedoes, missiles and mines both current and proposed), but also its navigation, sensors and comprehensive worldwide communication suite. Design flexibility was also to be extended to other areas such as the propulsion system. Also emphasised was the requirement to keep the crew size to less than 50. For the Royal Navy the significant consideration was a complement large enough to achieve continuous and effective operation of the combat systems in extreme North Atlantic conditions. On the other hand it had to be low enough to be comfortably accommodated in the design. These criteria necessitated the extensive use of remote-control facilities and automation.

Description

To achieve the optimum underwater performance criteria laid down in the NSR, a single-skinned, tear drop shaped hull with a beam: length ratio similar to that of the latest classes of SSN was adopted. As well as providing excellent manoeuvrability characteristics, this also enabled a two-deck arrangement to be incorporated. Ballast tanks are sited fore and aft.

One of the most striking aspects of the 'Upholder' design is its excellent signal-noise ratio that makes it ideal for use as a sensor platform. Operating conditions have been optimised by concentrating on the stealth aspect and carefully selecting appropriate operating frequencies for the equipment. Stealth has been optimised by mounting elastomeric acoustic tiles on the outer hull, technology transferred from the nuclear submarine programme.

The pressure hull is constructed of HY-80 high-tensile steel in three main watertight compartments.

Internal high-tensile steel frames stiffen the circular hull, the after section being built of truncated conical sections conforming to the optimum hydrodynamic shape of the vessel. The fore and aft sections of the pressure hull terminate in dome bulkheads. The after watertight compartment contains all the machinery (diesels, air conditioning plant, electric motor and so on). Outside the pressure hull are Nos 3 and 4 main ballast tanks; there is space in one of the tanks for a secondary drive motor if required. The extreme aft end of the structure is free flooding and contains the hydroplane and rudder bearings, shaft, and linkages that are of cruciform arrangement.

The propeller shaft runs the full length of the aft external structure, passing through the aft dome bulkhead and main ballast tank bulkheads. Beneath the machinery deck in the after compartment are fuel, lubricating oil and compensating tanks; all the fuel and lubricating oil is carried within the pressure hull.

The after compartment is provided with an escape tower sited in the middle of the compartment, which also serves as an access. There is also an easily removed shipping opening, large enough to permit quick removal and shipping of a complete diesel engine, which gives unrestricted access during maintenance periods.

The amidships watertight compartment houses the control room which includes communications, ESM, and COs quarters on the upper deck level with accommodation and auxiliary machinery spaces below. Underneath these two decks are oil fuel, fresh water and compensating tanks and No 2 battery compartment.

Two hatches allow access to the amidships compartment, one aft of the fin providing general access and battery loading, with the other sited inside the GRP-clad fin exiting to the navigation position and the five-man lock-out chamber which is used by divers when the boat is submerged.

The forward watertight compartment houses the main weapon stowage and handling and discharge equipment on the upper deck to full magazine standards, with ratings accommodation and extensive sonar processing equipment on the lower deck. Beneath is sited No 1 battery compartment with oil fuel tanks built into the wings.

The compartment is provided with three hatches, one of which is set at an angle for weapon loading. Embarkation rails are permanently fitted together with powered movement for handling the weapons. The other two hatches in the forward compartment are a single-person escape tower and a general access hatch.

The torpedo tubes penetrate the forward dome bulkhead of the pressure hull into the free flooding bow space; beneath is the large cylindrical sonar array that is protected by a GRP fairing. Also housed in this bow section is the water transfer equipment for the positive air turbine (pressurised water) discharge system of the torpedo tubes. Weapons handling is fully automated, both to speed up loading and to reduce manpower requirements.

The forward free-flooding external structure also houses Nos 1 and 2 main ballast tanks. No 2 main ballast tank incorporates a recess housing the hydroplanes, which retract within the lines of the hull.

Both the escape towers are fitted with docking seats built into the flat top of the casing capable of taking a deep submergence rescue vehicle.

The single, seven-bladed, fixed-pitch propeller is directly driven by a single air-cooled twin armature DC electric motor with shunt fields fed by two DC/DC static converters and driving the shaft via a thrust block. A third converter is available on standby for use in emergency. The motor is separated from the diesel generators by a thermal and acoustic bulkhead. The motor operates in an oil-free environment using an open-loop air cooling system; water heat exchangers cooling the hot air as it leaves the motor.

The motor, which avoids compensating windings in order to minimise noise and simplify maintenance, can be connected either in series or in parallel, as can the two battery sections. In conjunction with shunt field control this gives a continuous speed range of approximately 20 to 100 per cent. Below 20 per cent control is achieved by means of armature voltage and field control. Selection of motor/battery combinations is achieved through motor-driven camshaft-operated contractors, with circuit breakers for fault protection. The system can be operated in a number of ways ranging from fully automatic, closed-loop control of shaft speed, through reducing automatic modes covering failure of system components to direct manual control of camshaft and field armature regulators.

The high battery capacity required is divided between two battery compartments, each of which contains 240 lead-acid cells developed by Chloride Power Storage. The internal design of the cell uses modern lead-acid technology.

The batteries provide power for the ship's electrical system, which operates at battery voltage (340 to 720 V) and at three other voltages through converters: -

- 440 V 60 Hz 3-phase, transformed and reduced to 115 V
- 115 V 400 Hz 3-phase and single phase
- 24 V DC

Battery charging is accomplished in three stages. Firstly at constant current or power when the battery is recharged to the point where it starts to gas. It is then charged at constant voltage to top up the battery and the current gradually falls to a low level. Charging can then be completed at a constant low level of current to ensure that all the cells are charged to the same level. Each charge cycle can be automatic.

High power is achieved with two high-speed, lightweight VALENTA RPA 200SZ diesels driving GEC 1.4 MW AC generators with built-in rectifiers. These are multiphase machines using brushless exciters and closed air cooling with dedicated seawater heat exchanger. The 4-stroke 16 cylinder diesels are of the direct injection mechanically supercharged and intercooled V-type. They are directly connected to the very short, single-bearing AC generators, each with the rectifier mounted on top and overhanging the bearing. The generator is a self-excited double three-phase alternator, the two three-phase systems being displaced by 30° and through bridge rectifiers, paralleled on the DC side.

A single gear-driven centrifugal compressor drives the supercharger at the free end of the engine through an intermediate fluid coupling. Using a mechanically driven supercharger allows well over twice the engine power to be produced compared with normally aspirated engines in submarine conditions. It also leads to good cylinder scavenging under all service conditions.

The diesel exhausts include inboard silencers and independent surface and snorkel outlets. A cooling facility is provided to reduce the IR signature of the exhaust gases. All engines and generators are carried on resilient mountings to achieve the required noise and shock attenuation levels.

Remote control for most, and surveillance of all, ship and machinery control systems are centralised at two positions. The ship control console, sited in the control room, incorporates as well as machinery control surveillance, a new single-person ship control system. The centralised control and surveillance systems comprise three major units:

- Surveillance panel, including VDUs
- Electrical, diesels and battery panel
- Ship control panel

Automatic (closed-loop) systems are available for depth, course, speed, and battery charging. Other systems (for example trimming) make use of semi-automatic control in which the operator decides when a response is required.

In the event of failure, comprehensive local instrumentation and manual controls are provided to enable safety and integrity to be maintained.

The advantages gained using these automated systems lead to a reduction in watchkeeping effort and ensure a high degree of efficiency and safety.

The main armament comprises six 533 mm bow torpedo tubes that are capable of handling the latest weapons. Up to a maximum of 18 full size reload weapons are carried on shock-protected mountings. The weapon handling equipment can handle weapons of varying lengths and diameters, and can be operated in fully automatic, power assisted, or manual mode.

Weapon discharge is microprocessor controlled, using fibre optic sensors to feed back data on the state of the tube and the weapon inside. This provides the combat system with rapid, up-to-date information on the weapon state. By using this system full control of the weapon, including actual discharge, can be exercised from the control room-based command system rather than from the tubes themselves. A sequence of hydraulic and mechanical interlocks ensures safety of operation at all times. This, again, results in considerable saving in personnel requirements.

A number of sonar arrays are fitted, including a bow cylindrical array Type 2040 (French Thales Argonaute) consisting of three layers of transducers set in 48 staves, providing both intercept and range data. Data gathered by the sonar is digitally processed covering adaptive, active, medium-range passive and intercept modes simultaneously. Using adaptive processing simultaneously over LF/HF bands in passive mode, good target discrimination over long ranges is obtained, even under adverse conditions. An important feature of the sonar bow array is its size (3 m high and 3 m in diameter), the height of the array being very important for frequency operation and so on. The vertical aperture can also be varied.

In addition to the bow sonar the class also carries a Type 2046 VLF passive search sonar, Type 2007 passive LF ranging sonar with three flank arrays on either side of the hull and a Type 2019 Passive/Active Ranging and Intercept System (PARIS).

For surface search the Type 2400 is fitted with Pilkington CK035 search periscope with a passive ESM receiving antenna on top of the periscope; and/or an active, vertically polarised antenna for signals in the communications bands. The attack periscope is the CH085 fitted with LLTV and thermal imaging giving it complete day/night capability.

The communications suite provides comprehensive coverage for transmission and reception across the military HF and UHF and the International VHF band. In addition, reception facilities will cover VLF/LF and MF bands. Equipment includes an HF transmitter (with spare); two MF/HF receivers; two VLF receivers; a UHF transceiver (with spare); VHF transceiver for International Marine band. Also carried are two teleprinters, and three remote voice user positions are sited around the boat. The MF/HF section incorporates a facility for full remote frequency channel selection, the first time this capability has been fitted in a submarine.

Modernisation

As part of the deal with Canada, the 'Victoria class (formerly the RN 'Upholder' class) are being upgraded to enable them to meet Canadian requirements. Part of the plan is to reuse some of the systems already installed in Canada's 'Oberon' class boats, such as the combat system, in order to provide compatibility with the existing heavyweight torpedoes in Maritime Command's inventory. Also included in the upgrade will be a new communications suite to provide standardisation with Canadian communications equipment.

Before handover, the boats will have new batteries installed and their machinery reconditioned.

In Canada, the boats will have their weapon handling and discharge system modified to allow them to deploy the Mk 48 Mod 4 heavyweight torpedo. This will include an air turbine pump discharge system. Other alterations include replacing Outfit DCC with the Lockheed Martin Librascope SFCS Mk1 Mod C (BYG-501) fire-control system that was installed in the 'Oberon' boats. The existing sonar suite will be retained with the addition of a retrofitted Canadian SUBTASS tail with a Hermes Electronics acoustic array, that was installed in the 'Oberon' boats. The ESM system will be the Sperry Guardian Star system.

The boats have been renamed in Canadian service and the first, 'Victoria', was delivered to Maritime Command in October 2000.

Operational status

Entered service with the Royal Navy in the early 1990s, laid up 1994-95 under defence review cuts and subsequently put up for sale. Leased to the Canadian Maritime Forces in 1998 with option to purchase. Three of the four boats had been delivered to Canada by the end of 2003.

Specifications

Displacement:
surface: 2,168 t
submerged: 2,455 t
Dimensions:
length: 70.3 m
beam: 7.6 m
draft: 5.5 m
Electronics:
combat management system: SFCS Mk 1, Mod C (BYG-501)
sonars: Type 2040, Type 2007, Type 2041,Type 2046, SUBTASS, Type 2019
radar: Type 1007
electronic warfare: Guardian Star
countermeasures: Type 2066, Type 2071

Weapons:
torpedo tubes: 6 × 533 mm
torpedoes: 18 × Mk 48
mines: n/k
Machinery:
diesels: 2 × Valenta 16RPA 200SZ
power output: 2.7 MW
batteries: 2 × 240 cell lead acid
electric motor: 1 × GEC double armature
power output: 4 MW
shafts: 1
Speed:
surfaced: 12 kt
submerged: 20 kt
Range:
surfaced: n/k
submerged: 270 n miles @ 3 kt
Schnorkelling: 8,000 @ 8 kt (snorting)
autonomy: 50 days
operating depth: > 250 m
Personnel: 7 officers, 41 crew

Contractor
Cammell Laird (VSEL), Birkenhead.

UPDATED

United States

ASDS (Advanced SEAL Delivery System)

Type
Long-range dry submersible system.

Description
Design
The ASDS long-range submersible has been specifically designed to deliver special operations forces for clandestine missions. Compared to earlier SDVs (SEAL Delivery Vehicles), the ASDS offers improved range, speed and payload. The design is specially engineered to undergo safely the same shock loads as the parent submarine.

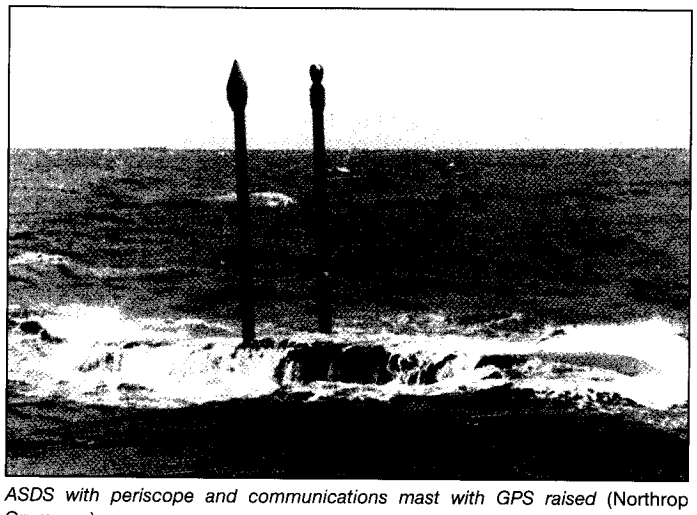
The dry cylindrical pressure hull is built of steel with rounded bow and stern sections of composite material. The pressure hull is encased in a rectangular exostructure of the same composite material as the nose and tail fairings. Shock requirements dictated that the ballast tanks originally due to have been fitted in the nose and tail outside the pressure hull, be resited within the pressure hull.

The crew of two is accommodated in a forward compartment, while the SEAL team is carried in an after compartment. A spherical lock-in/out chamber separates the two compartments and is also used to mate the vehicle to the parent submarine. The hyperbaric chamber is linked to the underside hatch, which is designed to mate to Los Angeles and six Virginia class submarines. The vehicle can anchor on the seabed at depths from 0.6 to 58 m.

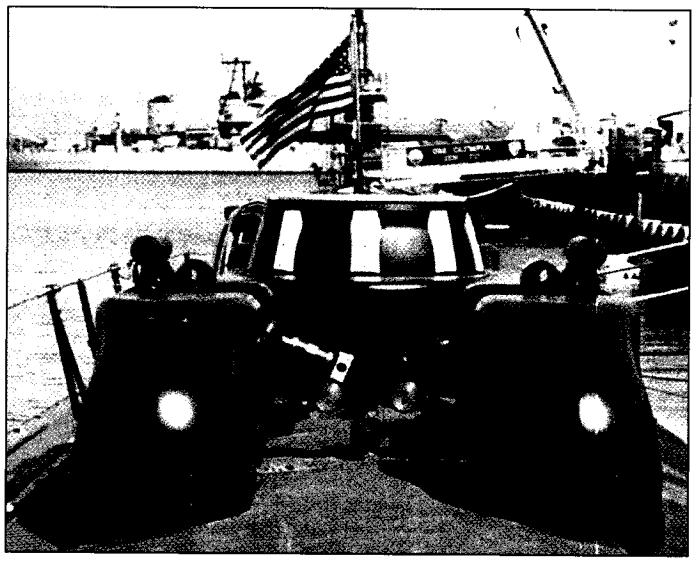
Procurement of new nose and tail assembly is provided for under the FY04 budget.

The vehicle is transported to the target area by specially configured Los Angeles class submarines, where it will be carried on the after casing of the boat. Alternatively, it can be carried by a C-5 or C-17 transport aircraft or in the well deck of an amphibious vessel.

Propulsion
The electrically powered vehicle (it is equipped with 14 large high-energy zinc-silver oxide batteries of higher density than previously, powering a 67 hp motor and four small, retractable electric side thrusters, two on each side forward and aft) is



ASDS with periscope and communications mast with GPS raised (Northrop Grumman) 0137940



Anchoring pylons and hatch for ASDS on a US nuclear attack submarine (Northrop Grumman) 0137941

manned by a crew of two and carries an eight or 16-man SEAL team (depending on their equipment), together with its mission-oriented specialised equipment. The batteries are housed in individual titanium cylinders mounted outside its pressure hull. A proposal has been made to replace the current batteries with a commercial lithium ion polymer model that has been funded under the FY04 budget. Lithium ion batteries, it is claimed, would provide over 10 times the life cycle of the existing batteries. To meet this need NAVSEA has awarded Northrop Grumman a contract to develop the necessary technology. A maximum of four Lithium Ion batteries are to be procured from Yardney Technical Products Inc with delivery to be completed by 2009.

Sensors
The vehicle is controlled from an integrated joystick control and four multifunction displays incorporating the primary control system, inertial navigation system (identical to that in the F/A-18 strike fighter), forward looking and side-looking sonars and dual-redundant flight control computers and software. This equipment has all been supplied by Draper Laboratories. The pressurised hull of the vehicle is fitted with a forward HF and side scan sonars. The two masts developed by Thales in the UK are a non-hull-penetrating periscope to port and a communication mast with GPS to starboard are both hydraulically raised and retracted, folding down into grooves atop the hull.

Operational status
FY09 – Delivery of ASDS-2 scheduled.
26 June 2003 – ASDS-1 handed over to US Navy.
Spring 2003 – ASDS-1 Operational test and evaluation carried out.
Late FY02 – Production of ASDS-2 due to commence.
September 2002 – ASDS-1 Multiple launch and recovery sequences conducted with USS *Greeneville*
1 August 2002 – ASDS-1 completes first operational mission exercise with SEALs.
30 May 2002 – ASDS-1 successfully completes 12 separate docking manoeuvres with host simulator on seabed.
1999 – Trials completed
Mid-FY99 – first of six ASDS on order for US Special Operations Command delivered.
September 1994 – detailed design and manufacturing development contract awarded.

The USS *Greeneville* and USS *Charlotte* have been modified to act as a test platform for the ASDS. Four other Los Angeles class submarines (*Columbus, Charlotte, Hartford* and *Greeneville*) and the Seawolf class submarine *Jimmy Carter* will be equipped to operate ASDS. Four Ohio class boats which are to be converted into SSGNs, will also be adapted to carry up to two ASDS each. The new Virginia class SSNs will also be fitted to deploy the ASDS.

Specifications

Displacement:	
surface:	55 t
submerged:	60 t
Dimensions:	
length:	19.81 m
beam:	2.44 m
draft:	2.66 m
Electronics:	
combat management system:	none
sonars:	forward and side scna sonars
periscopes	optical non-penetrating
radar:	none
electronic warfare:	none
Weapons:	
torpedo tubes:	none
torpedoes:	none
missile tubes:	none
missiles:	none

Machinery:
- **AIP:** none
- **batteries:** 1,200 kW silver-zinc
- **electric motor:** 1 ×
- **power output:** 67 shp
- **nuclear plant:** none
- **auxiliary system:** none
- **shafts:** 1
- **propellers:** retractable thrusters

Speed:
- **submerged:** 8 kt

Range:
- **submerged:** >125 n miles @ 8 kt
- **operating depth:** >60 m

Personnel: 2 + 16 SOF personnel

Contractor
Northrop Grumman, Electronics Sensors and Systems Division, Oceanic Systems, Baltimore, Maryland.

UPDATED

Cutthroat LSV-2

Type
Submarine test vehicle.

Description
Northrop Grumman Newport News with General Dynamics Electric Boat Company, under contract to US Naval Sea Systems, has designed and built an autonomous quarter scale model of the Virginia class to carry out studies into improving the acoustic and operational performance of future submarines.

Known as LSV-2 (Large Scale Vehicle) *Cutthroat*, the test vehicle will be used as a demonstrator platform for advanced technologies planned for the Virginia class. Using the Autonomous Underwater Vehicle (AUV) LSV-2, the US Navy will develop and evaluate new technologies for major improvements in the performance of the class. The main emphasis will be on stealth, hydrodynamics, hydroacoustics and propulsion design, allowing developing technologies to be inserted into current and future submarines.

The forward compartment of *Cutthroat* contains 1,680 lead acid batteries and the after compartment contains the propulsion and auxiliary systems together with data recording and control systems. The vehicle will operate at the full speed and depths specified for the Virginia class. Propulsion comprises a permanent magnet electric motor and pulse density drive modules developing 3,000 shp coupled with an electric motor controller. The system can be uprated to 6,000 shp with additional motor controlled modules.

The onboard data acquisition system records 512 channels. The recorded data is downloaded from the vehicle for processing and scientific analysis.

Cutthroat has been designed and fabricated by an industry team led by Northrop Grumman Newport News Shipbuilding and including Electric Boat division of General Dynamics.

Final assembly of *Cutthroat* was undertaken at the Acoustic Research Detachment in Bayview, Idaho. Following initial testing and certification it has been put in service at Lake Pend Oreille by the Acoustic Research Detachment in Bayview, Idaho. The facility is managed by the Naval Surface Warfare Center Carderock Division.

Operational status
Cutthroat was christened on 15 November 2000 and the vehicle is undergoing testing by the US Navy.

Specifications
Displacement:
- **surface:** 205 t

Dimensions:
- **length:** 33.83 m
- **beam:** 3.05 m
- **draft:** 2.7 m

Machinery:
- **batteries:** 1,680 lead acid
- **electric motor:** 1 × permanent magnet
- **power output:** 2.23 MW
- **shafts:** 1

Speed:
- **submerged:** 34 kt

Personnel: none

Contractors
General Dynamics, Electric Boat Company, Groton.
Northrop Grumman Newport News Shipbuilding, Newport News, Virginia.

UPDATED

Dry Deck Shelter (DDS)

Type
Housing for Swimmer (SEAL) Delivery Vehicles (SDV).

Description
The DDS (Dry Deck Shelter) has been developed since 1978 to fit on submarines to facilitate the carriage of Swimmer Delivery Vehicles (SDVs). These shelters are used to transport and launch the SDV or to lock out combat swimmers. Submarines are equipped with special fittings and with modifications to their air systems as well as additional systems to enable them to carry the DDS abaft the sail. These adaptations permit free passage between the submarine and the DDS while submerged. The watertight connection allows the divers to enter the DDS while the boat is still submerged and to exit the DDS together with their SDV, equipment and/or rubber inflatables and carry out their mission.

The air transportable DDS can be installed on modified submarines in about 12 hours.

The DDS is constructed of HY-80 steel and is subdivided into three watertight compartments housed within a GRP fairing. The forward spherical compartment is a hyperbaric chamber used to treat injured divers. The middle spherical compartment is a transfer chamber which allows divers to enter and exit from the submarine and to enter either or both of the other compartments in the DDS. The aft compartment is a hangar with elliptical ends, used to carry an SDV, other vehicles or special equipment for the divers.

Operational status
The concept for a transportable DDS was conceived in the late 1970s and the first unit was completed by General Dynamics Corporation in 1982. The following five units were built by Newport News Shipbuilding between 1987 and 1991 and it is anticipated that they will remain in service until around the end of the 2020s. Currently, five SSNs of the Los Angeles class are fitted to carry DDS. These are SSN-688, SSN-690, SSN-700, SSN-701 and SSN-715. SSN-23 will undergo conversion to accommodate DDS while units of the new Virginia class will also be adapted to transport DDS. All Virginia class SSNs will also be fitted with an integral lockout chamber capable of holding up to nine divers and their equipment.

An unspecified number of DDS (at least three) are also being acquired by the UK Royal Navy with HMS *Spartan* being the first UK submarine to be fitted with a DDS.

Specifications
Length: 11.6 m
Diameter: 2.75 m
Displacement: 30 t
Payload: 1 SDV

Contractors
General Dynamics Electric Boat Division, Groton, Connecticut.
Northrop Grumman Newport News Shipbuilding, Newport News, Virginia.

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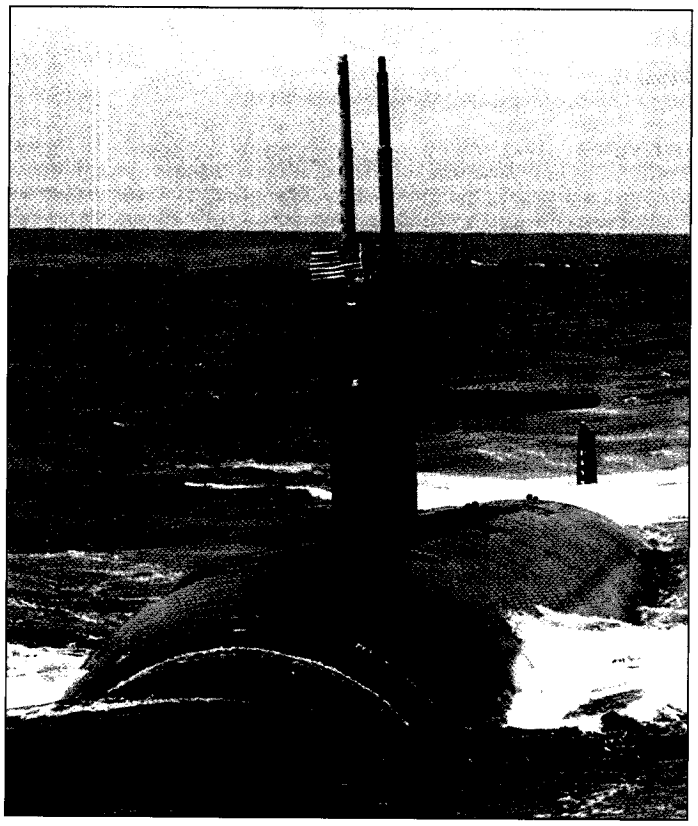
Los Angeles class

Type
Nuclear powered attack submarine.

Development
Work on designing the Los Angeles class SSN (SSN-688) began in 1968. Since then ship design has undergone a revolution and the technology of the 1960s and 1970s has been replaced by the computer and computer-aided design and manufacturing technology. Technology has done much to assist in the upgrading of the class throughout its life. Modular construction technology was introduced during the construction of the class. This involved prefabricating eight large cylindrical sections that were extensively outfitted prior to assembly as the main hull. The design was configured to meet the requirement for SSNs to operate with the carrier battle groups and to counter the Russian Victor class SSNs. A fundamental change was made to the combat system with the introduction of digital computer technology to replace analogue technology. This enabled the boats to handle more complex tactical situations than previously.

The design has been progressively upgraded since the first boat put to sea in 1976 and major combat capabilities have been incorporated since 1985, beginning with USS *Providence* (SSN-719) and subsequent units. Among additions incorporated into the design are 12 vertical launch tubes mounted externally for deploying Tomahawk cruise missiles and the AN/BSY-1 advanced combat system and Mk 117 fire-control system which was installed in 1986 in the USS *San Juan* (SSN-751) and subsequent units. Other upgrades installed include the addition of under ice navigation equipment and minelaying capabilities. These changes have resulted in three distinct subclasses. The modifications have left virtually no volume or weight margins for additional equipment, which has led to the need for a follow-on design. Eleven units in the class have now been decommissioned.

Description
The Los Angeles class is built of HY-80 steel. In units from the *San Juan* (SSN-751) onwards, the sail-mounted planes have been repositioned near the bow and made retractable for under ice navigation, while the sail has been hardened to cope with the stresses imposed as the submarine surfaces through the Arctic ice.



Los Angeles class submarine Key West (USN) ***NEW***/0016320

As originally designed, the class was armed with four midships torpedo tubes for launching Mk 48 torpedoes (subsequently replaced by Mk 48 ADCAP), the Subroc missile and Sub-Harpoon. The boats no longer carry Sub Harpoon. It was intended that as Subroc became obsolescent during the 1980s it would be replaced by a new missile, the Sea Lance. However, the latter was cancelled and Subroc was withdrawn from service in 1990. The first units to be modified to fire the Tomahawk missile from a torpedo tube was the *La Jolla* (SSN-701), with the *Atlanta* (SSN-712) being the first to operationally deploy the missile. The normal payload comprised eight Tomahawk missiles, but for specific operations this number was increased, for example during Operation Desert Storm. The introduction of the Tomahawk missile meant that the analogue Mk 113 fire-control system could no longer be used, and so the Mk 117 digital fire-control system was introduced on later boats and retrofitted to earlier vessels in the class. From USS *Providence* (SSN-719) onwards all boats have been fitted with 12 vertical launch tubes for the Tomahawk missile. These are sited just behind the bow sonar and in front of the forward dome shaped bulkhead outside the pressure hull. With special launch tubes allocated for the Tomahawk, the boats have been able to redress the reduction in numbers of torpedoes carried when the missiles were fired from the torpedo tubes. This does not preclude the boats from carrying the standard number of eight Tomahawk missiles internally for launching from the torpedo tubes should it be deemed necessary.

The original sonar sensor outfit comprised the large BQQ-5 spherical bow array (since upgraded through various modifications to the latest BQQ-5E) and a clip-on towed array. Under the ARCI (Acoustic Rapid COTS Insertion) AN/BQQ-10 programme undertaken from 1997 to 2002, the boats have been backfitted with BQQ 5 sonars with open system architecture. The towed array is stored in a large channel on the starboard side of the casing. The ice navigation sonar BQS-15 was subsequently installed.

The class is fitted with the S6G pressurised water reactor. The last boat in the series, *Cheyenne*, is fitted with the prototype propulsion plant for the Seawolf class. Noise reduction improvements have also been incorporated in many of the boats, including anechoic tiles which have been applied to the outer hull.

As the last Sturgeon class SSN are decommissioned, five of the Los Angeles class are being fitted with the Dry Deck Shelter (DDS) carriers (SSN-688, SSN-690, SSN-700, SSN-701 and SSN-715), and four to operate the ASDS (SSN-772, SSN-766 – modification nearly complete, SSN-762 – work commenced, and SSN-768 – work due to start in FY2003) to take on the role previously performed by the 'Sturgeon' boats. The DDS houses a Swimmer Delivery Vehicle (SDV), or inflatable boats or a platoon of SEALs.

Operational status
A total of 51 boats are operational. Early boats are gradually being retired from service.

Specifications
Displacement:
- **surface:** 6,082 t
- **submerged:** 6,927 t (SSN-751 onwards 7,147 t)

Dimensions:
- **length:** 110.3 m
- **beam:** 10.1 m
- **draft:** 9.9 m

Electronics:
- **combat management system:** CCS Mk 2 (in SSN-688/750); BSY-1 (SSN-751/773); Mk 113 or Mk 117 (SSN-712 onwards)
- **sonars:** BQQ-5D/E (integrating BQR-7 and BQS-13); BQG-5D (SSN710 and SSN 773); TB 23/29; TB 16; BQS-15 (MIDAS) (SSN 751 onwards)
- **radar:** BPS 15H/ BPS 16
- **electronic warfare:** BRD-7; WLR-1H (in SSN-771/773); WLR-8(V)2/6; WSQ-5 (periscope); WLR-10; BLQ-10 (in some units)

Weapons:
- **torpedo tubes:** 4 × 533 mm
- **torpedoes:** 26 × Mk 48 ADCAP Mod 5/6
- **missile tubes:** 12 VLS (SSN-719 onwards)
- **missiles:** 14 × Tomahawk (TLAM C/D and TLAM-N)
- **mines:** 78 × Mk 60 or Mk 67 (in lieu of torpedoes)

Machinery:
- **nuclear plant:** 1 × S6G PWR
- **power output:** 26 MW
- **steam turbine:** 2 ×
- **auxiliary system:** 1 electric motor
- **power output:** 242 kW
- **shafts:** 1

Speed:
- **surfaced:** 18 kt
- **submerged:** 32 kt

Range:
- **submerged:** unlimited
- **operating depth:** 450 m

Personnel: 13 officers, 120 crew

Contractors
Northrop Grumman Newport News Shipbuilding, Newport News, Virginia.
General Dynamics Electric Boat Division, , Groton, Connecticut.

UPDATED

Mk VIII

Type
Swimmer delivery vehicle.

Description
The electrically powered Mk VIII SEAL delivery vehicle is designed to deliver up to six combat swimmers and their equipment. The Mk VIII is a 'wet' vehicle, meaning that when it submerges the hull is completely flooded, the swimmers wearing underwater breathing apparatus (UBA). The vehicle is carried in a dry deck shelter.

As originally built, the Mod 0 version featured a frame comprising round piping which also served as part of the vehicle's ballast system. The vehicles have recently undergone a major upgrading to the Mod 1 version. Under this upgrading, the structure has been rebuilt using flat aluminium framing. This represents a significant improvement over the Mod 0 round aluminium frame in that it is lighter, stronger and easier to maintain and makes component replacement simpler and easier. It has also provided increased internal space allowing internal components such as the air flasks to be repackaged. Externally there is no difference between the Mod 0 and the Mod 1 vehicle and dimensions remain the same (length 6.7 m). With the lighter aluminium frame, it has proved possible to increase the internal payload. Electronics (for example the navigation system and sonar) have also been upgraded and are housed in watertight containers.

Other changes to the Mod 1 include a much improved sensor suite with precise Doppler sonar and integrated GPS receiver, secure communications and digital displays. Finally the pulley-based movable-weight system of the Mod 0 has been replaced by a new ballast/trim tank system.

Power to the single propeller is provided by rechargeable silver-zinc batteries and a new electric motor has resulted in a much quieter vehicle with speed increased from 5 to 9 kt. The radius of action has been increased from 18 to 36 n miles.

Vehicle buoyancy and pitch are controlled by a ballast and trim system. Movement in the vertical and horizontal planes is controlled using a manual control stick to manipulate the rudder, elevator and bow planes. The SDV travels at a depth of around 6 m.

A computerised Doppler navigation sonar system is used to control all other movement including speed, distance, heading, depth and so on. All electronics and instruments are housed in watertight containers.

In typical operating mode the Mod 0 SDV travels at about 6 m below the surface at a speed of around 4 kt. The combat swimmers (a total of six can be carried) in wet suits breathe compressed air from onboard tanks before switching to their UBA apparatus when nearing the target.

Operational status
A total of 10 Mod 0 boats have been upgraded to Mod 1 and are in service with US forces and three Mod 1 boats are in service with the UK Royal Marines Special Boat Squadron, having been acquired in 1999.

Specifications
Mk VIII Mod 1
Length: 6.7 m
Speed: 9 kt
Range: 36 n miles
Operating depth: 6 m

Contractor
Coastal Systems Station, US Naval Surface Warfare Center, Dahlgren.

UPDATED

Ohio class SSGN

Ohio class SSGN.

Development
October 2005 - Conversion of *Georgia* scheduled to begin
October 2004 - Conversion work on *Michigan* due to commence
April 2004 - *Florida* due to commence conversoin
3 March 2004 - US Navy contracts General Dynamics to convert *Florida* to SSGN
26 February 2004 - US Navy contracts General Dynamics to convert *Georgia*
November 2003 - Conversion work on *Ohio* commences
October 2003 - *Michigan* began refuelling
August 2003 - *Florida* enters dockyard for refuelling
14 January 2003 - Northrop Grumman completes initial test on Stealthy Affordable Capsule System (SACS)
13-17 January 2003 - The *Florida* carries out demonstrations to prove the validity of launching UUVs and Tomahawk land attack missiles from a MAC
26 November 2002 - General Dynamics awarded 5-year contract to produce detailed designs for conversion and begin procurement of long lead items
17 November 2002 - *Ohio* enters dockyard for refuelling
September 2002 - US Navy awards General Dynamics contract for design and support work to convert four Ohio class SSBNs to SSGNs

Following the completion of preliminary design work, the US Navy began work in October 2003 on a US$3.5 billion project to convert four Ohio class Trident missile submarines into conventionally armed SSGNs to conduct land attack, SOF insertion and support and ISR missions.

It was planned that the SSGNs would be delivered for operational evaluation and testing in 2007 to be followed by initial operational capability in 2008. It is anticipated that the conversion will take around 2 years.

The other two submarines to be converted are the *Florida* and *Georgia*.

Description
The conversion of the Ohio class boats involves removing the 24 Trident missile silos and replacing them with either missile canisters capable of firing conventionally armed cruise missiles, or configuring the existing tubes for Special Operations Forces (SOF).

The converted Trident missile tubes will be adapted to incorporate Multi-All up round Canister (MAC) assemblies, each of which will hold seven cruise missiles. Each SSGN will have a total of 22 MACs and depending on configuration each submarine will house up to a maximum of 154 Tomahawk and Tactical Tomahawk land-attack cruise missiles in the full strike configuration.

Boats that are configured for the SOF role will have missile tubes 3 to 10 allocated for stowing SOF canisters, while tubes 5 and 6 will be used to store ordnance canisters. This would allow these boats to deploy 98 Tomahawk missiles from the remaining 16 tubes. In either configuration tubes 1 and 2 will be removed and replaced by a 9-man lockout chamber that will also provide access to an ASDS and/or Dry Deck Shelter.

The MAC and SOF canisters are interchangeable at the dockside.

A possible medium term enhancement to provide a time critical strike capability for the four SSGNs could involve the US Army's Tactical Missile Systems (ATACMS). This would overcome the limitation of the Tomahawk not meeting requirement against mobile, time critical targets. The ATACMS payload could include anti-personnel, sub-munition and penetrator warheads. The missile would be contained in a large buoyant encapsulation packed three on three in each tube.

A maximum of 66 berths will be provided on the second deck below these two tubes for SOF personnel and space for their ordnance and equipment. For short periods of time the boats can accommodate up to 102 SOF personnel. The SOF personnel will be able to remain at sea for up to 90 days.

The missile control centre will be replaced with the Tactical Tomahawk weapon control system, which will manage both Tactical Tomahawk and Tomahawk block III missiles. In addition the boats will be fitted with two high data rate antennas, each capable of supporting two multiple EHF channels.

In the navigation centre the strategic navigation system will be replaced by a WSN-7A ring-laser gyro navigation system. The additional space generated by the removal of the strategic navigation system will be used to provide a mission planning centre for the SOF and a control centre for the co-ordination of operations. In the longer term any remaining space may be used for control equipment associated with AUVs or UAVs.

Two major encapulsation technologies are currently under development to potentially provide the SSGNs with a major variable payload deployment capability.

Northrop Grumman has conducted trials with the expendable Stealthy Affordable Capsule system, which would be used to launch UAVs after the capsule has been released from the submarine. The trials demonstrated the capsule hydrostability, payload support and payload ejection in the actual envrionment. The next stage involved additional waterborne tests in 2003 and is being followed by fitting the SACS with alternative payloads for a series of at-sea and submarine launched demonstrations. SACS would allow the use of any conceivable type of naval weapon to be fired from the SSGN.

The Navy is also developing the Broaching Universal Buoyant Launcher (BUBL). BUBL is a watertight capsule which would allow weapons and payloads to be carried up to the sea surface for deployment without the need for them having to transit through the water and broach the sea surface.

Operational status
On 14 January 2003 two Tomahawk land attack cruise missiles were fired from a single submarine ballistic missile tube on the submarine *Florida*. For the trials the *Florida* was fitted with a 3-missile Multiple All-up-round Canister (MAC) to enable it to launch two Block III Tomahawk missiles, plus an inert instrumented vehicle. The test firing was followed by a further experiment, the first in a series, involving transformational payloads and sensors. This experiment combined an ISR function with nuclear, biological and chemical force protection capability involving SOF operating from the submarine. The experiment involved the submarine in launching a Seahorse AUV from one of the Trident tubes to carry out a route survey in advance of an insertion by an SOF team aboard an ASDS (the latter emulated by a rubber raiding craft). The SEALs detected, classified and destroyed a weapons of mass destruction site from a single platform. The ISR input was provided by a small, low-flying ScanEagle UAV launched from the ground but controlled by the submarine to act as a communications relay between the SOF and networked with a P-3 with an APY-6 radar emulating the Global Hawk UAV, which has been selected for broad area maritime surveillance tasks.

Specifications

Displacement:	
surface:	16,600 t
submerged:	18,750 t
Dimensions:	
length:	170.7 m
beam:	12.8 m
draft:	11.1 m
Electronics:	
combat management system:	DEWS-118, CCS Mk 2
sonars:	AN/BQQ-6, AN/BQR-15, AN/BQR-19, AN/BQS-13, AN/BQS-15, TB 23
periscopes	2 × UMM
radar:	AN/BPS 15
electronic warfare:	AN/WLR-8(V)5, AN/WLR-10
Weapons:	
torpedo tubes:	4 × 533 mm
torpedoes:	Mk 48 ADCAP
missiles:	up to 154 Tomahawk
other:	2 × ASDS
Machinery:	
diesels:	none
power output:	none
AIP:	none
power output:	none
batteries:	none
electric motor:	none
power output:	none
nuclear plant:	1 × PWR S8G
turbines	2 × 44.8 MW
auxiliary system:	1 × Magnetek electric
power output:	242 kW
shafts:	1
Speed:	
submerged:	24 kt
Range:	
submerged:	unlimited
Personnel:	15 officers, 140 crew

Contractors
General Dynamics Electric Boat Division, Groton, Connecticut.

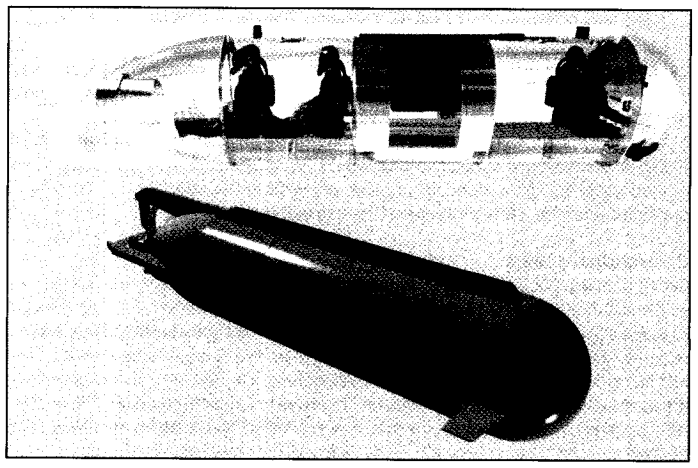
NEW ENTRY

SDV-X and Piranha

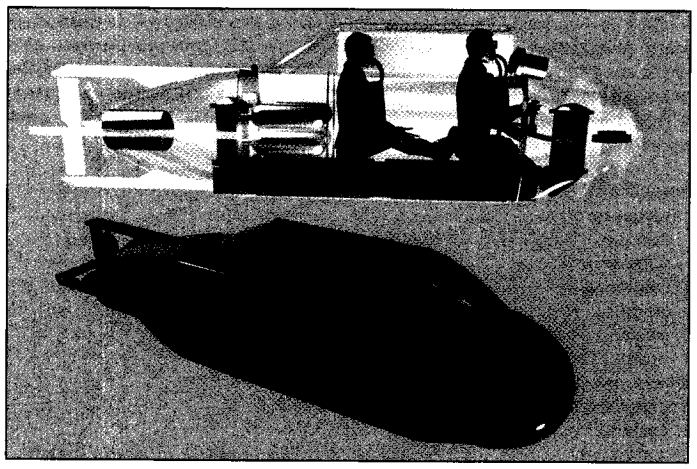
Type
Swimmer delivery vehicles.

Description
These SDVs have been designed for insertion and extraction of special forces teams, hydrographic reconnaissance, ship/harbour attack and MCM operations.

The vehicles are constructed using glass fibre and an aluminium skin over an aluminium frame. Propulsion is provided by brushless DC motors that are both



Outline of the SDV-X vehicle (RJE International Inc) 0097304



Outline of the Piranha vehicle (RJE International Inc) 0097305

powerful and covert and are powered by silver zinc batteries. The operators use a colour LCD with VGA resolution to view navigation and position data and sonar displays. The navigation equipment includes a GPS interface and Doppler velocity log as well as a speed log, fathometer and depth gauge. Diver and surface radio communications are provided

The SDV-X is capable of transporting between six and eight personnel to a range of 50+ n miles, while the Piranha is manned by a crew of two. The SDV-X has a maximum burst speed of 8+ kt and can operate to depths of 46 m. A high-resolution, multibeam sonar is fitted for obstacle avoidance.

Operational status
In service with US and UK forces.

Specifications

	SDV-X	Piranha
Length	7.3 m	4.57 m
Beam	1.5 m	0.91 m
Displacement	2,363 kg	1.633 kg
Speed	8 kt (max)	7 kt (max)
	5 kt (cruise)	5 kt (cruise)
Range	56.5 n miles	27.5 n miles
Operating depth	69 m (max)	45 m (max)
Transit depth	91 m	70 m
Payload	crew 2	2
	6 to 8 personnel	

Contractor
Columbia Research Organisation, Panama City Beach, Florida.

UPDATED

Sea Shadow

Type
Diver propulsion vehicle.

Description
The Sea Shadow diver propulsion vehicle is designed to transport one or two divers and their equipment to the operational area. The vehicle is available in a one- or two-person configuration and can be configured for training and mission battery configurations.

Rechargeable 24 V DC lead-acid batteries power the neutrally buoyant vehicle to give it a range in excess of 5 n miles at cruising speed of 2 to 3 kt. The hull is of moulded high-density polyethylene plastic exhibiting a low magnetic signature. The propellers are fitted with guards to ensure diver safety, while the bow planes fold in and motors rotate to allow the vehicle to be deployed through a 762 mm hatch in a ship. The vehicle features electronic speed control with manual back-up mode and, optionally, electronic drift compensation. A liquid crystal display provides the diver with details of speed, depth, thrust, battery duration remaining and voltage. A flashing alarm signals a preset time for battery charge remaining and unsafe ascent and descent rates.

Operational status
In service with US forces (26 units) and being marketed to overseas customers.

Specifications
Displacement: 43.1 kg (without batteries); 107 kg (with batteries)
Length: 2.13 m (single operator), 3.04 m (2 operator configuration)
Beam: 889 mm
Height: 510 mm
Speed: 4 kt (2-person variant); 5 kt (1-person variant), 2-3 kt (cruising)
Range: >5 n miles (at cruising speed)
Operational depth: 30 m (max)

Contractor
Anteon Corporation, Panama City Beach, Florida.

UPDATED

Seawolf class

Type
Nuclear attack submarine.

Development
Work on defining requirements for a new nuclear-powered attack submarine design began in 1982, and a programme for the new design, subsequently known as the 'Seawolf' (SSN-21), was formally initiated in 1983. This would require a construction programme of some three to four boats a year. It was planned to start work on building the lead ship of the new class in 1989 with delivery due at end of 1994 or beginning of 1995.

The aim of the project was to define a multimission platform whose primary task would be to provide a counter to Soviet SSNs deployed in protecting their SSBNs and the Soviet landmass, or engaged in attacking US or allied shipping, naval battle groups or land targets.

To ensure continuity of capability over a period of time the design had to exhibit significant growth potential so that major improvements could be incorporated which would enable the boats to counter more sophisticated threats which might develop in the future. Hence, the design had to be physically evolutionary and revolutionary in capability. This led to the programme team (operating under the name Group Tango) to define six goals (*not* requirements) for potential performance parameters. These were to be the subject of detailed study and development for incorporation in the design and which might be achieved during the boat's service life between 1995 and 2035. These six goals or ideal parameters were identified as being: quietness, speed, depth, weapons load, launch tubes, and ability to operate under ice in the Arctic.

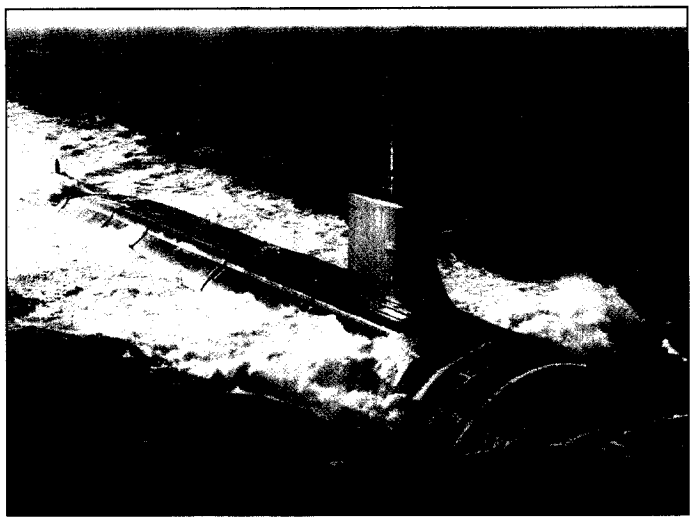
Originally, the US Navy intended to acquire a force of 30 of the new submarines to supplement the Los Angeles class (SSN-688). Following the ordering of the lead ship in 1989 under FY89 Budget, it was planned that two boats would be acquired in FY91 and then an average of three a year would be ordered until 2000, when the target goal of 30 boats would be reached. Then, in 1990, with the lead ship already under construction, the programme ran into a major funding problem when the Senate Armed Services Committee voted to delete all funds for the construction of 'Seawolf' boats under the FY91 and future programmes. This vote was rigorously opposed by the House Armed Services Committee and on 13 August 1990 the then Secretary of Defense, Dick Cheney, approved funding for one more 'Seawolf' (SSN-22) under the FY91 Budget.

A major controversy surrounded the programme with a number of objections being voiced. Among the objections raised were the cost of the programme, the level of technology incorporated in the design, the impact of the cost on the numbers planned and the industrial base that would supply all the equipment, and the capability of the design. At this point, some observers noted that the design would only meet two of the goals set out in the original plan, namely quieting and the ability to operate under ice in the Arctic.

In June 1991 the US Navy discovered serious cracks in the welding in the hull of SSN-21 which would require replacement of all welds completed up to that date. This resulted in a major delay in the construction of the lead ship.

Finally, in late January 1992, it was announced that after the third 'Seawolf' submarine (SSN-23), to be built under the FY92 Budget, no more submarines would be authorised for construction for a period of seven years.

Although authorised under the FY92 Budget, approval for partial funding of US$700 million for SSN-23 was not finally given until the FY96 Budget. Also under the FY96 Budget, funds were allocated for the completion of *Seawolf* (SSN-21) and *Connecticut* (SSN-22).



The USS 'Seawolf' (US DoD) 0033728

The decision to discontinue construction of the highly controversial and very expensive 'Seawolf' was, in the main, influenced by a very much constrained defence budget, technical problems and, to a degree, the perceived diminished threat from the Russian Fleet.

Description

The hull is constructed of HY-100 steel enabling the boat to dive to much greater depths (in the region of 600 m) than the 'Los Angeles' SSN-688 class. Although many of the improvements which have been embodied in the later units of the Los Angeles class have been incorporated in the design, the 'Seawolf' shows a significant improvement over the SSN-688 design in a number of areas. For example it achieves a greater diving depth, higher speed, and exhibits a much lower overall acoustic signature (it was planned that the 'Seawolf' should be 15 dB quieter) which has been aided by the full use of acoustic cladding. In addition it achieves a 30 per cent greater weapons payload (50 weapons compared to the 37 of the SSN-688). The significant reduction in acoustic signature has resulted in the 'Seawolf' being able to maintain speeds of 25 kt while still being able to effectively operate a passive sonar (this is referred to as the maximum acoustic speed). The only other submarines capable of achieving such maximum acoustic speeds are the Russian 'Akula' and presumably, Severodvinsk classes.

Among the new features are a smaller length: beam ratio which improves manoeuvrability. This has resulted in a teardrop hull that is nearly 30 per cent larger than the SSN-688. Manoeuvrability is further aided by a fin leading into the lower part of the faired sail, bow planes which can be withdrawn into the boat for under-ice operations, and six fixed stern fins.

The increased volume of the 'Seawolf' has allowed for the incorporation of modern sound-shielding materials and enhanced radiation safety features. The propulsion system comprises a newly designed pressurised water reactor, the S6W developed by General Electric. The system has been designed to meet stringent noise and weight reduction targets which have been achieved by the development and application of new, high-strength, lightweight materials in the major reactor components, piping and foundations which have also reduced the possibility of corrosion. Developing 52,000 hp (38.8 MW) to give a maximum quoted speed of 35 kt, the reactor drives two turbines feeding a single-shaft shrouded pumpjet. Secondary propulsion is provided by a Westinghouse motor.

The US Navy examined various alternative designs for the stern arrangement and eventually selected a British-designed pumpjet propulsor, similar to those fitted in the Royal Navy's Trafalgar class.

The heart of the 'Seawolf' design is the AN/BSY-2 fully distributed combat system which incorporates extensive use of modular software and local processors to provide targeting, weapon and mine setting, launch processing and after launch control, over-the-horizon targeting and combat system management. This is the first fully distributed system to enter service with the US Navy and is based around UYK-44 computers with a fibre optic LAN databus in the combat centre.

Sensors integrated by the BSY-2 include:

- the BQG-5 wide aperture hull-mounted passive flank array providing long-range detection and localisation
- the TB-16 passive array (part of the BQQ-5 sonar system) which is stored in a sheath along the boat's hull
- the TB-23 thin-line array (part of the upgraded BQQ-5D) which is reeled into the ship's main ballast tanks
- a large, bow-mounted, spherical MF active long-range panoramic sonar with listening mode
- the short-range, active, high-resolution, HF BQS-24 sail-mounted sonar capable of detecting small targets including mines (MIDAS - Mine and Ice Detection and Avoidance System).

Armament comprises eight 660 mm torpedo tubes mounted in the hull abaft the large, bow-mounted sonar array. These large tubes (outside dimensions 762 mm) are designed to enable them to accommodate various combinations of 50 weapons including cruise missiles, various ASW weapons including mines and, at some time in the future, UUVs. The weapon mix includes: TOMAHAWK (both land attack and anti-ship versions) cruise missiles; HARPOON anti-ship missiles; and ADCAP Mk 48 torpedoes. Alternatively, up to 100 mines, including the CAPTOR, can be carried in lieu of the HARPOON and torpedoes.

Other systems fitted include a Kollmorgen Type 18 periscope and the AN/WQC-6 underwater communications system.

The 'Seawolf' is manned by a crew of 133, including 12 officers.

The delay in starting work on the third boat in the series, the *Jimmy Carter*, has enabled it to be reconfigured for the operation of Special Operations Forces (SEALs). This has meant reconfiguring the torpedo room to provide a much more habitable area for the SEALs. Also incorporated in the design is a lock in/lockout chamber capable of accommodating an eight-man SEAL team and its equipment. The boat will also be able to host the Advanced Swimmer Delivery System (ASDS), a Swimmer Delivery Vehicle (SDV) housed in Dry Deck Shelter (DDS). The boat is also being modified to enable it to accommodate advanced technology for tactical surveillance and mine warfare operations. These alterations will modify the basic design in the areas of ballast control, mission management spaces and various services. It is said that these features can be easily retrofitted into SSN-21 and SSN-22 if required.

The hull is being lengthened aft of the sail by about 30.5 m to allow for the insertion of an Ocean Interface module providing larger apertures to the sea for the accommodation and deployment and recovery of larger payloads without having to use torpedo tubes. Modifications will increase submerged displacement to 12,139 tons. Incorporation of these modifications will delay delivery of the boat to 2004.

Operational status

The lead ship *'Seawolf'* is now operational. Although scheduled for completion in 1995, construction was delayed when defective welds were discovered in the hull in July 1991. The problem was traced to unduly high carbon content in the wire used to weld the HY-100 steel. This led to brittle and cracked welds throughout some 16 per cent of the hull that had been completed at that time. In addition, concern over the titanium torpedo hatches led to a change to HY-100 steel in the construction of eight breech doors. Sea trials in late 1996 showed that the boat exceeded expectations for speed, stealth, and sensor performance. A further delay then resulted before the boat could be commissioned in early 1997, when some contour panels over the wide aperture sonar array became detached from the hull and had to be refitted.

Specifications

	SSN 21/22	SSN 23
Displacement:		
surface:	8,060 t	8,060 t
submerged:	9,142 t	12,139 t
Dimensions:		
length:	107.5 m	138.1 m
beam:	12.9 m (diameter)	12.9 m (diameter)
draft:	10.9 m	10.9 m
Electronics:		
combat management system:	BSY-2, Mk 2 FCS	BSY-2, Mk 2 FCS
sonars:	BQQ-5D, TB16, TB29, BQS-24	BQQ-5D, TB16, TB29, BQS-24, BLQ-11 UUV minehunting
periscopes:		
radar:	BPS 16	BPS 16
electronic warfare:	WLQ-4(V)1, BLD-1, WLY-1 countermeasures	WLQ-4(V)1, BLD-1, WLY-1 countermeasures
Weapons:		
torpedo tubes:	8 × 660 mm with Mk 21 air turbine discharge pump	8 × 660 mm with Mk 21 air turbine discharge pump
torpedoes:	38 × Mk 48 ADCAP	38 × Mk 48 ADCAP
missiles:	12 × Tomahawk TLAM-N, TLAM-C/D	12 × Tomahawk TLAM-N, TLAM-C/D
mines:	100 in lieu of torpedoes	100 in lieu of torpedoes
other		UUVs, DDS, ASDS
Machinery:		
turbines:	2	2
power output:	33.57 MW	33.57 MW
nuclear plant:	1 × Westinghouse PWR S6W	1 × Westinghouse PWR S6W
power output:		
auxiliary system:	1 Westinghouse	1 Westinghouse
power output:	n/k	n/k
shafts:	1	1
propulsor:	1 pumpjet	1 pumpjet
Speed:		
surfaced:		
submerged:	39 kt	39 kt
Range:		
surfaced:	unlimited	unlimited
submerged:	Unlimited	unlimited
autonomy:	n/k	n/k
operating depth:	c 610 m	c 610 m
Personnel:	14 officers, 120 crew	14 officers, 120 crew

Contractor

General Dynamics Electric Boat Division, Groton, Connecticut.

UPDATED

Virginia class

Type
Nuclear-powered attack submarine.

Development
Following the truncation of the Seawolf class, the US Navy embarked on a study to examine a new attack submarine design as a low-cost complement to the Seawolf.

Referred to originally as the Centurion and NSSN, it is now called the Virginia class. Under the FY96 National Defense Authorization Act, funds were specifically allocated for long-lead and advance procurement items for the lead boat. Four attack submarines were authorised and funded in FY98-02. It is anticipated that this might eventually result in a class of 30 boats.

The US DoD has agreed that NSSN is the most affordable solution to meet the replacement requirement and to preserve the US Navy's critical undersea warfare capabilities.

With the ending of the Cold War, one of the US Navy's redefined primary mission requirements is the ability to covertly insert military forces ashore in a hostile environment. The Virginia class has been configured for a wide range of missions including:

- Mine warfare
- Special Operations Forces insertion and extraction
- Battle group support
- Intelligence collection and surveillance
- Sea control
- Land attack

The modular design offers reduced costs and minimal rework to adapt the design as well as simplifying system integration because construction, assembly and testing of systems can be carried out prior to installation in the hull.

Description
To meet the criteria for the incorporation of new technologies, and to meet the demand for a very wide range of mission possibilities, the whole design concept of the Virginia is centred on modularity. As such, therefore, the design and manufacturing processes will have to be sufficiently flexible to adapt to future mission requirements that may not at present be fully anticipated.

The design will feature three main areas of modularity:

- construction — the boats will be assembled from self-contained subsystems which themselves will be assembled and tested before integration with the main hull
- technological — subsystems will be assembled using open architecture components offering an adaptable configuration which will facilitate maintenance and the incorporation of new technology throughout service life of the boat
- operational - the baseline design will emphasise the capability to reconfigure the boat to undertake a number of different missions, either through construction of different variants of the basic design or through post-construction upgrades.

The weapons payload will incorporate a mix of land-attack weapons in 12 vertical launch cells and 26 other torpedo tube-launched weapons including:

- Mk 48 ADCAP Mod 6 torpedoes
- anti-ship cruise missiles
- advanced mobile mines
- and, for certain missions, Unmanned Underwater Vehicles (UUVs).

Other weapons under evaluation for possible use include a submerged launch version of the US Army's enhanced fibre optic-guided (E-FOGM) anti-helicopter and anti-ship missile and Unmanned Aerial Vehicles (UAVs) to provide real-time monitoring of the near and overland battle space. For self-defence the boats will carry a wide range of countermeasures.

To provide for the deployment of SEALs and Special Operations Forces and their equipment for extended periods in forward areas, the design will feature a dry deck shelter and the Advanced Swimmer Delivery System (ASDS). A special lock in/lock out chamber will accommodate a SEAL team. The torpedo room will also be reconfigurable to provide for improved habitability for Special Forces during transit to the operational area.

To provide the necessary capability for the new boat to undertake the wide range of missions envisaged, the sail configuration will house two new advanced photonics masts (AN/BVS-1) in place of the standard periscopes. These will be fitted with LLTV, IR and a laser rangefinder. Signals from the photonic and advanced ASTECS ESM (the AN/BLQ-10) sensors will be relayed to the Combat Control System Mk 2 and AN/BSY-2 command system via a fibre optic link and presented on flat panel displays. The combat system will enable the Virginia class to play a key role in the Network Centric Warfare concept as it will be able to fully link with external targeting and intelligence grids. Within the hull a wideband LAN built to commercial industry standards will link all the combat control and communications systems. Modular, open system architecture will allow full use of COTS and government provided hardware which will be key to the functioning of the system. This approach will allow the integration of more advanced microcomputers, signal processors and software algorithms to be implemented as requirements change or increased capability becomes available.

All masts will be of the non-hull penetrating type. Sonar sensors will include a large spherical active/passive bow array sonar, the LightWeight Wide Aperture Array (LWWAA), dual towed arrays (the TB-16 and TB-29) and a large wide area passive flank array, as well as passive ranging sonar, intercept sonar and HF sail- and chin-mounted active sonars for mine detection and ice navigation. The LWWAA consists of six LightWeight Planar Arrays (LWPA) mounted three on each side of the hull. It is envisaged that the Virginia class will be able to deploy the Advanced Deployable System (ADS) for the detection of quiet submarines and mines in shallow water regions over a long period of time.

Provision is also being made to fit an advanced submarine communications suite incorporating a mast carrying SHF frequency antenna for satellite links for secure, high-volume, high-data rate with instantaneous transmission of images to other ships and submarines. A new high data rate multiband dish antenna will allow the boats to communicate directly with a wide variety of satellite systems, including both military and commercial systems. The communications suite will also enable the boat to communicate with offboard underwater, surface, airborne and space-based assets, giving it the ability to operate with other platforms at far greater ranges than is currently possible. This is vital if the boats are to be properly integrated with the entire battle force for both strategic and tactical missions in both shallow and deep waters.

With the focus that the US Navy now places on operations in littoral waters and particularly for operations in potentially mined areas, the design will incorporate an electromagnetic silencing system and advanced mine detection and avoidance systems.

The Virginia class will be powered by an S9G PWR reactor and is the first specifically designed not to need refuelling during the entire 30-year service life of the boat. The reactor takes up less volume than the system in the Seawolf, and, with fewer pumps and valves, is a quieter system. A commercial turbocharged diesel engine provides auxiliary and emergency power. The boat's control surfaces will be electrically controlled from a digital fly-by-wire control station manned by a crew of three, replacing the more usual crew of five.

Motion is provided by the pumpjet propulsor unit (an enclosed propulsor with alternating rotor and stator stages).

The hull is constructed of similar high tensile steel to the Seawolf, but not being required to dive as deep, the thickness of the hull is not as great as that of the Seawolf.

Operational status
July 2004 – Delivery of *Virginia* scheduled.
29 January 2004 – Multi-year contract awarded to Northrop Grumman and General Dynamics to build five Virginia class.
1998 – *Virginia* (SSN-774) ordered.
1997 – Teaming agreement between Northrop Grumman and General Dynamics to co-operatively build Virginia class.

A total of 30 units is planned.

Specifications

Displacement:	
submerged:	7,800 t
Dimensions:	
length:	114.9 m
beam:	10.4 m
draft:	9.3 m
Electronics:	
combat management system:	CCSM
sonars:	TB 16, TB 29A, LWAA, AN/BQQ-10, AN/WLY-1
periscopes	2 × AN/BVS-1 photonics
radar:	AN/BPS-16
electronic warfare:	AN/WLQ-4(V), AN/BLQ-10
Weapons:	
torpedo tubes:	4 × 533 mm
torpedoes:	Mk 48 ADCAP Mod 6
missile tubes:	12 VLS
missiles:	Tomahawk
mines:	Mk 60 and Mk 67
other	14 external and 1 internal reloadable decoy tubes, anti-torpedo torpedoes
payload:	38 weapons mix including UUV
Machinery:	
diesels:	none
AIP:	none
batteries:	none
electric motor:	none
nuclear plant:	1 × S9G PWR
turbines:	2 × 14.92 MW
auxiliary system:	1 × turbocharged diesel
shafts:	1
Speed:	
submerged:	34 kt
Range:	
submerged:	unlimited
operating depth:	c 488 m
Personnel:	134

Contractors
General Dynamics Electric Boat Division, Groton, Connecticut.
Northrop Grumman Newport News , Newport News, Virginia.

UPDATED

SUBMARINE ESCAPE AND RESCUE SYSTEMS

Introduction

Background

The increase in submarine operations around the world brings with it problems not only of a strategic or tactical nature, but of a humanitarian kind also. The loss in August 2000 of the Russian Oscar class submarine *Kursk,* and her crew of 118, highlighted this. The nuclear-powered Oscar class submarines are among the largest in the world and deemed by Russian experts to be unsinkable. However, there nearly always exists some unrecognised or forgotten factor that can emerge to confound the experts and theorists. No ship is completely unsinkable!

Submarine escape and rescue refer to the two different ways in which a crew can leave a distressed submarine. In escape the crew leave the boat through their own endeavour, and conduct a free ascent to the surface without any external assistance. While many navies practise this form of recovery of a crew, it is restricted in depth to around 180 m. Even then, such an escape is fraught with danger and, for anyone injured, is well nigh impossible (depending of course on the injuries sustained). Among the most serious of problems faced by escaping crew are burst lungs, embolisms, hypothermia and the bends. In a rescue situation, outside agencies are used to enable trapped crew to exit the distressed submarines in a relatively safe and dry environment – usually by means of a bell, rescue capsule/pod/sphere that is an integral part of the submarine, or DSRV (Deep Submergence Rescue Vehicle).

All submarines carry escape suits/hoods for the crew and most submarines' escape hatches accommodate special fittings that allow a DSRV to attach itself to the hull to facilitate a rescue. The latest escape survival suits (the *Kursk* carried such suits as do all British submarines, and American submarines will be adapted for their crews to use such suits which the United States is buying from Britain to replace an older hood system) incorporate in different systems closed circuit breathing, heater and, in some cases, a one-man liferaft.

Loss of the *Kursk*

The loss of the *Kursk* raised a number of questions concerning submarine safety and rescue which are relevant not only to the Russian Navy, but to any navy operating submarines.

Firstly, it does not appear that the *Kursk* sent out any distress signals when the disaster first occurred, nor subsequently. The question must therefore be asked "What prevented the emergency distressed submarine (DISSUB) signal being sent, and even prevented distress buoys which were carried from being released?" Certainly for the Russian Navy, this is a question that must be addressed.

A variety of distress signals is available to submarines in the form of flares which emit a coloured smoke on reaching the surface, communications buoys which are automatically released in the event of an accident and which automatically transmit a distress signal on reaching the surface, and capsules which can be ejected from the boat's submerged signal ejector (SSE).

Then there is the question of a rescue mission relating to a sunken submarine and any of its crew who remain alive, any number of whom may be injured. In the case of the *Kursk*, there appears to have been a considerable delay before any rescue operation was set in motion. The real reasons for this are not known. A rather belated and inadequate response by the Russian Navy was eventually initiated.

The Russian Navy does possess a number of Deep Submergence Rescue Vehicles (DSRV), but in the prevailing conditions they proved inadequate to the task of rescuing any crew who might have remained alive in the *Kursk*. Both the United Kingdom and the United States offered the use of their DSRVs, but initially the Russians refused this, presumably for security reasons, but also possibly through overbearing pride in their own capability and expertise. This is a factor which is endemic to the Russian character and which is of considerable influence within the Russian naval high command. After finding they were unable to conduct an effective rescue mission, the Russians finally accepted the offer of help from the Royal Navy. By that time, it was almost certainly too late to rescue any crew who might have remained alive. Eventually a team from the Norwegian oil industry, under the direction of the Russian Navy, was able to effect an entry to the extreme after part of the *Kursk* and retrieve some dead members of the crew.

Lessons to be learnt from *Kursk*

Firstly, it is essential that the moment a major emergency occurs on board a submarine, it is reported to the higher command who can initiate an immediate response, advise and assist where necessary. This will be in addition to any action taken by the crew of the submarine to contain the emergency.

If the emergency is such that the submarine is in imminent danger of sinking, or has sunk, then every suitable emergency and rescue service (both military and possibly civilian from the offshore industry) must immediately be assembled. They must be fully briefed, co-ordinated and sent to the boat's last reported position with all despatch. Now, this will have a *caveat* in that submarines frequently operate alone and are under strict orders to maintain communication silence. If the emergency is so catastrophic that the boat is unable to send a DISSUB or similar distress signal, then the navy may have difficulty in establishing precisely the submarine's position, for it may have travelled many hundreds of miles since its last communication. Hence, the requirement that all submarines should carry an emergency locator beacon that can be automatically released immediately a disaster occurs.

Nevertheless, it may take the rescue services and equipment hours or perhaps even days to reach the site of a disaster – but the effort has to be made.

Initiating rescue services to a DISSUB sets in train an enormous range of assets. First on the scene will be MPA (Maritime Patrol Aircraft) and any surface forces in the area of the submarine's last reported position. In the absence of any communication from the boat, they will initiate a normal ASW search pattern in order to try and establish the boat's precise position. While this is in progress, shore-based rescue services will have been alerted and the necessary logistic support assembled to transport rescue equipment to the position of the distressed submarine, once its position has been determined. This may well involve road transport to move DSRVs to airports for rapid transhipment overseas, then to a suitably equipped dockside where they can be placed on a suitable and available mother ship which may be another submarine, military salvage vessel or chartered offshore support ship. Ideally, the mother ships require some form of dynamic positioning and should be extremely manoeuvrable in order to allow the mother ship to maintain its precise position over the submarine. In addition, once the submarine has been located, ROVs which may be available can be used to carry out preliminary surveys, establish contact with the submarine crew and generally survey the area and prepare it for the DSRV to carry out its mission. Also required on site will be decompression chambers for treating anyone suffering from the bends, and medical teams trained in underwater accidents and nuclear (if the submarine is an SSN) accidents.

Certainly, a type of vessel ideally suited to act as a mother ship in such situations is an MCMV, for it will be already equipped with precise positioning and tracking systems, carry some form of ROV, divers and, in many cases, a decompression chamber.

In the case of a submarine disaster, an occurrence that is fortunately very rare, outside offers of assistance are usually very quickly given by other navies. Whether they are accepted or not is, of course, entirely up to the navy and government concerned. However, if there is any doubt as to a navy's own capability to conduct an effective submarine rescue, then such offers should be willingly accepted at once, even if it does mean the possibility of compromising certain aspects of security.

The Russian Navy does operate a submarine rescue service, and valiant efforts were made by the crews of the Russian DSRVs to effect a rescue, at considerable risk to their own lives. However, the vehicles were just not up to the task. If the Russian Navy continues to conduct submarine operations on the scale of the exercise involving the *Kursk*, then it will have to address urgently the need for a much more capable and sophisticated DSRV and rescue service. For this the necessary financial resources must be made available from the cash-strapped funds of the navy.

Conclusion

The lessons from this disaster must be taken to heart by many of the navies that have now begun to build up submarine forces. It is to be hoped that the Russians are willing and will feel able to share any lessons they have learnt from the *Kursk* disaster with the world's submarine community.

It is also essential that all submariners and navies regularly conduct submarine escape and rescue exercises. These should be carried out both nationally and, on occasions, internationally. Included within these exercises should be training manoeuvres designed to ensure that everyone is fully aware of how DSRVs are used.

It will be necessary for international submarine rescue exercises to be conducted on a much more frequent and regular basis than they have to date. This will ensure that navies are fully aware of other forces' operating procedures and that all submarine rescue and escape equipment is fully compatible. A combined international effort in the area of submarine rescue and escape must now be seen to be an essential element in underwater operations.

Supposing that a nuclear submarine suffered an accident and became stranded in a damaged or leaking state on the seabed with the majority of the crew alive, but some injured. What then would be the situation regarding the rescue of the crew? Potentially between 50 and 60 men at least from depths of between 100 and 1,000 m would have to be rescued. The largest DSRVs currently in existence are the US vehicles carrying 24 men each and the Swedish URF capable of rescuing up to 35 men. Assuming that mating the DSRV to the stranded submarine is a straightforward operation (which it most likely is not) and that the DSRV has been taken to the location by another submarine, then one could reasonably assume that at least three missions will be required. Each of these would last in the region of a half to one hour to complete, depending on prevailing conditions. This surely must be an ideal situation in which to effect a submarine rescue. Conditions are not likely to favour the rescuers and, above all, time is not on their side.

At the very least, to give the crew of a stranded and damaged submarine a reasonable chance of escape, two DSRVs should be in attendance and possibly three. One would be transiting to the damaged submarine, one transiting from it and mating with the parent rescue platform, and one mated with the damaged submarine rescuing the crew, some of whom are probably injured.

The UK and US have a close agreement relating to submarine rescue. In cases where they are allowed to co-operate, the Royal Navy provides a rapid response with emergency rescue capabilities in advance of the US DSRVs, which provide more extensive rescue facilities but take longer to mobilise because of their logistic requirements.

It is interesting to note that, even before the loss of the *Kursk*, a NATO Submarine Rescue System (NSRS) project team in the UK had invited interested companies to a briefing on NSRS at NATO headquarters in Brussels, since when an Invitation to Tender has been issued. France, Norway, Turkey and the UK have a requirement for an NSRS to enter service around 2005.

The Royal Navy has issued a Recommendation for Proposal for a new DSRV to replace the current *LR5* on the basis of this ITT. ***VERIFIED***

Australia

Safety Flare

Type
Submarine-launched flare.

Development
The submarine-launched flare was designed to meet a Royal Australian Navy requirement for a product that could visually signal a submarine's position to surface vessels over a long range. Stringent reliability, safety and performance requirements were specified for the product.

Description
The flare is compatible with 3 in submarine signal ejector tubes in many submarines around the world, and also with 4 in ejectors fitted with a standard 3 in conversion sleeve. The flare offers maximum performance in situations ranging from emergency signalling to combat training. During attack exercises the flare indicates that a torpedo fired at the same time would have hit a target.

The flare is ejected from the submerged submarine, travels to the surface under its own buoyancy and then launches a parachute supported pyrotechnic signal. A combination of sensors ensures that the flare will only launch when it is in position to achieve maximum effect.

The sensors notify the flare when it reaches the surface and is in a suitably vertical position to launch the signal. The device can operate in heavy sea states up to Sea State 6, with the sensors preventing the premature sub-surface or under wavewash firing of the flare or firing it at more than 20° from the vertical. Built in safety measures allow safe handling at all times, including removing an unfired flare from the ejector. The flare cannot be accidentally discharged onboard ship, and can only arm itself after it has been launched, is within 5 m of the surface and the power unit has been exposed to sea water.

The flare provides enhanced visibility and can reach a height of 170 m above sea level with a visibility range of up to 30 km. The flare also features an extended burn time and increased brightness levels compared to other flares.

The flare is fitted with two ignition systems to ensure full back up in the event of a failure in the initiation circuit.

Operational status
In service with the Australian Navy Collins class submarines and acquired by the Norwegian Navy.

Specifications
Length: 1 m
Weight: 4 kg
Operating depth: 750 m

Colour	Burn time	Candella	Visibility at sea level
White	30 s	1,000,000	30 km
Red	60 s	200,000	20 km
Green	60 s	120,000	15 km

Contractor
ADI Ltd, Sydney, New South Wales.

NEW ENTRY

NATO

NSRS

Type
Deep submergence rescue vehicle.

Development
Plans for a new system to replace the UK LR 5 were first discussed in the mid-1980s with a collaborative programme initiated in 1987. A prefeasibility study was carried out in 1990-91 followed by the forming of a NATO Project Group in 1994 under which the UK was instructed to evaluate the study. The initial Project Group involved 12 nations, but only five provided funding for the study that began in 1996. The original five nations included France, Italy, Norway, the UK and US. Italy and the US withdrew to develop their own replacements, Italy the SRV300 designed to replace the MSM1, and the US to develop a design more suited to their own specific requirements. In 2000, Turkey joined the Project Group, and Australia, Canada and Sweden joined as observers.

On 18 August 2000 France, Norway, Turkey and the UK signed an MoU which committed the four nations to a two-year Project Definition Phase (PDP). This was followed by an Invitation To Tender (ITT) for the PDP. The PD study contract was awarded to WS Atkins early in December 2000. This was completed in late 2001 and identified and assessed the technology required to procure, operate and support a new system. Another MoU, signed in June 2002, committed the participating nations to the demonstration and manufacture phase of the NATO Submarine Rescue System (NSRS). This in turn was followed by an ITT for the demonstration and manufacture of the new system in July 2002. The first NSRS is due to enter service about March 2006.

The UK will host the demonstration and manufacture and initial in-service support phases, the contract being awarded under UK law. One or more full rescue systems may be purchased.

Description
The future NSRS will provide a rescue capability for France, Norway, Turkey and the UK and will form the cornerstone of an emerging worldwide submarine rescue capability.

Working on behalf of the four NATO nations, the UK Defence Procurement Agency and WS Atkins will work to develop the multinational system that will be compatible with almost all NATO and many non-NATO submarines. It will be capable of operating from a wide range of commercial and military mother ships and be air-deployable worldwide at short notice.

Other primary requirements for the NSRS are: availability; the capability of worldwide deployment and operation (excepting the ice covered regions and open ocean areas); the capability to operate in any environmental condition likely to be encountered in order to successfully complete a rescue mission; the ability to reach a DISSUB in under 72 hours from the vehicle's area of operation; the ability to rescue up to 150 personnel from a DISSUB; a maximum rescue depth of at least 600 m and preferably 700 m; to rescue personnel from a DISSUB at internal pressures ranging from 1 to 5 bar absolute (objectively 7 bar absolute); the ability to mate with a DISSUB at seat angles of up to 45° with the aim of reaching 60°; the ability to mate with the DISSUB without the need of assistance from the DISSUB crew. This latter requirement grew out of the experience with the *Kursk* disaster in which the crew would not have been in a position to assist the DSRV.

The system will incorporate a number of elements including:
- rescue vehicle
- portable launch and recovery system
- decompression facilities
- ROV for underwater support tasks
- emergency life support stores
- C^3 equipment.

A number of current designs have been proposed as possible candidates for the rescue vehicle. These include:
- Remora (Oceanworks of Australia)
- LR7 (Perry Slingsby)
- S-SRV (Kockums)

Operational status
A contract for the first project definition/assessment phase of the NSRS to replace the LR 5 was awarded to WS Atkins teamed with Hard Suits Inc, Kongsberg Simrad Ltd, National Hyperbaric Centre, Rumic Ltd, Stolt Offshore Ltd, Telelogic, Top Express, and Virtual Present Ltd. Since completion of the project definition/assessment phase, Turkey has withdrawn from active participation and become an observer. A MoU was signed by the UK, France and Norway in 2003 and committed the nations to a 29-year programme of building, owning and operating a single shared system. An ITT was issued to BAE Systems, BMT Marine, Devonport Royal Dockyard, James Fisher Rumic, QinetiQ, Rolls Royce Power Engineering and Stolt Offshore Ltd in June 2003 with responses due in October 2003 and a contract award planned for March 2004.

UPDATED

South Africa

SM-5 D12

Type
Submarine escape and rescue decompression system.

Description
The SM-5 D12 submarine escape and rescue decompression system is designed to provide protracted split-level decompression treatment for up to 50 survivors and attendants at a time. The system features identical triple-lock compression chambers each with a capacity for 25 occupants. Each chamber has its own machinery package with low and high-pressure compressors, environmental conditioning plant, emergency air supplies and electrical distribution systems.

The system is designed for use on COOP vessels and the chambers are installed in two standard 12 ISO containers with the machinery packages each in a 6 m ISO container. With the system mounted on the vessels, commissioning requires only the connection of air and power supplies and other services.

Total weight of the system is 57 tonnes.

Operational status
Delivered to a Southeast Asian Navy in September 2000. This system is the largest and most technically advanced in the region.

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

VERIFIED

Sweden

S-SRV

Type
Deep submergence rescue vehicle.

Description
With the URF nearing the end of its operational life, Kockums has begun to design and develop a new deep submergence rescue vehicle, the S-SRV. The S-SRV is a further development of the URF and, like the URF, will be capable of rescuing an entire submarine crew of 35 persons in a single mission. The S-SRV will be capable of rescuing crews from depths down to 700 m, mate with a submarine lying at an angle of 60° and safely transfer the crew from the pressurised environment of a sunken submarine at pressures up to 7 to 9 bar, to a recompression chamber on a surface vessel. The navigational aids will include advanced sonar technology and the latest underwater cameras. The vehicle will be manned by two pilots and a rescue attendant.

The vessel will be fitted with a more powerful propulsion system giving it a speed of 4.5 kt.

Like the URF, the S-SRV will be transportable by road and various types of surface vessels as well as by air. It will also be capable of operating from another submarine.

Operational status
Under development and being marketed to new submarine forces such as Singapore.

Contractor
Kockums AB, Malmö.

UPDATED



Artist's impression of the S-SRV (Kockums AB) 0114382

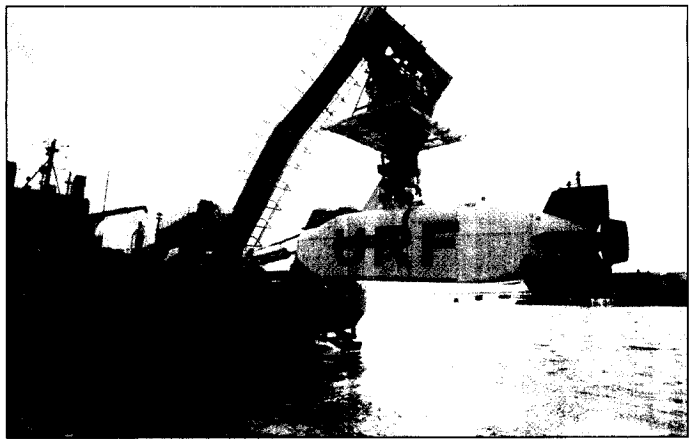
URF

Type
Deep submergence rescue vehicle.

Description
Kockums launched the URF deep submergence rescue vehicle of the Swedish Navy on 17 April 1978 for the rescue of submariners. The double-hulled vehicle has a length of 13.9 m, beam of 3.2 m, draught 2.8 m (surfaced) and a displacement of 52 tonnes and is built of HY-130 steel. The vehicle is powered by an electric/hydraulic system driving a single shaft for a speed of 3 kt and operates at depths of 460 m. The crushing depth is 900 m. The submerged endurance is 85 h and the vehicle is capable of rescuing 35 persons (the average crew strength of a Swedish submarine) in a single mission. The vehicle is equipped with a lockout chamber



URF rescue submersible (Kockums AB) 0114381



URF rescue submersible being recovered by the support ship Belos (Kockums AB) 0114502

that can support two divers to 300 m. With the lockout chamber the URF can rescue submariners directly from the pressurised hull of the submarine and transfer them, still under pressure via airlocks, directly to a compression chamber fitted on the salvage vessel *Belos* for treatment and controlled decompression. The URF can mate with the hull of a submarine even at angles up to 45°. The URF is crewed by three persons.

The vehicle is normally based at the Naval Diving Centre at Berga but can be transported by road using a specially designed trailer to a site suitable for loading on to its support ship, the submarine salvage vessel *Belos*.

Operational status
The URF is nearing the end of its operational life and Kockums is developing a replacement submarine rescue vehicle, the S-SRV. The URF has recently been refitted and will remain in service until 2005. Early in 1995 Sweden signed an agreement with Norway to provide submarine rescue services for the Norwegian Navy. Sweden has also signed a rescue agreement with Denmark.

Specifications
Length: 13.9 m
Beam: 3.2 m
Draught: 2.8 m
Displacement: 52 t
Speed: 3 kt
Operating depth: 460 m
Endurance: 85 h

Contractor
Kockums AB, Malmö.

VERIFIED

United Kingdom

Beaufort SEIE Mk 10

Type
Submarine escape suit.

Development
The Beaufort SEIE Mk 10 has been developed using extensive trialling and testing including live ascents at sea from submarines and simulated escape from 200 m. The Royal Navy's Submarine Escape Training Tank at HMS *Dolphin* and DERA Gosport have worked closely with Beaufort and MoD Navy to develop the new suit.

Description
The Beaufort SEIE Mk 10 comprises a submarine escape and immersion suit with an attached stole and ascent breathing hood, an inner thermal liner to help prevent the onset of hypothermia and an attached personal gas-inflated single seat liferaft to provide a safe environment for the submariner on reaching the surface. The entire equipment is carried in an outer protective stowage valise. The suit keeps the escapee dry and protected from cold shock during the ascent and also acts as a thermally efficient immersion suit on reaching the surface. Full protection is therefore provided whilst deploying and boarding the liferaft. The suit with stole and ascent hood provides sufficient lifting force to take the escapee from the submarine to the surface at a safe speed of around 2 to 3 m/s.

The inner thermal suit is worn over normal clothing and can be used by crew as protection whilst awaiting escape and prior to donning the outer escape suit.

The escape suit is a single layer waterproof one-size garment with improved simplified inner hood and ankle adjusters. It features an inflatable stole with two relief valves, an ascent hood with offset zipper and large clear view visor,

overshoes, wrist seals and integral cape leather gloves that provide additional protection to hands and improve dexterity. Splashguards are fitted to both the escape suit and the liferaft to prevent the ingestion of spray.

The use of the liferaft is deemed to substantially improve the escapees' chances of survival as it overcomes the crew member floating horizontally on the sea when they surface. Medical evidence has shown that this can result in severe kidney damage and can cause extreme musculo-skeletal pain, vomit ingestion and disorientation.

The suit is fully qualified for escape down to 180 m using escape towers fitted with the hood inflation system. The suit can be put on in 40 s and the crew member enters the tower, air is supplied to the breathing hood via a charging valve and the submariners automatically exit through the escape hatch.

Operational status
The Beaufort SEIE Mk 10 entered service with the Royal Navy in 1994 and is on board all submarines of the Royal Navy. The US Navy placed a contract for the system in 2000 with an order for up to 12,000 systems to be delivered over a six-year period. The Beaufort system is also in service with 15 other navies.

Contractor
RFD Beaufort Ltd, Birkenhead, Merseyside.

UPDATED

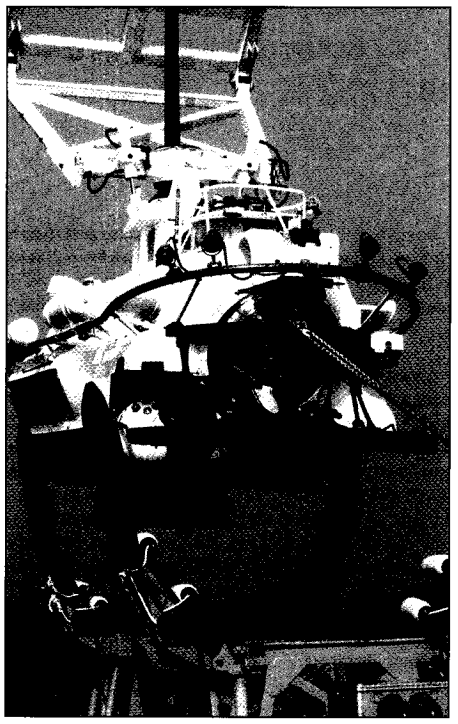
LR 5

Type
Deep submergence rescue vehicle.

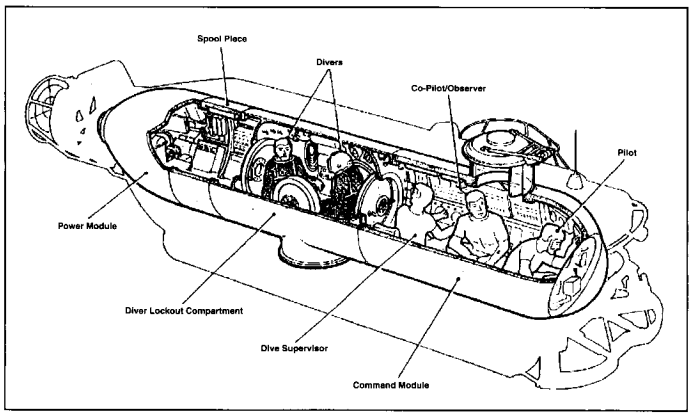
Description
LR 5, which is kept at 12 hours standby together with the ROV Scorpio 45 to meet a DISSUB call-out, is designed to provide a rapid reaction rescue capability ahead of the American DSRV in Northern European waters. In addition LR 5 complements the US capability for large-scale rescue scenarios such as would involve a nuclear submarine DISSUB. In operation the Scorpio 45 is used to survey, inspect and mark the DISSUB and then transfer life-support stores in special containers via the submarine's escape hatch.

The LR 5 consists of a primary pressure hull comprising a GRP cylindrical pressure hull with hemispherical command compartment containing an acrylic view port at the front end and a separately pressurised large rear steel rescue/diver lockout chamber. External structures contain the battery pods, ballast tanks, propulsion duct and fairings to the pressure hull assembly and a 15° wedge and connecting mating skirt. This transfer skirt is a hemispherical pressure-resisting shell that is attached to the rescue chamber of LR 5. The skirt incorporates seals that make the pressure-tight connection between the LR 5 and the DISSUB. 'Mating' with a DISSUB can be accomplished with the heel at 10° or with the bow at an angle of 60°, the wedge enabling the angle of the transfer skirt to be adjusted to mate correctly with the DISSUB.

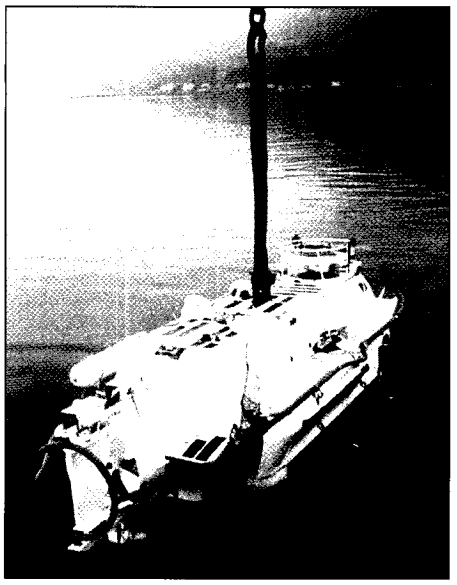
The 21.3 tonne vessel measures 10 × 3.2 m and is manned by a crew of three. It is capable of operating down to 400 m and can rescue up to 16 personnel in a single lift. LR 5 is powered by two 6 kW brushless DC electric motors which derive their power from batteries mounted in cylindrical pressure-tight pods. The motors drive two 660 mm diameter, 3-bladed steerable propellers to a speed of 2.5 kt measured against a seabed current of 1.5 kt. To assist with precise manoeuvring to



LR 5 submersible
(H M Steele)
0073841



Cutaway view of pressure hull (Perry Slingsby Systems) 0114384



LR 5 being lowered into the water. Stern view
(Perry Slingsby Systems)
0114383

enable the LR 5 to mate with the DISSUB auxiliary propulsion and steering is provided by four 4.5 hp hydraulically driven thrusters. Two hydraulic transverse thrusters are mounted at the bow and stern of LR 5 in addition to two amidships side thrusters, the latter tiltable through 180° (horizontal to vertical) to aid dry transfer docking.

Controls allow the pressure in the hemispherical shell to be reduced to match that of the remainder of the submersible, normally atmospheric pressure. When this condition is achieved personnel can then be transferred between the DISSUB and LR 5.

The vehicle is equipped with a Model 250A CTFM obstacle avoidance sonar, an AS 360M close range sonar and a 27 kHz pinger receiver. For navigation LR 5 is fitted with a gyrocompass, echo sounder, autopilot, and a tracking transponder can be carried. Communications equipment includes underwater telephone operating at 10 and 27 kHz, a Type 2056 voice and pinger operating at 10, 27 and 45 kHz and a 37.5 kHz pinger. In addition the vehicle carries various types of camera (still, video and so on), powerful lights and a manipulator arm that can be fitted with a variety of tools.

In 2000, LR 5 underwent a major redesign that featured a new steel rescue chamber, permitting an increase in payload capability.

The normal operating crew required to support LR 5 on a 24-hour basis consists of eight qualified personnel. The submersible crew normally consists of a pilot, a co-pilot and a rescue chamber operator.

Operational status
The LR 5, built in 1978 by the then Slinsgby Systems (now Perry Slingsby Systems Ltd), is operated by the commercially owned UK Submarine Rescue Service. The Service is owned, managed and operated by Global Marine Ltd (formerly Cable & Wireless (Marine) Southampton) and James Fisher Rumic Ltd on behalf of the UK Royal Navy who have retained the LR 5 contract since 1983. LR 5 forms an integral part of NATOs rescue system.

Specifications
Length: 9.2 m
Beam: 3.2 m
Height: 3.4 m (including mating skirt and wedge)
Weight: 21.5 t (including mating skirt and wedge)
Speed: 2.5 kt
Operating depth: 400 m
Crew: 3
Rescue capacity: 15

Contractor
James Fisher Rumic Ltd,
Dalton-in-Furness, Cumbria.

UPDATED

SARBE 10

Type
Submarine personal locator beacon.

Description
The SARBE 10 (Search And Rescue Beacon) is a new survival radio designed specifically for use by submarine crews. The submarine personal locator beacon is designed for immediate activation prior to commencement of the escape procedure to ensure that it begins transmitting when it reaches the surface.

Once activated, SARBE 10 transmits an internationally recognised distress signal on the COSPAS/SARSAT compatible frequencies of 121.5, 243 and 406 MHz. Additionally, the 406 MHz transmission contains a uniquely coded signal that declares the user organisation or code number as required. Central to the beacon's operation is a micro-controller that manages power, signal modulation and input/output logic.

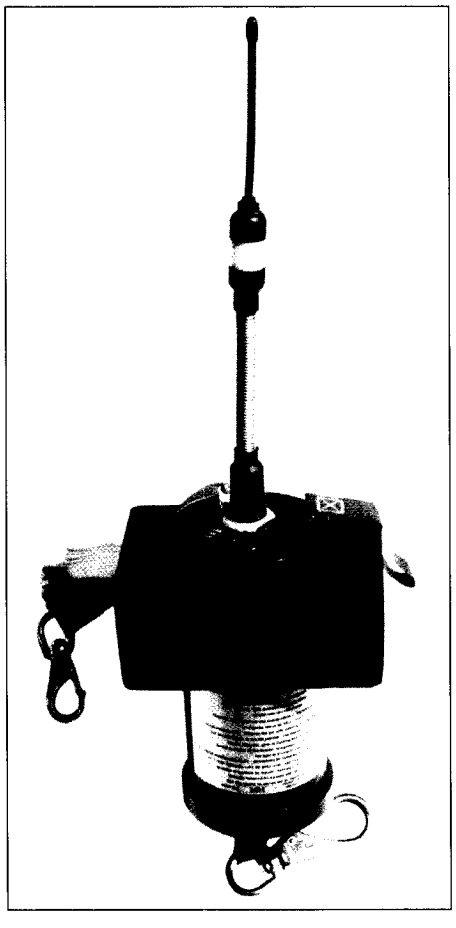
The fully sealed flotation beacon has a homing range of 70 n miles at 10,000 ft and can withstand pressures in excess of 35 bar, equivalent to a water depth of 350 m and provides a minimum operational endurance of 48 hours. The whip antenna features a radiation pattern of ¼ wave on 243 and 406 MHz and ¼ wave loaded on 121.5 MHz. A lithium manganese dioxide battery powers the unit.

The beacon comes with its own harness and was developed specifically for use with the Beaufort SEIE Mk 10 to which it can be attached to the liferaft by an integral lanyard, although the beacon is compatible with all escape suits and jackets. Additionally, the system is positively buoyant so that on reaching the surface the survivor can readily deploy the beacon allowing it to float nearby whilst remaining attached.

Specifications
121.5/243 MHz transmitter
Frequency: 121.5 MHz ±6 kHz, 243 MHz ±12 kHz (simultaneous operation)
Modulation: AM
Modulation rate: >85%
Endurance: >48 h
Range: >70 n miles @ 10,000 ft
406 MHz transmitter
Frequency: 406.028 MHz ±2 kHz
Output power: 5 W
Transmission duration: 440 ms (short message) every 50 s
Repetition rate: 47.5 to 52.5 s
Endurance: >24 hr
Range: >70 n miles @ 10,000 ft

Contractor
Signature Industries Ltd, London.

VERIFIED



AIC3
0132792

Scorpio 45

Type
Remotely operated rescue vehicle.

Description
The primary role of the Scorpio 45 is to assist in locating a DISSUB, survey the damage, then transfer life support stores in special containers via the submarine's escape hatch.

Scorpio 45 was extensively modified to support manned submarine emergency and rescue facilities for the Ministry of Defence. The system can be containerised for easy transportation at short notice.

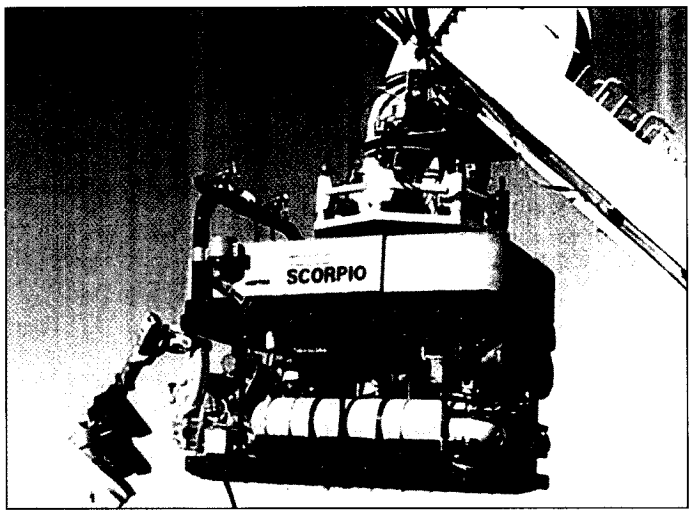
The hydraulic power pack has been upgraded by a 50 hp unit and the thrusters upgraded to 10 hp high-displacement units to allow operations to be conducted over a wide range of tidal conditions. The vehicle is fitted to operate a variety of specialised tools and sensors including: the TA9 manipulator, supply pod grab/manipulator, a full surveillance suite, and a pinger receiver.

Specifications
Length: 2.75 m
Beam: 1.8 m
Height: 1.8 m
Displacement: 1,400 kg
Operating depth: 1,000 m

Operational status
Managed by James Fisher Rumic Ltd on behalf of the UK Royal Navy.

Contractor
James Fisher Rumic Ltd, Dalton-in-Furness, Cumbria.

UPDATED



The Scorpio 45 vehicle showing manipulating arm 0131452

SRS INTO

Type
Integrated navigation and tracking outfit.

Description
Kongsberg Simrad Ltd have developed the portable INTO system, which is suited to rapid installation and deployment on any vessel of opportunity, where operational management of sub-sea assets is required.

The system displays surface and subsurface navigational data provided from integral (or external) sensor packages, to present the user with a full real-time object oriented database in a ECDIS type Windows network environment. The system has been developed to meet the UK MoDs ARM requirement for submarine rescue operations and contains integral: DGPS, gyro-compass, acoustic tracking system and display network hardware. The master/slave display network runs on an Ethernet with optional radio linkage to other vessels. Upgrade paths have been identified to provide data transmission to the rescue submersible and to distribute sonar and video images throughout the display network.

Operational status
Three systems are in service with the UK Royal Navy's submarine rescue service.

Contractor
Kongsberg Maritime Ltd, Aberdeen, Grampian

NEW ENTRY

SSE-launched Transponder

Type
Acoustic positioning device NSN 5845-99-325-0387.

Description
The SSE-launched Transponder is an integral device capable of ejection from a distressed submarine (DISSUB) via the Submerged Signal Ejector (SSE). The unit enables rescue assets to rapidly position the DISSUB using a number of commercial and naval acoustic tracking systems. In-service with the UK Royal Navy, the UK variant is compatible with Type 2059 and Type 2093 sonar and the Kongsberg HPR and HiPAP system range.

The unit contains an integral SSE ejection mechanism and a ballast weight at its base. Immediately upon ejection the rear section containing the ballast weight separates from the main unit by means of an approved separation device.

Operational status
The devices are in service with the UK Royal Navy's submarine fleet.

Contractor
Kongsberg Maritime Ltd, Aberdeen, Grampian.

NEW ENTRY

Type 639

Type
Submarine indicator buoys.

Description
The role of the Type 639 Submarine Indicator Buoy (SIB) is to alert sea rescue authorities to the plight of a submarine in the event of its inability to surface.

The distress submarine indicator system, developed by GEC-Marconi in collaboration with Bradley Electronics and Patrick Engineering, is designed to provide an integrated distress submarine indicator for new build and in-service submarines.

One or two units are installed on each submarine, stored in a nest outside the pressure hull. When two are installed, each can be released independently from within the vessel, one tethered forward, one aft. On release, the unit is automatically activated and transmits for a period of at least 72 hours.

The distress message is pre-programmed to identify the buoy and the submarine, and broadcast at 406 MHz. The distress message is processed by the Global Maritime Distress System for Ships (GMDSS) utilising the COSPAS-SARSAT satellite system.

In addition, the SIB radiates the international SARBE tone at 243 MHz for radio direction-finding, and as a high-intensity beacon to assist final location. The SARBE tone is a swept frequency dropping from 1,320 Hz to 440 Hz (nominal) in 40 ms, repeated twice followed by a 0.8 second quiet period. The cycle is then repeated.

The modular system comprises a GRP moulded nest, buoyant covers (to protect and streamline the Type 639 installation), retaining lockbolts, 'buoy gone' indication, mooring line dispensing system and associated internal control unit. The GRP moulded nest and streamlining covers can be customised to suit specific requirements. A single, customer selectable, pressure hull penetration is required.

A GMDSS modification kit is available for existing in-service Type 639 SIBs and the GRP moulded nest and associated features are available for retrofitting to existing Type 639 installations.



Type 639 indicator buoy

Operational status
The buoy, originally developed as the Type 639 for the Royal Navy is also in service with the Brazilian, Canadian, Indian, Royal Netherlands and many other navies. It is now available with full GMDSS (COSPAS-SARSAT) capability.

Specifications
COSPAS-SARSAT transmitter
Frequency: 406.025 MHz
Transmission mode: BI phase modulation
COSPAS SARSAT message
Format: digital message with submarine and SIB identity
SARBE tone transmitter
Frequency: 243 MHz + 7.5 kHz
Effective radiated power: 250 mW minimum
Transmission mode: amplitude shift keying

Contractor
AMS, Frimley, Surrey.

VERIFIED

Type 2073

Type
Emergency underwater telephone.

Description
The Type 2073 is an emergency underwater telephone/pinger which has been designed to assist in locating and communicating with a submarine or submersible in distress. In an emergency, the equipment can operate as a pinger producing low-frequency (10 kHz) tone pulses, with the receiver operational at the same time. As a rescue vehicle approaches, the pinger can be changed to a higher frequency (37.5 kHz) to enable the vessel to home in on the submarine or submersible escape hatch. For naval use, a 43.5 kHz frequency is included for communication with divers.

The equipment can also operate as a throughwater communication system, on any of three standard channels to communicate with rescue vessels, divers and other ships.

Operational status
In service with the Royal Navy.

Specifications
Underwater telephone
Frequency: 10, 27 and 43 kHz
Range (min): 3,600 m (low frequency); 2,200 m (mid-frequency); 685 m (high frequency)
Pinger
Frequency: 10 and 37.5 kHz
Range (to a sonar): 7,300 m (10 kHz); 1,800 m (37.5 kHz)

Contractor
AB Precision (Poole) Ltd, Poole, Dorset.

UPDATED

United States

DSRV 1 (Mystic) and 2 (Avalon)

Type
Deep submergence submarine rescue vehicles.

Development
Developed in the mid-1960s, following the loss of the USS *Thresher* in 1963 DSRV entered service in June 1970. A total of 12 DSRVs were planned, but owing to enormous cost overruns on the project the planned order was reduced to two units.

The size and weight was strictly governed by the perceived need for the vehicles to be air transportable in a USAF C-141 Starlifter cargo plane. A second Starlifter would carry logistic support.

Description
The primary mission of the DSRV is to provide a quick reaction, worldwide, all-weather rescue capability down to depths of less than 610 m in the event of a DISSUB mishap.

The vehicles comprise three 2.3 m diameter spheres built of HY-140 steel that are surrounded by a glass fibre outer hull. The spheres are connected by hatches, allowing personnel to move between spheres in the DSRV. The forward sphere houses the control and navigation equipment and is manned by a crew of two. The other two spheres are used to accommodate rescued submariners and two crew to

assist in recovering them. The spheres are designed to operate down to a maximum operating depth of 1,500 m. They have an underwater endurance of 30 hours at 3 kt and can maintain position in currents of 1 kt. Maximum submerged speed is 4 kt and rate of ascent/descent is 30 m per minute. Propulsion is provided by a 153 hp electric motor which derives its power from two silver-zinc 140 V DC 700 AH batteries. The motor drives a conventional shrouded pivoting propeller and for precise manoeuvring to position the vehicle over a distressed submarine, four thrusters are provided - two forward and two aft.

A variety of sonars are fitted including: a 27 kHz deep submergence obstacle avoidance sonar with a range of 7,315 m; a downward looking 500 kHz sonar with a range of 180 m used for mating the DSRV hatch with the submarine's escape hatch; a 24 kHz echo sounder; an 8 kHz communication sonar (a VQC voice and CW); a directional listening hydrophone tuned to 3-5 kHz to detect the submarine's AN/BQN-13 distress pinger; and a side scan sonar operating on 183 kHz with a range of 365 m either side of the vehicle. Other systems include a 35 mm still camera, five B/W video cameras, and one colour video camera in the bow. A single arm manipulator is fitted to clear hatches on disabled submarines, and a combined gripper and cable cutter are fitted.

All onboard machinery is designed to remain operational even with the vehicle at an angle of 45° submerged. A complete computerised control system allows the vehicle to mate with a submarine hatch at angles up to 40°, all onboard systems continuing to function normally. Up to 24 submariners can be rescued in a single lift.

The vehicles are transportable in C-141, C-5 Galaxy aircraft of the USAAF.

Operational status
DSRV-1 Mystic will remain in service on a constant rescue/ready status until 2005 when she is scheduled to be decommissioned and replaced by the SRDRS. DSRV-2 Avalon has been laid up.

Specifications
Displacement:	
surface:	30 t
submerged:	38 t
Dimensions:	
length:	15 m
beam:	3.28 m
draft:	2.4 m
Electronics:	
combat management system:	none
sonars:	27 kHz deep submergence obstacle avoidance; 500 kHz downward looking; 183 kHz side scan sonar; 24 kHz echo sounder; 8 kHz communication sonar; 3-5 kHz hydrophone to detect the submarine's AN/BQN-13 distress pinger
periscopes	none
radar:	none
electronic warfare:	none
Weapons:	
torpedo tubes:	none
torpedoes:	none
missile tubes:	none
missiles:	none
mines:	none
Machinery:	
diesels:	none
AIP:	none
batteries:	2 × silver zinc
electric motor:	2
nuclear plant:	none
auxiliary system:	4 ducted thrusters
shafts:	1
Speed:	
submerged:	4 kt
Range:	
surfaced:	24 n miles @ 3 kt
autonomy:	30 h
operating depth:	610 m (rescue), 1,525 m (max)
Personnel:	4 + 24 rescuees

Contractor
Lockheed Space Systems, Sunnyvale, California.

UPDATED

SEPIRB, T-1630/SRT

Type
Expendable submarine-launched emergency beacon.

Description
The SEPIRB (Submarine Emergency Position Indicating Radio Beacon), T-1630/SRT is an expendable submarine-launched emergency beacon that operates in conjunction with the international COSPAS-SARSAT distress system, having been granted COSPAS-SARSAT Type Approval, certificate No 116. The beacon is designed for launch from submarines in distress, and comprises a 406 MHz transmitter, integrated GPS positioning and 121.5 MHz beacon. Information transmitted includes unique submarine identification, elapsed time from activation, initial GPS position fix, and other distress data.

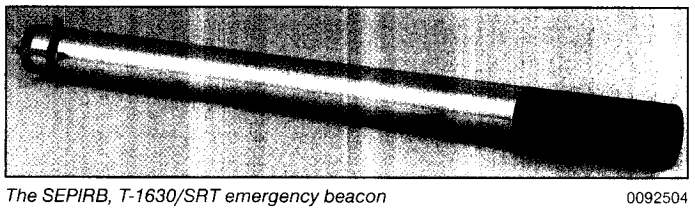
The beacon is deployed from a 76.2 or 101.6 mm (with adapter sleeve) signal ejector, or manually released via an emergency escape trunk. The beacon is powered by a lithium manganese dioxide battery.

Operational status
In production. In US Navy service, and is available to all approved countries.

Specifications
Diameter: 76.2 mm
Length: 1,003.3 mm
Weight: 3.62 kg
Data transmission: 406 MHz satellite message (national user format)
Beacon: 121.5 MHz (after 6 h delay)
Operating life: 48+ h

Contractor
BAE Systems North America, Advanced Systems, Green Lawn, New York.

VERIFIED



The SEPIRB, T-1630/SRT emergency beacon 0092504

MACHINERY AND PLATFORM CONTROL SYSTEMS

Introduction

One of the most significant developments since World War II, apart from nuclear propulsion for submarines, has been the adoption of the standard high-speed diesel for SSKs. Because it takes considerable time, effort and expense to develop a diesel, the main diesel manufacturers have tended to develop and adapt from existing ranges, engines suitable for submarine propulsion. However, while the diesel will continue to be the prime mover in a non-nuclear submarine, Air Independent Propulsion (AIP) systems are now a reality and will begin to enter service in increasing numbers.

Apart from the basic arrangement and type of nuclear power plants used in SSNs, few details concerning the specific designs are available. However, it is safe to assume that those navies currently operating SSNs will continue to develop these systems for their underwater fleets. Navies that currently operate SSNs are: China, France, Russia, the UK and the US. Navies that aspire to operate SSNs are Brazil and India.

The UK and the US are also carrying out studies into the viability of electric drive systems for SSNs, which would considerably improve their stealth capabilities, be more efficient and take up far less volume compared to current mechanical drive systems. The incorporation of an electric drive system would also enable all the power developed by the nuclear reactor to be available all the time for any system requiring electric power. Thus the power could be used not only for propulsion and hotel services on board the boat, but also to recharge high-endurance offboard vehicles such as UUVs, or to power directed energy weapons. The nuclear reactor can, in fact, provide a practically unlimited supply of electric power.

Since weight and space problems are of paramount importance to the submarine designer, the naturally aspirated diesel engines used during and after the Second World War have now been replaced by higher performance supercharged diesels. Diesel engines can be supercharged in one of three ways: by exhaust gas-driven compressors (turbochargers); by mechanically driven compressors (superchargers); or by a combination of both.

Continuing efforts are being made to improve diesel engine performance, bearing in mind the problems of greater exhaust back pressures and lower induction pressures developed when snorkelling. It is claimed that the mechanical supercharger is less sensitive to backpressure and develops a more consistent performance under varying conditions than the turbocharger. The latter, on the other hand, is claimed to have improved power:weight and power:volume ratios, as well as improved fuel consumption.

However, there are problems associated with supercharging a diesel while snorkelling. These include:

- a considerable drop in air intake pressure due to air pressure losses (between 0.10 and 0.15 bar) along the suction pipe inside the snort mast;
- high exhaust counter-pressure (currently >0.6 bar) due to the underwater level position of the gas discharge and the pressure losses inside pipes and the discharge valve;
- starting and running for a few seconds against the closed exhaust circuit leading to an exhaust counter-pressure increasing to about 1.5 bar until the exhaust discharge valve opens;
- and high air inlet temperature resulting from the fact that combustion air is used to renew the air in the submarine.

Furthermore, transient conditions induced by the sea swell period or resulting from the submarine's pitching, lead to a correlative increase in exhaust counter-pressure. This results from the increase of immersion and a decrease in inlet pressure after the air suction valve is closed.

From the first three conditions it is obvious that the engine has to act initially as a pump in order to counterbalance the loss in air intake pressure and the increase in gas outlet pressure. This places an additional workload on the engine compared to open air operating engines.

As a result a submarine's diesel cannot be supercharged in the same way as a surface vessel's diesel. This is because it is necessary to provide special timing on the engine valves with nearly complete suppression of the valve overlap period during which both inlet and exhaust valves are opened to prevent a counter-sweeping of the combustion chamber. Because of this, air cooling of the engine during the scavenging phase is reduced, leading to a higher temperature of the combustion chamber components in a submarine diesel than in a conventional diesel. This results in a power derating for thermal stresses.

Up to now most submarine engines have been supercharged by mechanically driven compressors. The advantages are:

- a positive system for maintaining air flow through the engine, which is largely unaffected by the snorting conditions, with a consistent performance over the whole output range;
- easy adjustment of the air flow;
- good load acceptance under all conditions;
- reduction of engine fouling;
- and tolerance to salt water.

However, since air compression work is taken on the engine crankshaft, there has to be a trade-off that leads to rather high specific fuel consumption in the region of 285 to 300 g/kW h at full load. This increases still more on part loads due to the fact that at constant engine speed there is constant compression work.

As a result of this limitation some manufacturers have adopted the exhaust gas driven turbocharger. Using this system it is possible to operate the diesel under snorting conditions by opening the exhaust valves a little earlier than on a naturally aspirated engine. This results in sufficient power being available on the turbine shaft of the turbocharger that is necessary to carry out compression. This results in improved specific fuel consumption figures in the range of 250 g/kW h.

However, three main problems are encountered with turbocharged engines:

- Firstly the boost pressure obtained by the compressor is very much affected by the difference between the absolute air inlet pressure and the absolute exhaust back pressure. Furthermore, when these two parameters suddenly change due to increased wave motion (the snort valve closes and immersion increases) the boost pressure is drastically reduced requiring a quick unloading of the engine to prevent overheating. Thus the turbocharger must be 'over matched' to overcome this problem which in turn results in surging as conditions improve. Then a waste gate is necessary to discharge the excess air that occurs in calm conditions.
- When engine power is reduced (at the end of the battery charging) the boost pressure drastically falls off and becomes insufficient to prevent the counter-scavenging of the engine by exhaust gases leading to rapid fouling of the engine.
- Inside the turbocharger the boost pressure is normally used as a seal to prevent the passage of exhaust gases towards the airside. As the pressure of the gases is higher than the air pressure, a separate compressed air supply is required to supply this seal.

The propulsion motor of the SSK is the low rpm DC electric motor connected directly to the propeller shaft and using two or four armatures. Speed control is achieved by grouping the batteries feeding the motor either in series or in parallel, variation between being achieved by altering the strength of the field. Developments in recent years have concentrated on increasing the power output and improving the cooling system using either direct water cooling or combined air/salt water-cooling. Work is now in progress on developing motors based on permanent magnets or a superconducting arrangement. The use of permanent magnets allows considerable reduction in weight (up to 30 per cent) and saving in space. One of the major advantages of a permanent magnet motor (PMM) is that the magnetic field is created without rotor losses. The use of permanent magnets to power submarine electric motors has been aided by the ability of rare earth cobalt magnets to combine high level magnetic properties with good temperature stability. However, there are some disadvantages in using the PMM compared to a conventional DC motor. Being fed from a DC source means that the motor can only be run after DC/AC conversion with its complete dependence on complex power electronics. This conversion introduces distortion into AC current waveforms which leads to torque ripples, vibrations and noise all of which have to be controlled. Finally the PMM does not allow short time overloads at high speeds through field weakening, a factor which must be taken into account early in the design of the submarine.

The other main machinery area in the SSK is the battery compartment.

The introduction of the silver-zinc battery has resulted in a considerable increase in the energy storage capacity. Experiments have been undertaken in the US with a lithium thionyl chloride battery, but the expense of such batteries precludes their consideration at the present time.

Batteries are extremely heavy and are placed in the bottom of the boat where they help to provide essential stability, accounting for about a quarter of the total displacement. Batteries have improved considerably in recent years, particularly in the areas of efficiency and service life. To provide control, batteries are divided into a number of sections (usually four) which are coupled in series or parallel.

The batteries are recharged by generators driven by V-form 4-stroke diesels that usually develop three-phase current which is rectified, although AC/DC units with static controls are also common. These AC generators have proved much more reliable with higher speed and higher output, resulting in a shorter recharging time than the older DC generators.

Continuing efforts to improve the discretion rate of conventional submarines and extend their range has spawned a whole new field of expertise relating to AIP systems. Diesel electric submarines are limited in submerged endurance by their battery capacity. Battery charging with the diesels is the most critical operational situation for submarines on patrol. The signatures of a submarine while battery charging are rapidly becoming more and more detectable, be it the radiated diesel noise, fumes and heat, or the emerging snorkel head.

A low-noise AIP is of vital interest, therefore, in being able to extend the submerged endurance, some sources quoting a doubling of range at a reasonable underwater cruising speed. Currently the most popular forms of AIP systems are fuel cells, the closed-cycle diesel engine, the Stirling engine and the closed-cycle

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

gas turbine. Some systems have been proven at sea, others are still under development.

The fuel cell uses an alloy as a catalyst with a mixture of liquid oxygen and hydrogen resulting in cold combustion to produce a direct current and water through chemical reaction. An alternative to the fuel cell is the closed-cycle engine such as the Stirling which uses cryogenic oxygen and various types of fuel. The disadvantage of such a system is the exhaust gases that have to be extracted and removed. Development work on the both the fuel cell and Stirling engine is continuing and more powerful engines are under development which, it is hoped, will ultimately be capable of completely powering a submarine.

In the United States the DoD is pursuing an advanced concept for submarine propulsion using pulsed water-jets. The Office of Naval research and DARPA are pursuing separate but complementary studies into the possibilities of developing such a system to propel submarines post-2010. Such a system would enable the submarine to carry increased payload while reducing costs. The DARPA study is examining the feasibility of building a distributed pump-jet propulsion system mounted outside the pressure hull. This would release a considerable amount of space inside the pressure hull for other systems without sacrificing acoustic, electric or magnetic signatures.

The distributed pump-jet propulsion system is being investigated in preference to the electric drive concept using large permanent electric magnet motors, as the latter technology is not considered sufficiently developed to meet submarine requirements.

Of critical concern to the management of a submarine is the machinery and platform control system. In a submarine the need to automate as much of the machinery/platform control as possible is a primary consideration in achieving satisfactory overall personnel levels. At the same time it is essential that these complex systems be as simple to operate and embody the optimum level of safety measures. This is a major undertaking given the constraints of volume and weight on board a submarine.

Many of the modern machinery/platform management systems are integrated systems (IPMS – Integrated Platform Management Systems) using modular distributed and redundant hardware and software configuration. To achieve the low crew levels required demands that much of the software in these systems is self-monitoring and self-diagnostic with fully automatic changeover to standby systems in the event of failure or damage. Hence the automated system must be capable of safely controlling and monitoring all the systems and equipment which are assigned to it. This covers the entire propulsion, power generation and distribution, auxiliary systems and stability. In addition the system must manage the general control of the submarine under all conditions of operation covering such diverse requirements as fuel status, lubricating oil status, ballast and trim tanks status, manoeuvring systems, cooling, air management, fire detection and regulate general damage control and so on. Such systems are necessarily complex in structure, but must be simple to operate and manage by a single crew member.

Future developments relating to IPMS include a much wider degree of integration of other ship board systems. An obvious aspect to further integration is that of navigation. For a submarine management system this will be a fairly complex system for navigation in submarines, carried out in three dimensions within the environment. Other systems which may logically be integrated into an IPMS include logistic and administrative functionalities. The final area to be integrated will be the combat management system. This will result in one large IPMS in which platform control, navigation, combat management and all ancillary services are all fully integrated leading to greatly reduced crew requirements and in which complete control of the platform and its weapons can be exercised from a centralised area.

The increasing use of automation to reduce crew requirements in submarines has led to improved capability but increasing complex systems for submarine control and management. To achieve the high level of security and reliability in such systems, extensive use is now being made of modelling and simulation to support concept development, definition requirements and evaluation of proposed design. In addition with the increasing sophistication of such systems and the increased dependence on computerisation there is an increasing need to provide risk reduction for the overall program.

The concept of the use of simulation and modelling in specific areas of the submarine and its systems is being taken even further with the realisation of the 'virtual submarine'. In this concept, examples of which include the Australian DSTOs Virtual Ship Project for the Collins class and the USA's similar project for the Virginia SSNs and modified Ohio class SSGNs, designers will be able to develop and evaluate new concepts, leading to more rigorous definition and improvements in the MMI interface. Perhaps the greatest benefit will be the possibility of improvement in risk reduction arising from system/platform compatibility issues which can thus be addressed very early on in design concept stage. This approach is being used by Saab Systems Pty of Australia in the development of the SCS-500 Mk 2 ship control system.

UPDATED

Canada

Control and instrumentation

Type
'Astute' class control system.

Description
The platform automation and control and instrumentation system for the 'Astute' class submarines provides integrated control of steering, diving, manoeuvring, depth control and complete platform management of the boat. The system employs modern distributed architecture digital control technology, which enables a considerable reduction in manpower requirements, while at the same reducing submarine production costs and providing enhanced operational effectiveness.

Operational Status
Developed for the UK 'Astute' class submarines under a contract awarded in 1999.

Contractor
CAE Electronics Ltd, Saint Laurent, Quebec.

VERIFIED

Fuel Cell

Type
Reformer fuel cell.

Description
Ballard Power Systems of Canada is developing reformer fuel cell technology. In reformer cells, hydrogen is carried in the submarine in the form of a hydrocarbon such as methanol. This is then converted into hydrogen and carbon dioxide catalytically.

Currently the Canadian Department of National Defence (DND) is funding development of a 50 kW exploratory development model of a reformer fuel cell that has begun proof-of-concept trials. Following the outcome of these trials the DND is considering funding a shore-based full-size 200 kW fuel cell generator. This generator would incorporate 12 of Ballard's Mk800 PEM fuel cell stacks to provide a nominal 400 V DC. In order to completely dispense with diesels Ballard has proposed that an air-breathing capability be incorporated into the system so that improved flexibility is available for both submerged on both air and pure oxygen. Trials with various elements of the AIP system (full scale reformers, combustors, hydrogen purifiers and fuel cell stacks) will continue until around 2002. Other tests will study the safety aspect of such a system including shock resistance, signature and so on. A shore based simulator with full scale power plant will be built to carry out many of these trials. From this a plug-in AIP unit will be designed for insertion into submarine hulls. Following proving trials the simulator will probably be used to train submarine crews.

The exploratory model uses methanol as the storage medium because it seems to provide the optimum storage medium for submarines, with the best energy density in terms of volume and weight. The other reactant in the process, pure oxygen, is stored cryogenically as liquid oxygen. The by-product of the reforming process (carbon dioxide - CO_2) is dissolved in the seawater. The cell uses a metal membrane of Palladium with high-pressure methanol steam reforming to generate hydrogen for the fuel cells.

Operational status
The Canadian DND has carried out studies into replacing the diesel generators from the 'Upholder' submarines with a mono AIP propulsion system. Should this plan be accepted then the 'Upholder' boats would probably be fitted with the AIP system during their first major refit in Canada, from about 2005 onwards. However, the Canadian Maritime Command allowed the contract with Ballard systems to expire during 2003, the contract not being renewed.

Contractor
Ballard Power Systems., Burnaby, British Columbia.

UPDATED

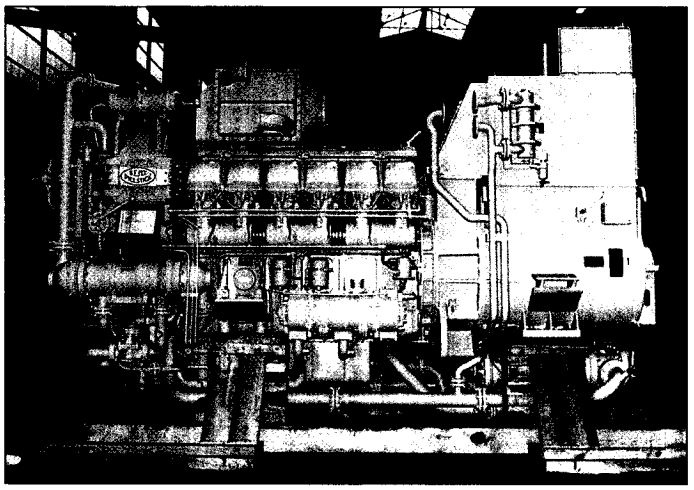
France

12 PA4 Series

Type
Supercharged diesel.

Description
Currently several types of submarine from seven different countries are fitted with SEMT-Pielstick PA diesels. The PA diesel installed in submarines differs from the standard engine in having a high exhaust back pressure in the exhaust manifold and a high suction at the engine inlet.

There are three standard ranges of submarine diesel: the PA4 185 SM, the PA4 200 SM, and the PA4 200 SMDS, all series being V-form diesels with 8 and 16 cylinders for the PA4 185 SM, 8 and 12 cylinders for the PA4 200 SM and 12 cylinders for the PA4 200 SMDS. The engines cover the range 480 to 1,330 kW. The two series are very similar using the same welded tunnel type of frame with V-form at 90°, same single camshaft and monobloc injection pumps, same bearing design and diameter, same variable geometry combustion system and same



A 12 PA4 200 SM diesel as fitted in the Walrus class of the Royal Netherlands Navy (SEMT-Pielstick) 0024692

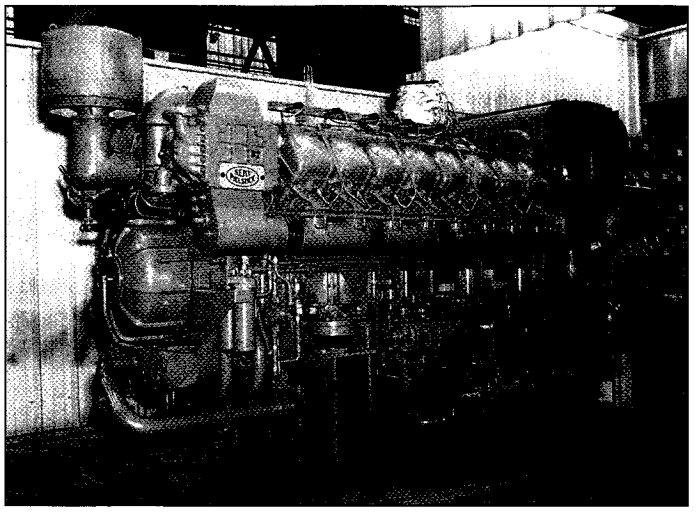
Specifications

PA4 V185 SM
Bore × stroke 185 × 210 mm

Type	Number of cylinders	Mechanical output			Dimensions (mm)				Mass (kg)
		rpm	kW	HP	A	B	C	D	
8 PA4 V185 SM	8	1,300	480	650	1,515	2,320	1,470	1,785	5,000
16 PA4 V185 SM	16	1,300	960	1,300	2,715	3,520	1,470	1,785	9,000

PA4 V200 SM
Bore × stroke 200 × 210 mm

Type	Number of cylinders	Mechanical output			Dimensions (mm)				Mass (kg)
		rpm	kW	HP	A	B	C	D	
8 PA4 V200 SM	8	1,300	700	950	1,515	2,320	1,470	1,785	5,500
12 PA4 V200 SM	12	1,300	1,050	1,430	2,115	2,920	1,470	1,785	8,000
12 PA4 V200 SM DS	12	1,300	1,330	1,810	2,115	3,120	1,670	2,130	9,200



A 16 cylinder PA4 V185 SM diesel as in the Agosta class submarines 0064609

compressor drive. They differ in that the bore of the 200 series has been increased from 185 mm to 200 mm (stroke remaining the same at 210 mm), increased diameter of crankshaft pins, a bevel cut type connecting rod design which enables the piston to be dismantled with its connecting rod through the cylinder liner, and a stronger, stiffer cylinder head design with improved air and gas circulation induction with new valves. The 12 PA4 200 SM uses a motor-driven compressor for supercharging to deliver 1,050 kW at 1,300 rpm at its coupling flange.

The 12 PA4 200 SMDS is supercharged with a compound system using both turbocharger and mechanically driven centrifugal compressor working in series on the combustion air feeding line. The combination comprises a conventional turbo-compressor in the first stage and a mechanically driven blower for the high-pressure stage. The work of the blower consists of re-establishing a pressure level at engine admission equivalent to the exhaust counter-pressure, and then to increase the power by using a turbo-compressor. In this configuration the engine delivers 1,330 kW at 1,300 rpm at the coupling flange.

In PA4 200 SMDS each of the two compressors is fitted with air intercoolers so that the supercharged air can recover a specific gravity consistent with good filling of the combustion chambers after its compression.

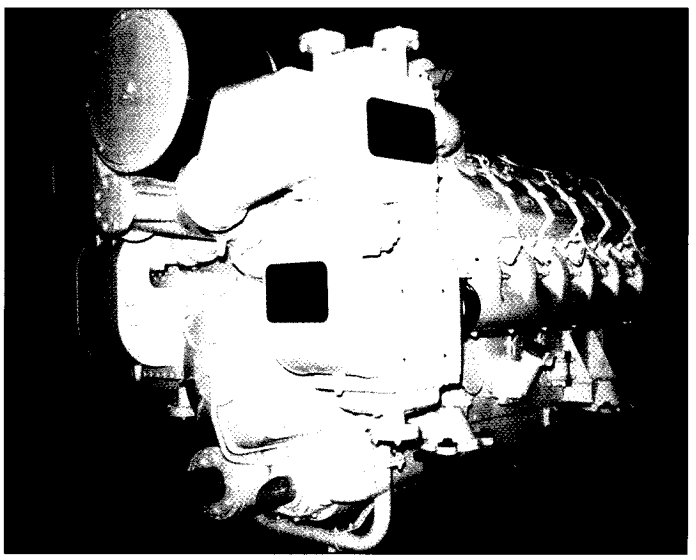
For surface operation a butterfly valve opens a bypass to discharge a part of the excess air exiting of the mechanically driven compressor to bring it back to the turbocharger air inlet, thus avoiding any surging of the compressor as well as excessive boost pressure/combustion pressure.

The two compressors in series can deliver a supercharging air pressure which can be as high as that in a conventional surface engine. Consequently, engine derating is limited to its minimum figure. Furthermore, due to the action of the mechanically driven compressor, the engine is fairly insensitive to variations in exhaust back pressure and loss of air suction pressure.

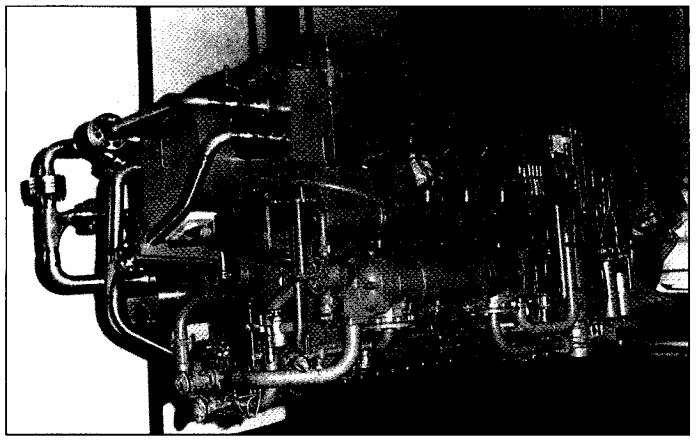
To obtain maximum efficiency the mechanically driven blower must be adjusted so that its compression ratio can restore the surface conditions, as seen, that is, from the turbocharger side. For instance, if the absolute air inlet pressure is 900 mbar and the absolute exhaust pressure is 1,620 mbar, the compression ratio must be: 1,620/900=1.8.

The power:weight ratio is improved by 20 per cent as the engine weight is only increased by about 10 per cent compared to a mechanically supercharged engine, while the power is increased by 30 per cent.

The specific fuel consumption (SFOC) is improved by so much that the mechanically driven compressor work is reduced. The SFOC figures are between 250 to 275 g/kW h. The air consumption of the engine is also reduced compared to the conventional supercharging system.



A 12 PA4 200 SMDS diesel as in the Scorpene class for the Royal Malaysian Navy 0125201



An 8 PA4 V200 SM 8 cylinder diesel as in the Le Triomphant class of the French Navy (SEMT-Pielstick) 0064608

The greatest advantage of this engine, however, is that it is insensitive to any deterioration in snorting conditions.

Tests have demonstrated that no derating is required up to 1,800 mbar at exhaust and 850 mbar at inlet with a 50° inlet temperature.

Operational status

The 12 PA4 V185 engine is in service aboard the Daphne class boats of France, Pakistan, Portugal, South Africa and Spain, while the 16 cylinder variant is operational aboard the 'Agosta' class of Pakistan and Spain and on the new 'Agosta 90B' of Pakistan. The 12 PA4 200 SM engine is in service in the Netherlands 'Walrus' class boats, while the 8 cylinder version of both the PA4 V185 SM and the PA4 200 SM is operational aboard all the SSNs of the French Navy.

The PA4 200 SMDS is the typical diesel engine for the Scorpene type submarine as for the Royal Malaysian Navy submarines.

Contractor

SEMT-Pielstick, Paris-Nord II. ***UPDATED***

Electric motor

Type

Electric motor.

Description

The Jeumont motor is of the totally enclosed pressurised type with a circuit water cooling system. The motor comprises one or two armatures coupled directly to the single shaft. A feature of the design is the ability to mount an auxiliary motor on the propeller shaft for emergency use or for extremely silent running at very slow speed.

Various methods are used to power the motor to efficiently provide a range of speeds. For low speeds the motor is powered by one or two batteries connected in parallel through a DC/DC converter, adjusting the field current and armature voltage. In the medium range, speed is adjusted by altering the field current, power again being supplied by batteries connected in parallel. For high speed, the batteries are connected in series again, adjustments of the field current providing variations in shaft speed. Speeds between the three fixed ranges are obtained by connecting the two halves of the motor in series or in parallel.

While batteries are being charged through the diesel generators the low and medium speed ranges are available. This is achieved by connecting one or two generators in parallel to supply the motor and having the batteries also connected in parallel with the generators. For diesel/electric propulsion when surfaced, either or both generators are used to power the motor directly, the batteries being disconnected. In this case armature voltage is adjusted by controlling generator voltage via the generator field.

Operational status

In widespread service around the world.

Contractor

Technicatome-Jeumont SA, Nantes. ***VERIFIED***

Magtronic

Type

Permanent Magnet electric Motor (PMM).

Development

The main advantage of the PMM over conventional electric motors for submarine propulsion is its power density, quietness, flexibility for operations and high level of reliability.

Development and research into the PMM began in 1987 when a small-scale (400 kW, 500 rpm) 25 phase PMM was built. A full-scale demonstration model rated at 1,800 kW at 300 rpm was tested between 1990 and 1996.

Initially the main differences between the conventional electric motor and the Magtronic relate to the stator winding and mechanical design. The stator comprises an assembly of an even number of segments each carrying a large number of phases in a single layer winding with low mutual inductances. To achieve an acceptable level of quietness the best compromise in the number of phases is 13. To increase the number of phases would lead to an increasingly complex system and an increase in the size of the electronics cabinets for very little improvement in vibration performance and hence noise reduction.

The stator windings are cooled by fresh water via a circuit inserted in the stator slots. Stator coil insulation is reinforced to overcome the constraints imposed by IGBT converters operating in a pulse width modulation mode.

The specific arrangement of the stator frame has resulted in a very compact mechanical design, which is light and shock resistant. If required the frame can be split in two without opening the winding or breaking into the cooling circuit. But the PMM itself requires almost no maintenance.

The company's permanent magnet synchronous motor is capable of achieving improved performance and is much more compact than conventional motors. The choice of permanent magnet and variable speed propulsion allows the company to offer radial-flux or axial-flux drive systems for submarines. These arrangements allow higher torque at low rotational speeds thus improving propeller thrust and acoustic discretion. From this, Technicatome-Jeumont can offer a magtronic system with a radial-flux permanent magnet motor or a magicdisc system based on an axial-flux permanent magnet motor, for submarines.

Description

The PMM Magtronic motor being installed in the Chilean Navy's 'Scorpene' type submarines develops about 3.3 MW at 160 rpm. The rotor is fitted with samarium-cobalt permanent magnets. The stator consists of 12 segments supporting 2 groups of 13 phases in alternation. Each group of 13 phases is supplied by a dedicated group of converters.

The motor is fed from two separate battery groups, independently, at up to 100/130 rpm and in serial coupling for higher speeds. The arrangement allows the basic splitting of the propulsion configuration into two halves in relation to the windings, the converters and auxiliary cooling systems while still providing 50 per cent of the rated output. However, the serial coupling of the battery sections can be used in the lower speed range but at the expense of the current ripple in the windings and efficiency.

The batteries and converters are protected by conventional DC air circuit breakers, while ahead of each set of converters is an electronic module which is fitted to preclude the generation of reverse currents from the motor and capacitor banks in case of a short in the breaker.

Operational status

Being delivered for installation in the Chilean 'Scorpene' type submarines.

Contractor

Technicatome-Jeumont SA, Nantes.

VERIFIED

MESMA

Type

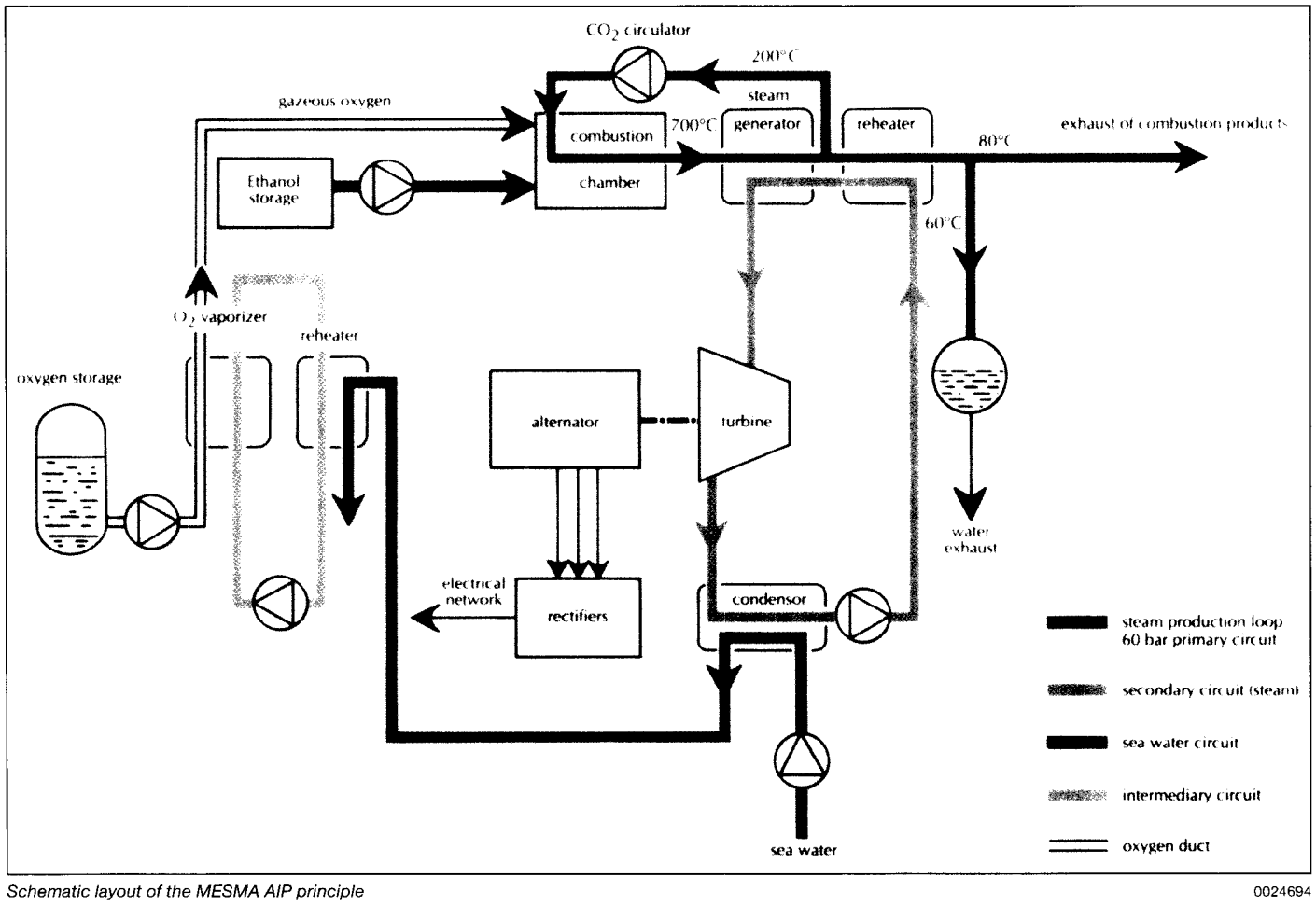
AIP closed Rankine-cycle engine.

Description

The MESMA (Module d'Énergie Sous-Marin Autonome) closed, cycle engine is being developed by DCN (prime contractor, secondary loop and systems integration) in partnership with Bertin Technologie (combustion chamber and primary loop), l'Air Liquide (LOX storage and cryogenic pumps), Izar (ethanol storage and integration), Thermodyn (turbine) and Technicatome (safety aspects). The system features a heat generation loop integrated with a Rankine-cycle steam turbine.

In the MESMA system, thermal energy is produced by the combustion of a gaseous mixture of liquid oxygen and fuel (ethanol (C_2H_5OH or diesel). The liquid oxygen is stored cryogenically at low temperature (–185°C) and low pressure (that is in liquid form at two to 10 bar) before being pumped into a vaporiser which increases pressure to 60 bar and turns it into gaseous form before combustion. In the combustion chamber the gaseous oxygen is mixed with the fuel to produce a thermal output of 700°C with a thermal energy of about 300 Whe/kg at around 60 bar. This thermal energy is used to heat a secondary circuit. The gases are passed through a heat exchanger (producing steam at 500°C and 18 bar pressure) and the primary part of a steam generator. In the secondary part of the steam generator water is vaporised and overheated and then passed through a turbine a conventional steam-driven Rankine-cycle turbine (steam generator, turbine generator and condenser) which is used to drive a high-speed turbo alternator-rectifier to supply DC electrical energy for the batteries, the propulsion plant and ancillaries. The oxygen and ethanol flow rates are monitored so that power production can be varied according to the submarine's requirements. Operating at about 95 per cent efficiency the steam turbine has an output ranging between 150 and 600 kW. Having passed through the steam generator and heater the hot gases are expelled directly outside the submarine at 60 bar pressure, which allows discharge at any diving depth without the use of an auxiliary pump. Part of these gases are bled off at the exit of the steam generator and returned to the combustion chamber to regulate its temperature.

The liquid oxygen and ethanol are stored separately in a dedicated section of the boat. The size of the cryogenic tank used to store the oxygen is determined by the



Schematic layout of the MESMA AIP principle

0024694

endurance requirement. The system has a high discretion value resulting from the silent and continuous combustion, the action of the high-speed turbine generator, and the constant-pressure waste disposal configuration. Because the system uses rotating rather than reciprocating machinery, the generation of LF machinery noise is virtually eliminated.

The MESMA module incorporates all the necessary command and control functions. It can be controlled locally through programmable logic controllers or remotely through the boat's IPMS. Using the IPMS, the operator can switch the AIP module on or off, monitor performance, and change the power setting from its main control room.

With an output of around 200 kW, the MESMA AIP allows a submerged submarine to increase its submerged endurance by a factor of around five at a speed of 4 kt.

An 8 to 10 m hull section will house the entire MESMA closed-cycle system in two modules, one for the LOX tank and one for the steam generator.

Operational status
Combustion tests on a 30-tonne core steam land-based prototype module of the MESMA AIP have been carried out by DCN. Full prototype testing of the MESMA system commenced in May 1998 with the first production system tested in the latter part of 1999. The LOX tank was installed in a hull subsection of the third Agosta 90B type submarine (the *Hamza,* formerly the *Ghazi*) for Pakistan on 18 April 2000. The steam generator was delivered in June 2000. The first production module (a 200 kW unit) was accepted by the Pakistani Navy in January 2002. The module was then shipped to Karachi for insertion into the *Hamza* which is expected to be fully operational in 2006. A further two systems will then be installed in the previous two 'Agosta 90B' boats. The 'Agosta 90B' boats are powered by a MESMA system using ethanol as fuel with a vertically mounted oxygen tank. The MESMA system offered for the 'Scorpene' boats, uses diesel oil as its fuel and a horizontally mounted oxygen tank.

Contractor
DCN, Paris.

UPDATED

PIC PL13

Type
Single helmsman submarine control console.

Description
The PL13 submarine control console provides all the necessary functions to control a submarine safely in three dimensions. Depth, trim, heading and speed are controlled in a centralised manner by the single helmsman. Platform control is achieved through the management of the submarine's diving and rudder planes, water tanks, and propulsion system, which are under full control of the PL13 console.

A very high level of integration and safety (reliability and availability) is achieved through the PL13 architecture. The main features of the system are:

- three modes of operation (automatic, manual, emergency — with components and modules separately dedicated to each mode both for display and control).
- constant system monitoring and automatic reversal to a safer mode
- three-channel fault-tolerant control computer
- three-channel sensors (depth and trim)
- two-channel plane management.

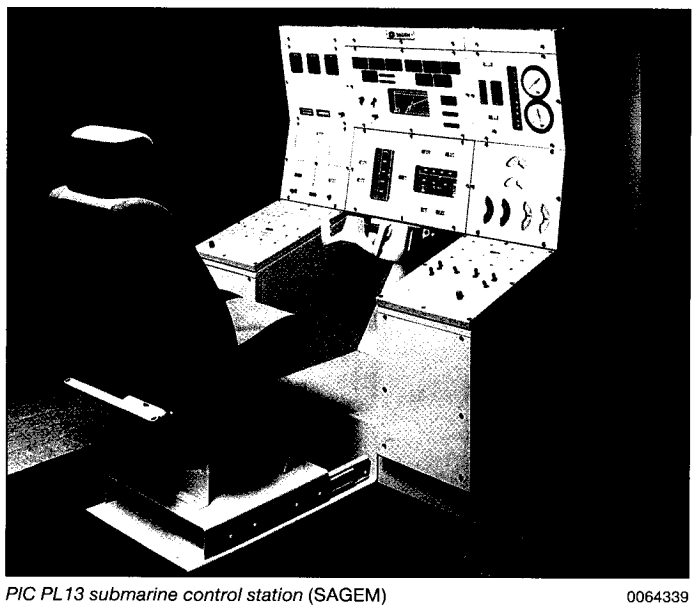
The PL13 incorporates a built-in autopilot which controls accurately and silently depth, trim and heading either in deep submerged conditions or at periscope depth under swell.

Maintainability is a key feature of the system. It offers multilayered, built-in tests, leading straight to the identification of the defective PCB in most cases. Its modular arrangement enables a fast access to the internal racks.

Operational status
Developed 1990. Production discontinued. Operational on board the French Navy Le Triomphant class SSBNs since 1993.

Contractor
SAGEM Navigation and Aeronautic Systems Division, Paris.

UPDATED



PIC PL13 submarine control station (SAGEM) 0064339

SS Mk 1

Type
Single helmsman submarine control console.

Description
The SS Mk 1 centralised control and monitoring console provides all the necessary features to control a submarine safely in three dimensions. Depth, trim, heading and speed are controlled in a centralised manner by a single helmsman. Due to its total functional and structural flexibility, it meets the present and future requirements in submarine control for boats in the 200 to 2,000 tonne displacement range.

The main functions of the system are:

- integrated course and depth control in three modes — automatic, manual servo-controlled, and manual non-servo-controlled
- calculation of settings and controls to accomplish manoeuvres
- remote control of buoyancy and trim tanks
- remote control of propulsion
- monitoring of all parameters relating to submarine control and safety (heading, depth, trim, speed and steering).

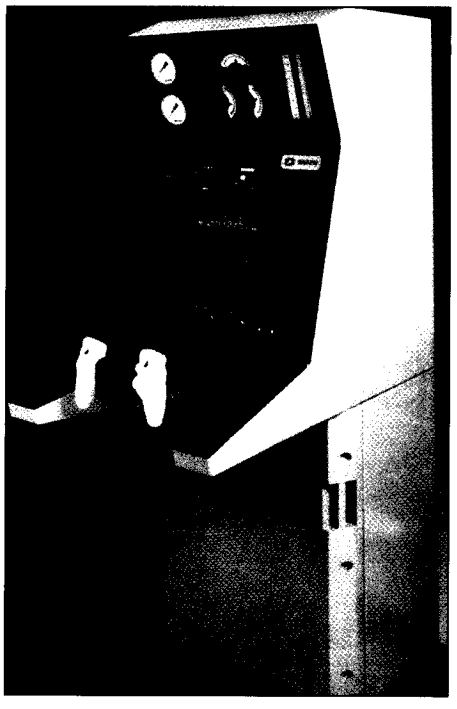
A high level of operational safety is ensured by the integrated multimode architecture of the system, which includes differentiated operating modes, multiple redundancies and automatic reconfiguration capability. The MMI is based on modern technology flat displays using colour active matrix LCDs and the modular management of the presentation screens.

The main primary functions provided by the system are:

- various autopilot modes required to meet all operational conditions
- depth prediction
- computation of submarine instability in trim and compensation and associated display of results
- 3-D representation to assist manual steering

Secondary functions provided are:

- plane control via control wheel
- emergency mode displays
- hydraulic valve control
- redundancy management
- automatic reversion to safer mode
- internal/external monitoring



SS Mk 1 submarine control station 0084887

Optional functions available according to design include:

- intercom
- main engine remote control
- emergency plane control
- bridge fin rudder remote control

The system integrates all hardware functions needed for submarine control including the multimode autopilot, redundant servo-control systems, monitoring devices and a large number of sensors. A high level of functional integration together with the very compact nature of the design ensures optimal installation conditions and maintainability. The system can be handled through a 700 mm diameter hatchway and allows separate installation of the upper and lower lockers inside the submarine. The design makes the system ideally suited to upgrade and modernisation programmes.

Operational status

Developed 1992 and prototype developed and tested in 1993. Production discontinued. In service aboard Agosta 90B submarines of Pakistan Navy.

Contractor

SAGEM Navigation and Aeronautic Systems Division, Paris.

UPDATED

Germany

396 Series

Type

Turbocharged diesel for submarines.

Description

In the 396 Series MTU has developed a modular concept of turbocharging, enabling various combinations of turbine/compressor units to be matched to the specific needs of individual applications. The 396 Series is available in 8, 12 and 16 cylinder versions with direct fuel injection offering power rating up to 1,060 kW under snorkel conditions which meets the power demand of medium-sized SSKs, and can be delivered either for twin- or triple-engine installations.

These 4-cycle exhaust gas turbocharged diesels use the familiar 'V' configuration with direct injection and external charge air-seawater cooling. Other features include direct liquid cooling of exhaust pipes and turbines resulting in a maximum surface temperature of less than 100°C without the need for additional insulation and providing full sealing against exhaust gas leakages. Emergency air shut-off flaps are integrated into the charge-air manifolds to provide protection against the engine running at excessive speed. In the event of excessive intake air vacuum the engine shuts down automatically.

The diesel is started against closed exhaust flaps with an exhaust back pressure of 2.4 bar absolute, and operates under snorkel conditions at 0.86 bar absolute intake-air depression, and 1.8 bar absolute back pressure. During operation, exhaust flow prevents seawater from entering via the exhaust outlet

The composite pistons are oil-cooled with steel crown and light-metal skirt and valve rotators are fitted on each of the two inlet and two exhaust valves on each cylinder. Valve control is exercised through two camshafts located high in the engine 'V'. Exhaust gases pass through a water-cooled silencer and water-cooled exhaust ducting for ejection, usually below the waterline. High-performance sleeve bearings and high-pressure fuel injection is used for improved combustion, the multi-plunger injection pumps being located in the 'V'. The crankcase and bell housing are of nodular cast iron, with a light-metal oil pan, the crankshaft running in sleeve bearings with connecting rods grouped in pairs.

The turbochargers incorporate simple, radial turbine and radial compressor wheels that are integral cast pieces. They are less susceptible to blade vibrations and consequently permit higher circumferential speeds. Gas tightness between the turbine and compressor is achieved by a piston ring sealing.

Operational status

MTU 396 Series diesels are in service with Type 209 submarines of Brazil, South Korea and Turkey, the Swedish 'Gotland' class, the Norwegian 'Ula' class, the Israeli 'Dolphin' class, and are being installed in the Type 212A boats for the German and Italian navies. 396 Series diesels are also fitted to minehunters in a number of navies.

Contractor

MTU, Friedrichshafen.

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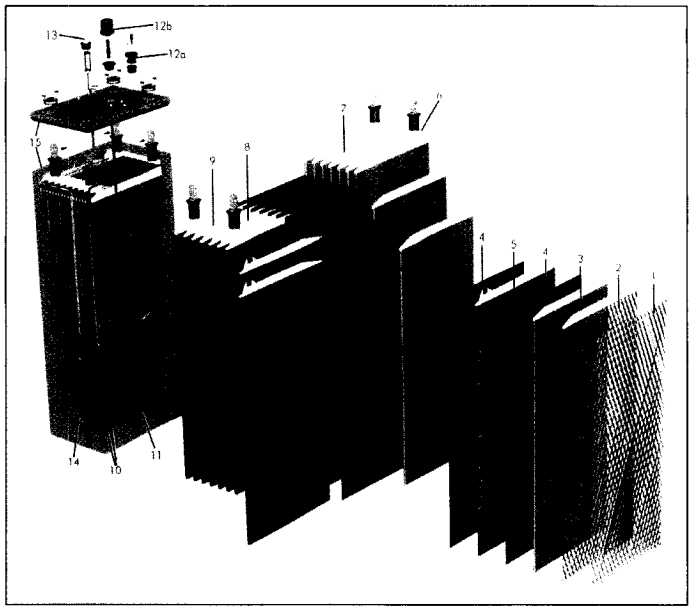
CSM Cell

Type

Submarine battery.

Description

Hagen has developed the CSM (Copper Stretch Metal) cell, in which the whole negative grid is made of expanded copper with a thin coating of lead, resulting in ×15 higher conductivity. The CSM is used to hold the active mass of fine crystalline porous lead to produce the best possible conductor, internal electrical resistance being reduced by about 60 to 70 per cent. It is possible to use copper for the negative grid because it is not electrochemically corroded, being in a voltage range of immunity. By reducing grid resistance to the point where voltage drop in the cell is lowered, current distribution becomes more uniform. The spines of the positive plate are electronically coated with low antimony lead to reduce the creation of hydrogen and achieve optimum charge during the first state of charging. The lead spines are surrounded by active material held by acid-resistant tubes made of glass-web. The top frames are composed of aluminium inlay to provide improved conductivity.



General arrangement of the CSM cell. (1)Negative grid of CSM cell (2)Lead-coated negative grid (3)Single negative plate (4)Separator (5)Single positive tubular plate (6)Negative pole bridge (7)Negative plate set (8)Positive plate set (9)Positive pole bridge (10)Acid agitation pipes (11)Lead strip for insulation measurement (12a) Service plug (vent) (12b)Backflash arrestor (alternative vent) (13)Acid level indicator (14)Rubber protection bag (15)Glass fibre container and cover 0024700

The electrolyte is diluted sulphuric acid using the highest possible concentration (1.3 g/m). Above this level corrosion is accelerated and performance would decrease.

Cells are housed in slim-walled high-performance GRP containers; the plate packages being entirely sealed by a rubber lining. Cell armatures provide easy access for control and maintenance.

Temperature differences in and between the battery rooms adversely affect the internal resistances of the cells. A single cell voltage can vary with 70 mV/10° change of temperature. Voltage differences in serial connections may add up in the partial batteries and subsequently affect deviating currents between these parallel-switched partial batteries. To avoid this undesirable effect, cooling water is lead through pole-bridge channels of each cell.

To prevent the electrolyte from developing an increased density in the lower volume of very tall cells, an auxiliary piping system is fitted to feed compressed air to the cells to agitate the electrolyte and ensure even density throughout the cell.

Operational status

In service with the navies of Chile, Germany, India, Indonesia, Israel, Netherlands, Norway and South Korea.

Contractor

EXIDE Nordic, Division HAGEN Submarine Batteries, Duisberg.

VERIFIED

Double-Decker

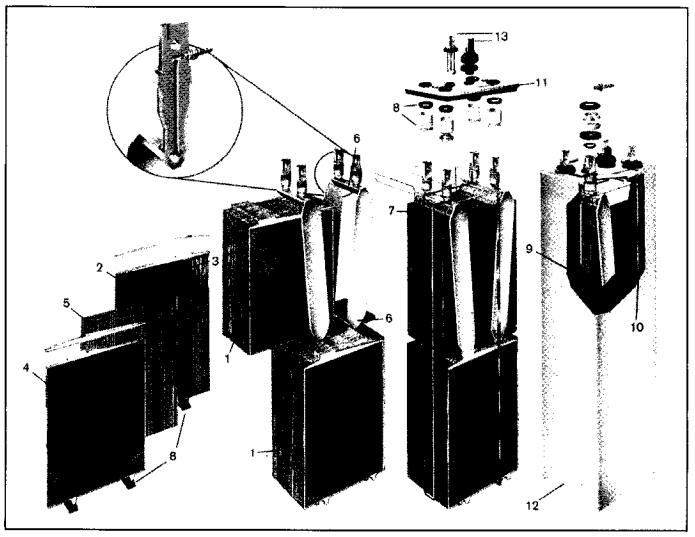
Type

Submarine battery.

Description

VHB Industriebatterien employs two different design principles in its batteries that are dependent on the requirements for the battery. In addition to cells of normal design with long, continuous full height plates, Double-Decker cells have been developed in which the negative and positive plates are only half as tall as in normal cells. This configuration allows the cell design characteristics to be varied within limits so that it can be adapted to meet specific demands with regard to low- or high-current capacity.

In the Double-Decker design two plate elements connected in parallel are arranged one above the other in one cell container. Lead insulated copper conductors join the two sets of cell connectors, which leads to greatly reduced



General arrangement of Double-Decker cell. (1) Plate element (2) Positive plate (3) Positive grid (4) Negative plate (5) Separator (6) Pole bridges (7) Acid circulation system in the cell (8) Shock absorption elements (9) Rubber liner (10) Insulation measuring sensor (11) Cell cover (12) Cell container (13) Service fittings 0024699

internal resistance of the cell. The Double-Decker cell employs low-antimony alloy technology to produce low inner resistance and hence good discharge performance, especially at medium- and high-power discharges. This results in more efficient charging leading to reduced snorting time.

Each plate element forms a unit made up of positive and negative plate groups, and their separators. The positive plate is of tubular design. The negative plate is a grid plate where the grid is both carrier of the active material and current conductor. The active material encloses the electrically conductive lead rods. The separator is a partitioning device mounted between the positive and negative plates.

The pole bridge is the physical connection between the plates and cell poles. Its main carrier consists of a several millimetre thick lead-coated copper tube, serving as a heat exchanger for connection to an external cooling system.

An important requirement for the function of submarine batteries is to achieve as uniform a distribution of acid density and heat within the cell as possible. As a result the acid must be circulated in the cell, especially during charging. In the Varta Double-Decker this is achieved using the 'air lift' principle.

Using an insulation-measuring sensor the insulation value between the measuring sensor and cell poles as well as between the measuring sensor and boat's hull can be determined. Openings in the cell cover accommodate acid level indicators, service plugs and vent plugs. The vent plug prevents explosion and flooding and covers against drying out of the acidic cell gas. An inspection glass is fitted to indicate the electrolyte flow during the acid circulation.

Cell protection is provided by spring elements, which support the plates to insulate them against shock, while the cell cover is of glass fibre reinforced material, which is extremely impact resistant, but at the same time highly flexible. The cell container is made of flame-resistant GRP resin, resistant to shocks and diluted sulphuric acid and prevents separate standing cells from bulging.

A computer developed jointly by Siemens and VHB automatically monitors the state of the cell. The computer collates, monitors, calculates, evaluates and registers data on battery and all voltage, energy charge and discharge, the state of the charge, acid density, acid temperature and energy remaining. More than 1,100 measurement points are collated in a 15 second cycle to present the operator with data such as ampère hours, charging factor, number of cycles and capacity available in the battery for differing speed requirements. Data is available automatically or on call-up on video display or high-speed printout.

The Double-Decker Plus battery differs from the standard Double-Decker design in that a copper conductor has been introduced to optimise the negative plate. This results in higher capacity during discharge, higher current capability in charging and a marked reduction in the heat produced in the cell.

Operational status

Double-Decker batteries have been installed in submarines of Argentina, Australia, Brazil, Colombia, Ecuador, Germany, Greece, Indonesia, Netherlands, Peru, Poland, Taiwan and Venezuela.

Contractor

VHB Industriebatterien GmbH, Hagen. ***VERIFIED***

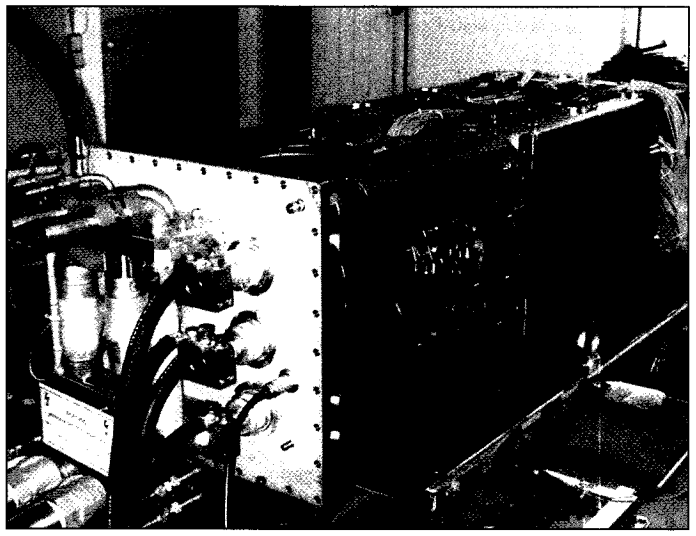
Fuel Cell modules for AIP Systems

Type

Polymer Electrolyte Membrane (PEM) fuel cell module.

Development

Since the early 1980s a consortium comprising Ferrostaal AG, IKL and HDW has funded research and development into a fuel cell AIP propulsion system for submarines. Exhaustive development tests with a land-based system were completed in 1986 and the German Navy Type 205 submarine *U1* was refitted at HDW's yard with a prototype propulsion system installed in a specially inserted hull section. Work on the refit began in March 1987 and the boat began sea trials in November 1988. Full-scale development of the fuel cell by Siemens was completed during the early part of 1995. The first cell module was delivered to HDW in August 1998 for integration into a shore-based total propulsion system for the Type 212 submarine.



A 120 kW PEM fuel cell module during performance tests 0059992

Description

PEM fuel cell modules are essential parts of fuel cell AIP systems for submarines.

In a PEM fuel cell a chemical reaction occurs to change the fuel (hydrogen with oxygen) directly into DC electric power with waste heat and water as by-products. This method of energy conversion gives important operational advantages to a submarine because no noise is radiated and very low heat is generated due to the low temperature process and to the high efficiency level (less than 80°C and efficiency of up to 70 per cent). Compared with conventional power plants, PEM fuel cells are more efficient and produce less pollution; the quantity of oxygen required for conversion is only about half that required in combustion engines. In addition PEM fuel cells offer low voltage degradation, long service life, favourable load and overload behaviour; they do not require a liquid corrosive electrolyte for their operation.

The heart of the fuel cell is the membrane electrode unit, the real place of the energy conversion. The chemical reaction between the hydrogen and oxygen at low-temperature in the Siemens PEM fuel cells produces DC with a voltage of slightly more than 1 V per cell at no load conditions. A certain number of single fuel cells connected in series (up to some hundred) forms the fuel cell stack.

The fuel cell module comprises the fuel cell stack, a humidifier, a separator for the removal of product water, and the necessary electromechanical and electronic control elements. Cooling water absorbs heat given off during energy conversion, part of this heat being used as energy to restore the hydrogen from the hydride and another part as evaporation energy for the liquid cold oxygen. The above mentioned parts of a fuel cell module are installed in a pressurised container and operated in a protective gas atmosphere.

At present two different types of Siemens PEM fuel cell modules are available: modules with an output between 30 and 40 kW and 120 kW modules.

A fuel cell AIP system as power source may comprise several fuel cell modules that can be connected electrically either in series or in parallel as required.

In the HDW AIP system the hydrogen is chemically stored in metal hydride cylinders where it is bonded in the metal lattice structure of a special alloy. The metal hydride tanks are sited between the pressure and outer hulls. The oxygen is stored cryogenically in liquid form in specially insulated double-walled tanks at below −180°C. These tanks may be installed inside the pressure hull or between the pressure and outer hulls.

The fuel cell plant is controlled from switchboards. In the case of modules with an output between 30 and 40 kW, two switchboards are necessary – one for the module electronics and one for control and monitoring of the AIP system including the safety system. In the case of 120 kW modules, one switchboard contains all necessary parts for control and monitoring of the AIP system. The fuel cell plant can be operated from the submarine control board (IPMS, for example, NAUTOS) and/or directly from the switchboards.

The German Navy has decided that its new Type 212 submarines will be fitted with this fuel cell technology as an integral part of a hybrid propulsion system. This decision was based on a successful development carried out by HDW/Ferrostaal/Siemens and supported by the German MoD/BWB. In the Type 212, the fuel cell, with an output range between 30 and 40 kW, will power a Siemens PERMASYN® electric propulsion motor to drive the submarine mainly in the range of low speed. The 120 kW fuel cell modules and a PERMASYN® motor (both from Siemens) will be basic parts for the new Type 214 submarines from HDW.

Operational status

On order for Type 212 submarines of the German and Italian navies (four and two boats respectively) and for the Type 214 submarines of the Greek and South Korean navies (four and three boats respectively).

Contractors
HDW, Kiel.
Siemens, Erlangen.

UPDATED

Nautos

Type
Integrated Platform Management System (IPMS) submarine optimised version.

Description
The Nautos integrated automated modular platform control system developed by Siemens AG is designed to control, monitor and co-ordinate all the technical equipment on board a submarine including, for example, an AIP system with PEM fuel cells and a PERMASYN® propulsion motor. Nautos forms part of a family of IPMS systems for surface ships and submarines ranging from a single operator station and local processing unit for data acquisition through to a complete shipboard automation system with decentralised distributed autonomous local processing units and section-by-section data actualisation. Directly assigned processes can be controlled and monitored via a local operating panel in the local processing unit.

Multi-server architecture and a redundant data bus system ensure a high level of fault tolerance and reliability.

Other features of the Nautos IPMS system are:

- long term data archives;
- optimum utilisation of power in process control of compressed air and of electrical energy;
- low noise control of tank pressurising;
- short cable routes and use of intelligent terminals and serial interfaces to other external systems.

Selected processes can be controlled and monitored rapidly and directly via controls and displays – bypassing the screens. Editing of process information into process displays allows fast access to information, and safe operation. Faults and messages are stored with details of date and time.

Operator control of process elements functions and the entry of values are checked for plausibility. When controlling the processes, the control system automatically takes into account the status of the submarine – whether snorkelling, silent running or ultra silent mode.

The system can also be used to acquire data on shipboard safety and security (for example measuring levels of toxic contamination, leaks, damage and so on). Using such data the system can be used to provide a complete damage control picture including managing communications between various sections of the vessel.

The system for the submarines is normally based around a central console for all operational control and supervision. The system will relieve operators of all routine tasks, making the boats easier to operate as well as being more reliable and safer.

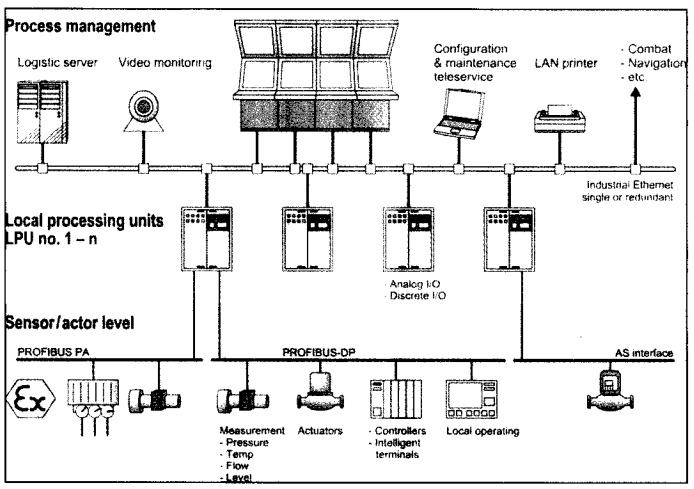
The system can also optionally integrate the following processes:

- steering control;
- cruise range calculator;
- battery monitoring system;
- hovering system.

Operational status
Delivered for the Israeli Dolphin class submarines. On order for the Type 212A submarines of the German and Italian navies (four and two respectively) and for the four Type 214 submarines of the Greek Navy and three Type 214 submarines of the South Korean Navy.

Contractor
Siemens AG, Erlangen.

UPDATED



NAUTOS system configuration. Note – the entire data bus can be provided either in fibre optic or copper – single or redundant (Siemens AG) 0122861

PERMASYN®

Type
Synchronous electric motor with permanent magnet field excitation.

Description
Siemens has developed the PERMASYN® permanent magnet field excited static inverter-controlled synchronous propulsion motor for the new generation submarines. The motor incorporates a bell-shaped rotor with permanent magnets and a polyphase stator winding with winding phases separately supplied by inverters. These inverters are fed by a DC power supply. The inverters are mounted inside the rotor (non-rotating). By means of pulse-controlled insultaed gate bipolar transistors (IGBTs), the inverters supply the stator windings with rotor position dependent AC. In this way the motor handles changing speeds in both forward and reverse directions with ease and offers step less speed variation over the whole forward and astern range.

Each inverter has its own open-loop and closed-loop control, which was specially developed for PERMASYN® drives. The control devices generate special pulse patterns to achieve minimum noise levels, minimum EMI and best efficiency.

All electronics for control and monitoring are mounted inside the motor housing.

The bell-shaped rotor has a magnetic yoke with high-energy capacity permanent magnets mounted on the outer circumference. With only low losses from the rotor, complex noisy air cooling apparatus is not required.

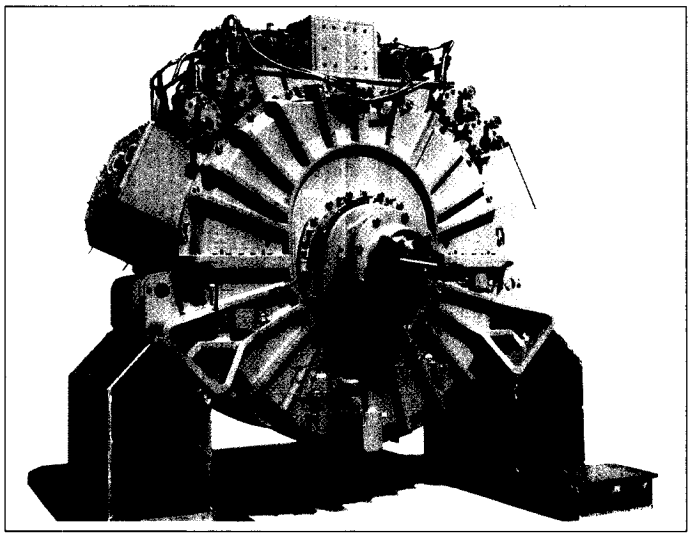
The stator consists of a solid, closed-yoke ring and is multiphase wound, each phase being electrically separated. The stator and the electronics are cooled via cooling water ducts and cooling plates.

The main advantage of the PERMASYN® motor compared with a conventional DC commutator motor developing the same torque, is that the motor as well as the entire propulsion system is much smaller. As such it will fit more suitably in a submarine design through better use of the available space. The design allows lower nominal speed and thus the use of propellers with better efficiency, which results in an overall lower noise emission.

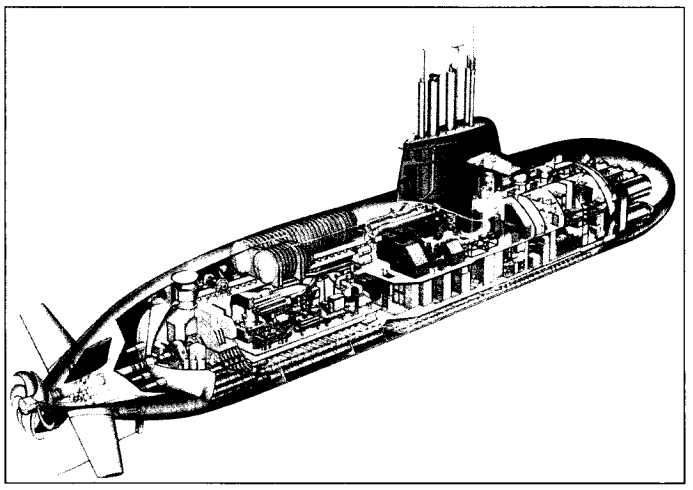
Operational status
On order for the Type 212A boats of the German and Italian navies (four and two boats respectively) and for the Type 214 submarines of the Greek (four) and South Korean navies (three).

Contractor
Siemens AG, Erlangen.

UPDATED



The new PERMASYN® motor (Siemens AG) 0105318



Cutaway of the U212 design which will incorporate the new PERMASYN® electric motor (Siemens AG) 0097210

Specifications

Typical performance of Type 209 battery in double decker configuration with tubular positive and lead grid negative plates

Discharge time	Discharge current	Capacity	Initial voltage Mean value	Minimum voltage Mean value	End voltage Mean value 80%	End voltage Mean value 100%	Minimum voltage Per cell
Hours	Amp	Ah	Volts	Volts	Volts	Volts	Volts
1	5,850	5,850	1.78	1.67	1.61	1.48	1.21
1.25	4,980	6,225	1.82	1.715	1.65	1.52	1.29
1.5	4,380	6,570	1.85	1.745	1.68	1.55	1.34
2	3,575	7,150	1.89	1.79	1.72	1.59	1.42
3	2,630	7,890	1.945	1.84	1.775	1.645	1.5
5	1,775	8,875	1.99	1.88	1.82	1.69	1.58
10	1,008	10,080	2.03	1.92	1.86	1.73	1.65
20	547	10,940	2.055	1.945	1.885	1.755	1.69
50	233	11,650	2.07	1.96	1.9	1.77	1.72
100	120	12,000	2.08	1.97	1.91	1.78	1.73

Greece

Batteries

Type
Submarine propulsion batteries.

Description
The Sunlight Company supplies batteries of the long tubular or flat positive and copper stretch metal (CSM) negative plates; double decker batteries with tubular positive and lead grid negative plates; and double decker batteries with tubular positive and CSM negative plates. The double decker battery with tubular positive and CSM negative plates is being supplied for the Type 214 boats for the Greek Navy.

Operational status
The Sunlight Company, a member of the Germanos Group of companies, signed a co-operation agreement with HDW of Germany in 2002 to supply submarine batteries for the four Type 214 submarines under construction for the Greek Navy at Hellenic Shipyards, Skaramanga, and for the three Type 209/1400 Mod boats under construction in Germany for the South African Navy.

Batteries have also been supplied to the Greek Navy for the Type 209 boats, to the Ukrainian Navy for the 'Foxtrot' class submarine, and to the Egyptian Navy for their 'Romeo' class boats.

Electrolyte density: 1.28 ±0.01 g/cm³ at 30°C
Internal resistance of a fully charged cell at 30°C: less than 0.05 m Ω
Short circuit current of a fully charged cell at 30°C: approximately 40 kA
Environmental testing: BV 0430, FGN\ fgn edition 03/85
Weight per cell:
uncharged and without electrolyte: 393 kg ±3%
charged and filled with electrolyte: 518 kg ±2%
Cell dimensions: height: 1,410 mm
Height (excluding poles): 1,336 mm
Length: 450 mm
Width: 290 mm

Contractor
Sunlight Company, Athens-Lamia.

VERIFIED

Italy

Gas exhaust valves

Type
External and internal watertight, cooled gas exhaust valves for submarine applications and relevant actuation systems.

Description
The design of the gas exhaust valve system is aimed at eliminating dangerous seawater leaks and noise during operations while having the valves remain operational and without having them replaced during the entire life of the submarine.

A special deformable sealing system is fitted in each valve to eliminate the possibility of even minor seawater leakages. The same sealing system matched with the use of a suitable water sprayer system eliminates the need for noisy grinding operations that are normally carried out in standard valves to avoid these leakages.

Each hull valve of the exhaust line system is made of special stainless steel to last the entire operational life of a submarine, and it only requires standard overhaul maintenance normally performed when the submarine undergoes its periodic maintenance about every five to seven years.

A cooling system used to protect the deformable gasket is also used to lower gas temperature thus reducing the IR signature.

Operational status
The gas exhaust valves have been produced for various installations since their first application over 25 years ago. They are currently in service aboard the Sauro class (Italian Navy), Agosta 80 (Spanish Navy), Agosta 90B (Pakistan Navy), U210 (Norwegian Navy), Walrus class (Netherlands Navy), TR 1700 (Argentine Navy) and are being delivered for the new Scorpene class for the Chilean Navy.

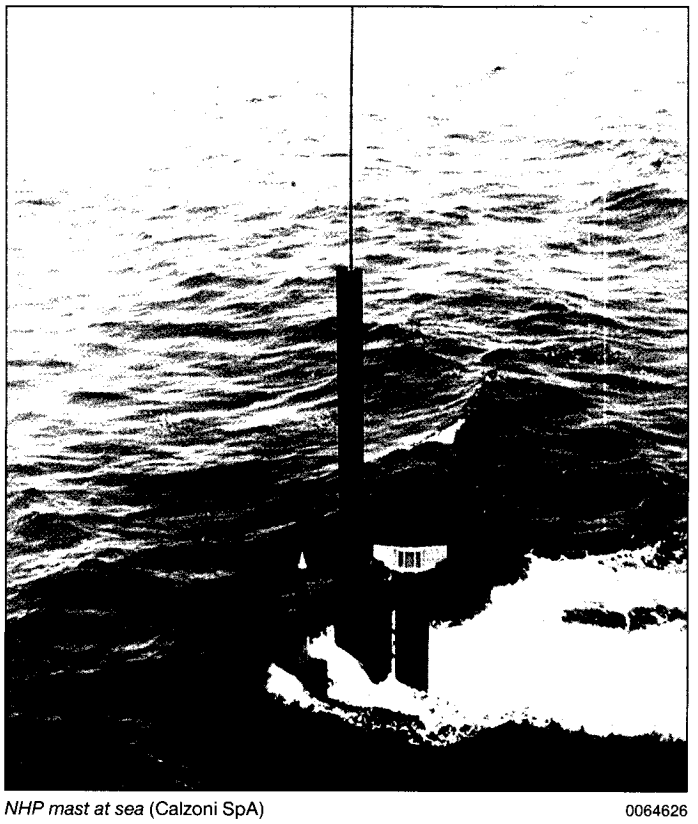
Contractor
Calzoni Srl, Bologna.

UPDATED

NHP masts

Type
Range of integrated modular non-hull penetrating masts for electro-optical sensors, ESM, MF/HF antennas, radars.

Description
Calzoni SpA produces NHP (Non-Hull Penetrating) modular masts for conventional and nuclear submarines. The NHP mast design consists of a cartridge compact module comprising an actuation mechanism (single or telescopic), a fairing assembly (to reduce hydrodynamic drag) and a guiding module consisting of a stiff, bolt-to-the-hull rectangular structure in which the entire mast is raised/lowered. This non-hull penetrating cartridge design, qualified through years of operations at sea, shows simple interfaces to the sail and to the pressure hull, eliminating expensive alignment procedures at installation and enhancing safety on board.



NHP mast at sea (Calzoni SpA) 0064626

Optronic mast
This is a double-stage hoist and retract system fitted with a closure door actuating mechanism. An electronic device is also fitted to provide continuous mast position indication along its stroke. In addition the equipment is fitted with a cable management system to allow a safe handling of the dip loop cable during mast deployment. Optionally the second stage may include an independent actuation system from the main fairing; in this case the optronic mast may be deployed using the wave-following mode to reduce exposure of the sensor above water.

Radar mast
The hydraulic actuator which controls the raising and lowering of the mast also houses a telescopic driving element to control the rotation of the radar antenna and a telescopic wave-guide. This overcomes the problem of the waveguide being exposed to the external environment.

As an alternative to the wave-guide telescopic system, the NHP radar mast can be fitted with a rotational drive unit interfacing the radar TX/RX unit mounted underneath the antenna. In this way the radar electronics and rotational unit will be self-contained in a sealed pod located at the top of the mast, with connections to the display consoles via a set of cables.

ESM sensor
The mast for ESM sensor comprises a single-stage hoist and retract antenna system, very simple in construction and thus highly reliable. It can be configured to include a wave-guide, rigid or flexible, to interface to a wide range of active or passive sensors. Optionally it can be provided with a closure door actuating mechanism.

Communications antenna
This is a three-stage hoist and retract system which can be fitted with different types of communications antenna. For example:

- HF whip aerial directly coupled to the HF tuning unit
- Multifunction antenna (VHF/UHF/IFF/SATCOM) that can be installed as a fixed or independently raised aerial.

The HF antenna is directly connected to an HF tuning unit, installed in a sealed box, and is contained in a GRP fairing where the antenna is deployed by a mechanical drive system actuated by hoisting the mast main fairing. In this way the HF aerial length is equivalent to the requirement for efficient TX/RX operation and features a minimum of 7 m radiating length.

Alternatively to the above configuration, a single HF/VHF/UHF/IFF/SATCOM multipurpose antenna can be installed, as a second-stage faired element into the mast main fairing.

MF antennas from different manufacturers may be installed. The MF antenna can include SATCOM receive capability and if separate from the HF antenna may be raised independently.

A suitable adapter allows the entire module to be integrated with the various sensors and in some cases allowing more than one type of sensor to be used on the same mast. This enables a certain sensor suite configuration in a submarine sail to be changed and tailored to the specific mission needs in a matter of hours.

Stealth features have been improved by the adoption of a deplumer device fitted at the masthead, by the ability to use on the entire fairing RAM/RAS materials and by fitting a 'closure doors system' with relevant actuation mechanisms to restore the sail hydrodynamic contour.

The NHP Masts are delivered completely factory pre-tested. Due to the compact highly integrated structure of the NHP masts, it is possible to provide the entire sail design as a pre-fitted and tested modular structure densely packed with NHP Mast (and sensor system) ready to be installed on the hull as a fully outfitted module.

Operational status
Calzoni SpA has supplied over 200 installations in several submarine classes both conventional and nuclear. Among new submarine programmes in which these systems will be/are installed are: the new Type 212A classes, and the SSN Virginia class. Current classes fitted with NHP radar and ESM masts include: Sauro, TR 1700, Type 210, Walrus, Type 206A and Collins. The US Los Angeles and Virginia classes are fitted with the optronic sensor mast. The communications mast is fitted in the Sauro, Type 210, Walrus and Type 212A classes.

Contractor
Calzoni Srl, Bologna.

UPDATED

Steering system

Type
Integrated steering system for submarines.

Description
The integrated steering system for submarines provides the person responsible for manoeuvring the submarine with automatic course and depth control and a manual follow up and emergency rudder plane control in the event of accident or damage. The fully redundant and fault tolerant system offers four operating modes:

- Fully automatic — providing way points (course, speed, depth and time parameters) which are preset using the control panel to define the boat's track. The vessel is then automatically controlled in all aspects of manoeuvre;
- Semi-automatic — using levers/joystick the operator can manually set the course and/or depth, the system then automatically controls the boat;
- Manual follow-up — the operator uses levers/joystick to control course and depth at all times;
- Emergency control — provides manual direct hard-wired control of the valve of each rudder plane.

The steering system provides precise manoeuvring of the submarine using data fed to it from depth sensors mounted in the hull of the boat via analogue and serial links and data from the combat system, platform control system, navigation system and bathygraph fed to it via BUS and/or serial links.

The steering console transmits control information via hardwire on/off link, hardwire analogue link and serial link to the hydroplane position control unit, the rudder actuator and sensors being controlled via hydraulic link, with rudder position data being fed back to the control unit via analogue link.

The system uses a fully redundant VME bus architecture with typical performances in the range of <0.2° in course error and <0.5 m in depth error.

Operational status
In service aboard Italian Navy Sauro class submarines and selected for the Type 212A programme of the German and Italian navies.

Contractor
Calzoni Srl, Milan.

UPDATED

Russian Federation

Kristall

Type
Fuel cell.

Development
Development of AIP systems using fuel cell technology can be traced back to the early 1960s and subsequent at-sea trials of a system aboard a Project 613 Whiskey class submarines. Studies into fuel cell technology were continued by the Krylov Research Institute, the Rubin Central Design Bureau for Marine Engineering and the Special Boiler Design Bureau Joint Stock Company. Between 1978 and 1986 it is reported that full-scale development of fuel cells to power submarines was undertaken. Systems were developed for three vessels: a Project 865 Piranha, the Poisk-6 deep submersible and Sirena-K swimmer delivery vehicle. Development was terminated in 1987-88 when funding was cut back. However, work on a hydrogen/oxygen generator for the Project 865 Piranha continued and was completed in 1991. This led to the ordering of a full-scale power plant powered by fuel cells known as the Kristall-20 fuel cell.

Description
Following the apparently successful testing of the Kristall-20 fuel cell, the Special Boiler Design Bureau Joint Stock Company continued design and development work into fuel cells resulting in the Kristall-27E system. From reports, it would appear that this design is now well advanced with engineering papers for a full-scale model under preparation.

Variants of this system are under development in co-operation with the Rubin Central Design Bureau for Marine Engineering for possible installation in the Project 1650 Amur class export design. In addition proposals for a fuel cell module based on the Kristall-27E system have been studied for retrofitting to Project 636 and Project 877EKM Kilo class submarines.

The basic system consists of two product water tanks, a liquid oxygen tank, hydrogen accumulators, heat exchangers and the fuel cell module incorporating electromechanical generators.

Operational status
Under development for Amur and Kilo class submarines.

Contractor
Rubin.

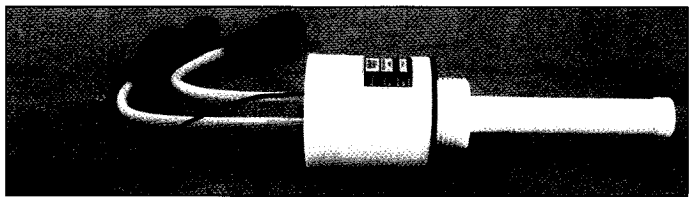
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Spain

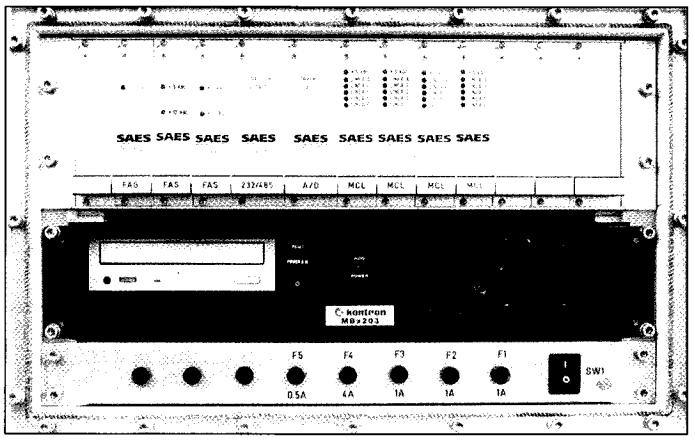
SVB

Type
Battery surveillance system for submarines.

Description
SCB is a monitoring and surveillance system for submarine batteries. The main functions of the system are to supply assistance to the operator in the control and surveillance of the batteries, monitoring the available electrical energy and identifying faulty battery elements.



SVB sensor (SAES) 1020651



The SVB console with monitoring and processing unit (SAES) 1020652

SVB provides the charge status of the battery, voltage, temperature and electrolytic level of each battery element, voltage, current and power from the battery switchboards, and detects failures and presents alarms.

The system also incorporates the possibility of evaluating the remaining autonomy in discharge or the residual charge duration.

The system comprises a console, which includes a PC and data acquisition central unit, and sensors installed in the battery elements.

Two surveillance modes are available: through the platform integrated control system of the submarine or through a laptop PC with access to the local MMI.

Operational status
In production and installed on board the first 'Scorpene' submarine for the Chilean Navy.

Contractor
SAES, Cartagena.

Sweden

NDC 1000

Type
Machinery control and monitoring system.

Description
The microcomputer-based NDC 1000 operates and monitors each of the two diesel engines on board the Vastergotland class submarines of the Swedish Navy. The installation controls the fuel and lubricating systems, engine cooling, speed, battery charging and exhaust and locking ventilators.

The diesel generators can charge the batteries via a rectifier even at periscope depths. Air is drawn in via the tower and exhaust is discharged underwater. This causes back-pressure which puts heavy demand on the control system to operate the relevant ventilators quickly and accurately.

The complex control system is designed to operate effectively in humid and pressurised conditions.

It is clear and simple to operate and only basic training is required.

Operational status
In service on board four Vastergotland class submarines of the Swedish Navy.

Contractor
Netzler and Dahlgren, Sweden. ***VERIFIED***

SCC-200 and ISCMMS

Type
Submarine steering control and ship management systems.

Description
The SAAB SCC-200 steering control system, already in service with the Swedish Navy, is also operational aboard the Norwegian Ula class SSKs and an upgraded variant equips the Australian Collins class SSKs. The one-man control system is a dual-channel system providing course and depth control, trim and compensation water control and speed control of the main motor. Control is carried out automatically or semi-automatically and the operator is kept informed of the full state of the boat on the display.

The much modified variant of the SCC-200 developed for the Australian Navy Collins class is referred to as the ISCMMS (Integrated Ship Control Management and Monitoring System). The system configuration comprises control consoles, general control consoles, manoeuvring control console, local control console, substations and the databus system.

Two types of control console are used – a general purpose console and a limited purpose console. The general control console consists of two full-colour VDU screens, a keyboard, hardwired controls and a general computer unit. The VDUs are provided with function keys integrated into the lower part of the mounting, adjacent to the screens. The keys are used to adapt the control possibilities of the system to the actual status of the system at any time. The manoeuvring console is a general control console configured for the task of manoeuvring. It is provided with autopilot software and reinforced redundancy. The local control consoles have limited functionality and consist of a monochrome display and command keyboard. They are connected to host computers. These consoles are intended for local control of the host nodes and all connected platform equipment. The databus is a dual-redundant Ethernet system.

The system uses distributed architecture with functionality being provided at substation level.

The display features a tiled window layout that ensures all displayed information is visible to the operator at all times. The separation of commands and detailed data (such as alert delays and object names) from the mimic diagrams leads to less cluttered displays and less operator overload.

The system is capable of displaying a large number of pages or mimic diagrams. Each page provides the operator with a clear and precise view of the platform system under scrutiny using computer-generated graphic colour mimic diagrams. Objects can be quickly selected using the cursor symbol.

Operational status
SCC 200 is in service aboard the Norwegian Ula class submarines and ISCMMS is operational aboard the six Australian Collins class submarines.

Contractor
Saab Bofors Dynamics, Jonkoping.

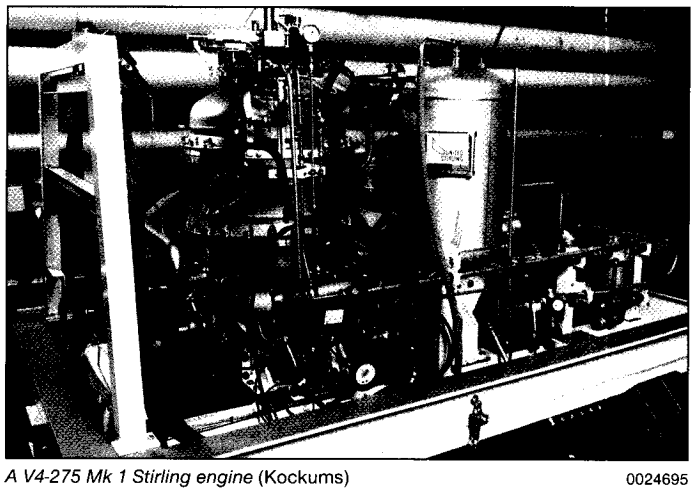
VERIFIED

Stirling AIP system

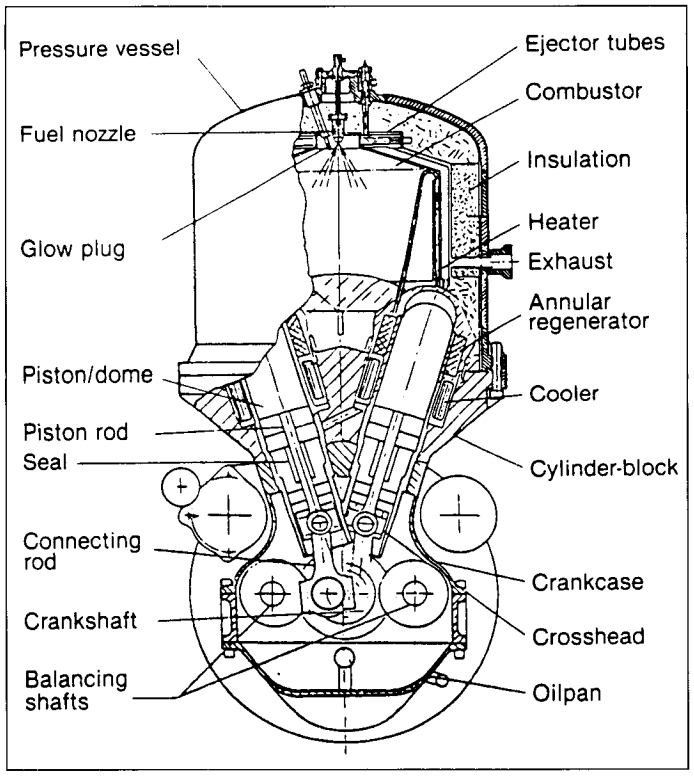
Type
Stirling AIP engine.

Development
Kockums began testing a prototype Stirling engine in 1983 and carried out tests on a floating platform in 1985. Two Mk 1 engines were then exhaustively trialed aboard the Swedish submarine *Näcken*. An 8 m long section containing two V4-275 SUB Mk 1 Stirling engines, two large Liquid Oxygen (LOX) tanks, and shock mounts and sound isolation equipment was inserted in the submarine. In the configuration adopted by the Swedish Navy the Stirling AIP plant is intended as an auxiliary low-power, long-endurance system to complement (but not replace) the conventional diesel/electric plant. The main function of the AIP source is to power the boat (with minimum radiated noise) during low- and medium-speed surveillance operations, allowing the main battery to remain fully charged and available for engagements demanding full speed.

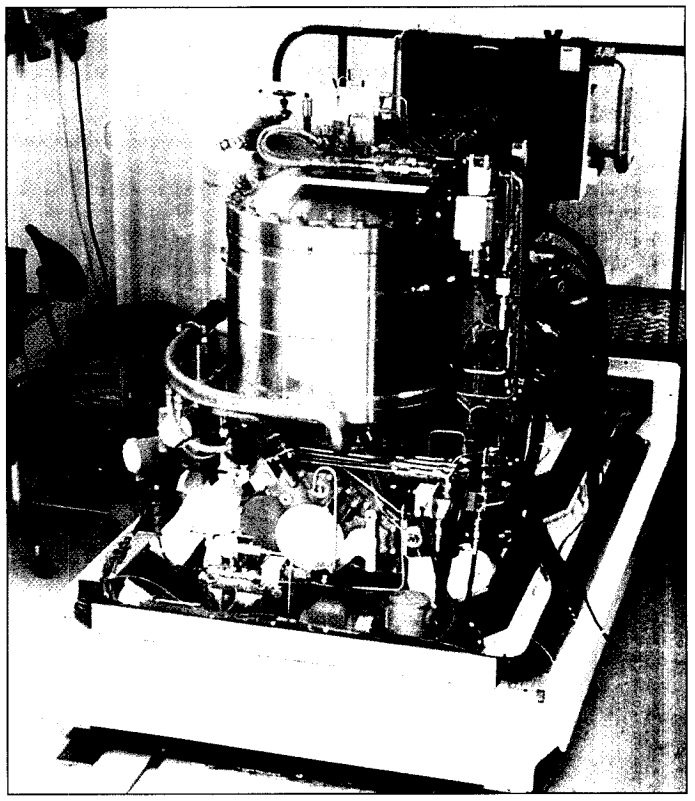
Description
In the Stirling AIP system heat energy provided by high-pressure diesel oil/liquid oxygen combustion is converted by the engine into mechanical power through a



A V4-275 Mk 1 Stirling engine (Kockums) 0024695



Block schematic of the Stirling engine 0024696

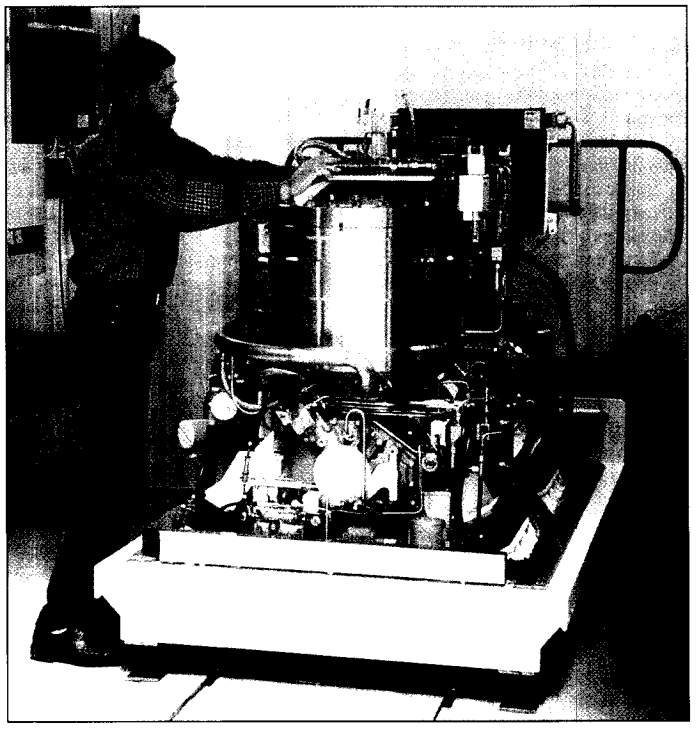


Stirling Mk 3 engine (Kockums) 0092002

thermodynamic process and then converted into electrical energy by a synchronous alternator. The AC current from the alternator is then rectified and fed to the boat's DC main in parallel to the battery. The LOX is stored in cryogenic tanks at a temperature below –180°C in the lower part of the AIP module. The tanks are well insulated, allowing the LOX to be stored for several weeks before pressure rises to a critical level. The efficiency of the engine is around 38 per cent. The V4-275R engine uses one part diesel fuel to four parts LOX, the two fuels being combined and burned in an external circular combustion unit.

The heat so generated is continuously transferred to the working gas (helium) contained in a closed-circuit heat exchanger inside a large bell-shaped chamber. A regenerator reclaims the heat energy, storing much of the heat contained in the gas after expansion and feeding it back into the cycle as the gas reverses direction. The working gas expands above each piston when heated and compresses below it when cooled, driving the piston up and down to rotate the crankshaft and provide mechanical output. The pistons in a double-action Stirling system have a dual function, each piston operating simultaneously in two cycles so that the hot (upper) surface of a piston works within the same cycle of the cold (lower) surface of the adjacent piston.

The engine exhaust consists mainly of carbon dioxide (CO_2) and water vapour. Following combustion, the exhaust gases are fed to a gas condenser where the water vapour is condensed. The residual gases are then fed to an absorber where the CO_2 is dissolved in the cooling seawater and discharged.

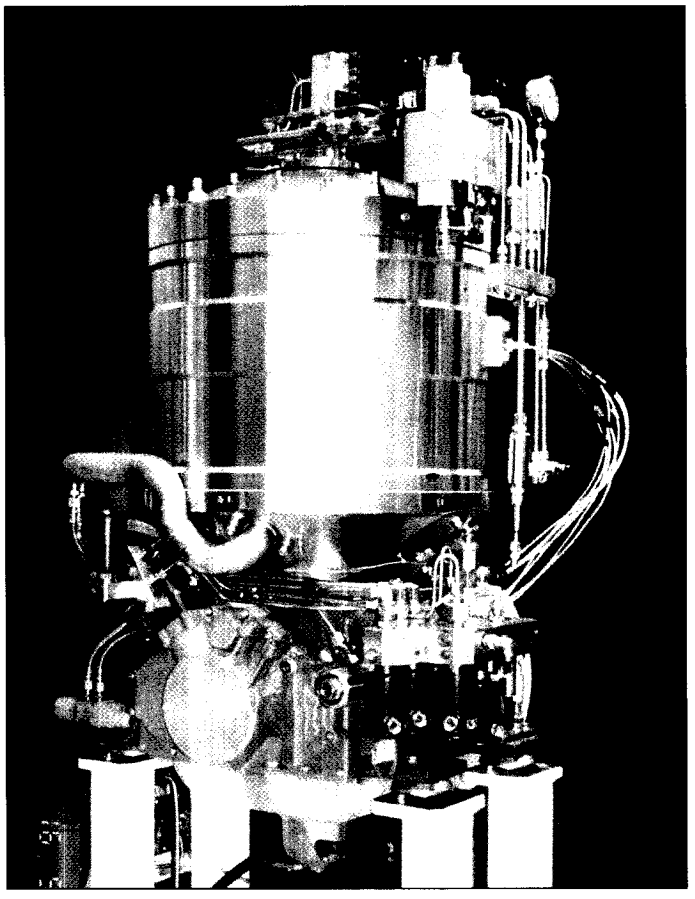


Stirling Mk 3 engine (Kockums) 0092003

The exhaust-cooling unit is integrated into the engine module and cools the gas from 800°C to around 25°C. Combustion pressure is maintained at 20 to 30 bar, independent of depth down to 300 m. This being higher than the surrounding seawater pressure, allows the exhaust products to be discharged overboard without using a compressor. This results in a noiseless and traceless system. The engine can be adapted to operate at depths beyond 300 m (down to 600 m), but only if an exhaust gas compressor is added, which would increase noise and fuel consumption. The pressure-proof combustion chamber is housed in a spherical casing for reasons of weight and strength.

Stirling generators are always run in parallel with the boat's batteries which simplifies power control and provides the submarine with complete independence in the event of a failure of the Stirling system.

The V4-275R is a 4 cylinder engine in a 'V' configuration, delivering a maximum output of some 75 kW with 110 kW of heat at 2,000 rpm and at a water temperature



Stirling Mk 3 engine (Kockums) ***NEW***/1032450

of 50°C. Fuel consumption is 250 g/kW h and oxygen of 830 g/kW h. The engine weighs 750 kg, has a swept volume of 275 cm³ and measures 0.8 × 0.8 × 1.4 m. The complete system, including compensating water tanks and all auxiliary systems are fitted in an autonomous hull section. The Stirling Mk 3 engine is a further development of the Mk 2 engine and features improved characteristics including higher continuous power output (70 kW), lower oxygen consumption, longer intervals between service, improved maintainability and overall efficiency and availability of the entire AIP system. It incorporates a new combustion chamber and more compact module arrangement.

Submerged endurance is determined primarily by the amount of LOX stored in the cryogenic tanks.

Operational status
The V4-275R Mk 2 is in service aboard the Swedish navy Gotland class boats. Each boat is fitted with two engines, although originally intended to carry three (the third engine was deleted for cost reasons). Kockums has been awarded a contract by FMV to further develop the Stirling propulsion system for the next generation of submarines. The latest development is the Stirling Mk 3 engine, which will be installed in two modernised Västergötland class submarines.

Contractor
Kockums AB, Malmö.

UPDATED

United Kingdom

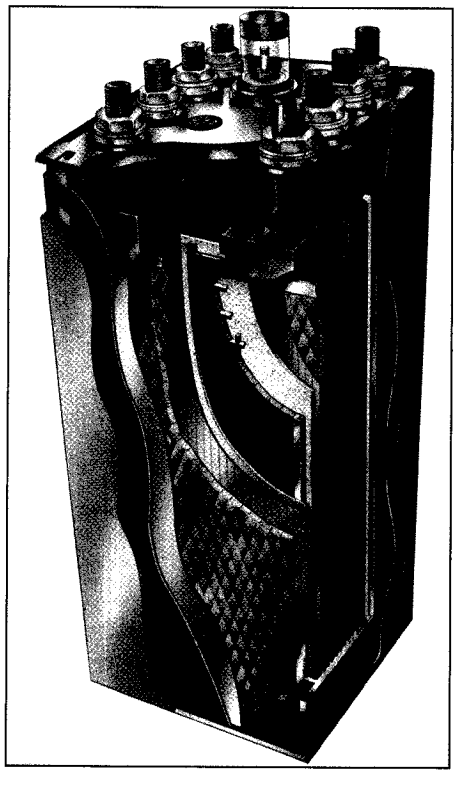
Batteries

Type
Lead-acid submarine batteries.

Description
Enersys Ltd (formerly Hawker Ltd/Chloride Industrial Batteries) manufactures lead-acid batteries for diesel/electric and nuclear-powered submarines. The batteries can be recharged without requiring rest periods on the surface, which greatly improves the boats' discretion.

The flat pasted positive plate cells comprise a lead alloy lattice grid with a paste of lead oxide (the active material) and sulphuric acid pressed into the matrices.

Shedding on the positive grid is overcome by using felted glass wool placed against the faces of the positive plates (which effectively retain the lead dioxide active material) as well as the usual microporous polyethylene separator fitted against the faces of the negative plates. The oxidation-resistant and highly porous glass wool is capable of compression during the assembly of the cell and provides good retention for the active material when placed next to the positive grid. The separators allow free circulation of the electrolyte to the active material and ensure a mechanical barrier against the possibility of short circuits.



Cutaway drawing of the new BLC submarine cell
(Enersys Ltd)
0024687

Flat plate (pasted plate) batteries are currently used in all Royal Navy SSNs and in many other overseas navies. Various designs are available with capacities ranging from 5,150 to 14,000 Ah per cell.

The plates are suspended from the cell cover, which gives enhanced resistance to shock and vibration and reduces the risk of short circuits caused by sediment. To provide the necessary support for the plates, the container of the cell is made of tough GRP. This also provides a reliable enclosure for the electrolyte and greater resistance to mechanical damage.

The production of hydrogen in cells occurs as a result of an electro-chemical reaction. This problem is overcome by the use of the single casting that allows the use of low-antimony lead alloys that reduce the evolution of hydrogen under open-circuit conditions.

In its latest development of the lead-acid battery, Enersys Ltd claims a 22 per cent improvement in performance at the high-discharge rates (necessary for high speeds) and a 6 to 8 per cent improvement at the low-discharge range. This new cell (BLC – Bottom Lug Connection) offers increased speed or range. This is achieved by the introduction of a high-conductivity electrical connection from the bottom of the positive plate in a cell to the main power take-off lug at the top. In this way it is possible to make use of the under-used stored energy in the lower part of the cell, especially under operating conditions which impose a heavy demand on the cells. Normally this stored energy is not used until the later stages of discharge, by which time the cell voltage has begun to fall so rapidly that it is no longer able to deliver sufficient power. In a further development a new thin-walled container construction (a glass fibre reinforced plastic material into which the resin is injected under pressure) allows the volume of acid in the cell to be increased and leads to improved performance at low-discharge rates. For a mid-sized cell this results in an increase of around 8 per cent of the total volume (or an additional 7 litres of electrolyte).

Operational status
Batteries are installed in all UK Royal Navy submarines as well as the Canadian 'Victoria' (ex-UK 'Upholder') class and a large number of other submarines around the world.

Contractor
Enersys Ltd, Swinton, Manchester.

UPDATED

Submarine Platform Control System

Type
Submarine Platform Control System.

Description
The platform control system provides control systems and instrumentation covering depth and course autopilots, controllers for trim compensation and hover all through a single operator console. Most platform control systems are customised to meet the needs of a specific class of submarine.

The systems provide precise depth control irrespective of ballast and trim errors together with better seakeeping when at periscope depth. The system also ensures that there is minimal overshoot when altering depth, together with a reduced risk of broaching when coming to periscope depth. The control also ensures that there is minimal hydroplane activity commensurate with manoeuvrability, which further reduces the noise signature. It also offers multiple rudder options such as split planes. Thus depth, pitch and heading are accurately controlled. Two separate autopilots for depth and course are available and can operate either separately or concurrently. This is of considerable value when turning as during such a manoeuvre it is difficult to maintain depth.

The control system can also incorporate an out of trim estimator. This calculates the approximate amount of additional water required in the tanks to maintain trim. This is an advise system only, and the operator may, for operational reasons, decide not to inject more water into the tanks (it may lead to additional noise which may jeopardise the security of the boat. This development is now at sea.

In an emergency the sophisticated autopilot will manoeuvre the boat back on to the correct depth and pitch and automatic trim if required. The autopilot can also control the pitch of the boat that will allow it to stay at constant depth with a slight bows-up attitude.

Operational status
The latest system to become operational is on board the Israeli Dolphin class. The RN Astute class will also be fitted with a system incorporating two separate autopilots. The platform system in the 'Astute' will be fully integrated.

Contractor
AMS, Camberley.

VERIFIED

Valenta

Type
Submarine diesel.

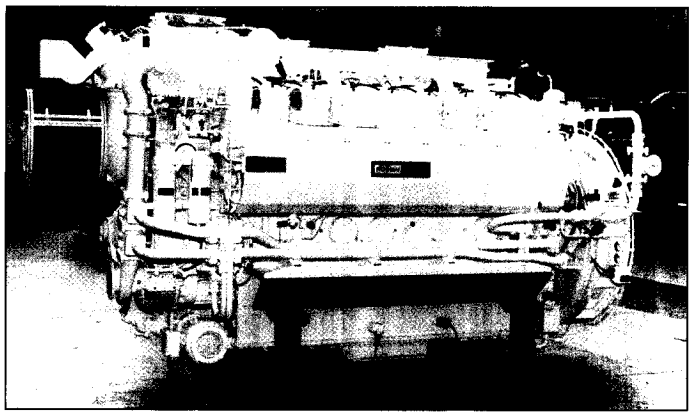
Description
The lightweight Valenta RPA 200SZ 4-stroke 16 cylinder mechanically driven, direct supercharged, intercooled V-type diesel was developed for the Upholder class SSK. The use of mechanically driven superchargers, insensitive to exhaust back pressure enables well over twice the engine power to be produced compared with normally aspirated engines and gives good cylinder scavenging under all submarine service conditions.

A single gear-driven centrifugal compressor drives the supercharger at the free end of the engine through an intermediate fluid coupling. This supplies air to the engine at a boost pressure ratio of approximately 2.4:1 through a seawater-cooled intercooler. The gear drive to the supercharger also drives the seawater pump that is mounted on the engine.

The supercharger comprises two main units each of moderate size and weight and easily handles within the confines of a submarine hull. This configuration maintains interchangeability with the standard Valenta engine.

The drive increases the 1,350 crankshaft rpm to 24,000 rpm in two stages. The primary speed increase is by epicyclic gears that drive into a fluid coupling before the secondary spur gear stage. The fluid coupling isolates the secondary stage gears from torsional vibration in the low-speed train arising from crankshaft vibrations and effectively isolates the high-speed train from these vibrations. It also allows the very high-speed supercharger rotor to overrun in the event of the engine being suddenly shut down. The engine output is 1,518 kW at 1,350 rpm.

One notable design feature of the Valenta is the arrangement used to extract any saltwater that may have entered via the exhaust manifolds and open valves when submerged. Before starting, the engine is rotated at low rpm while air servo cylinders mounted on the valve covers depress the engine inlet valves enabling any seawater in the engine and exhaust system to be purged through drain valves in the induction manifold. The exhausts incorporate inboard silencers and independent surface-use and snort outlets. A cooling facility is provided to reduce the IR signature of the exhaust gases.



Valenta RPA 200SZ as supplied to the Upholder class (ALSTOM) 0024686

Operational status
The diesel is no longer in production or being marketed. The Valenta equips the Upholder class submarines that have now been leased to the Canadian government. The 6RP200E version powers the Royal and Saudi Navy 'Sandown' type minehunters.

Contractor
MAN B&W Diesel Ltd, Stockport, Cheshire.

VERIFIED

ANTI-SUBMARINE WARFARE

Submarine and surface ship ASW combat management

Sonar systems
Surface ship sonar systems
Submarine sonar systems
Airborne dipping sonars
Sonobuoys
Airborne acoustic processing and receiving systems
Static detection systems

Countermeasures
Acoustic decoys
Electronic warfare

Underwater communications
Submarine communications systems
Underwater telephones
Communications buoys

Electro-optical sensors

Magnetic anomaly detection systems

SUBMARINE AND SURFACE SHIP ASW COMBAT MANAGEMENT

Introduction

Considerable advances have been made in combat management systems for submarines resulting primarily from major developments in the field of electronics. With the new generation of combat management systems using the latest developments in electronics, weapons can be deployed much more effectively. Improvements in sensors, particularly sonar systems, also provide the modern combat system with a much greater volume of more accurate data from which targets can be detected, tracked and localised, which further aids the effective deployment of weapons.

The sum total of these developments has had a considerable effect on the design and capability of combat management systems. The constant reduction in size and weight of equipments has had a two-fold effect on the submarine. First, it has enabled the smaller displacement submarine to be equipped with a fairly sophisticated combat management system, not always previously possible because of the weight and space requirements demanded by such systems. Second, it has enabled larger ocean-going submarines to be fitted with very sophisticated systems, which considerably enhance their capability.

The advent of passive ranging sonars (broadband, wideband and narrowband), intercept sonars, passive cylindrical bow hydrophone arrays, flank array sonars, active sonars, low-frequency sonars and towed array sonars, together with other vastly improved sensors such as EW and electro-optical systems, all provide the combat suite with a huge volume of data which is used to present the command team with all the necessary information from which to make its decisions. This will be further magnified under the joint operations scenario as the submarine's communications systems are enhanced and the combat management system is presented with much greater volumes of data gathered by other platforms to provide the command team with an overall tactical picture. All this data will have to be assimilated and compared against the boat's own processed data to ensure that profiles of various contacts and so on are correctly matched and misinformation and duplication is not presented to the command team.

Another area of considerable importance which affects the overall mission capability of the submarine is its navigation systems. Many submarines now fit inertial, satellite, GPS and other navigation systems, as well as the usual gyrocompass and log. All these assist in providing a highly accurate position-finding capability - essential if modern weapons are to be directed accurately onto their target.

This huge bank of data must be assimilated and processed at high speed to generate an accurate picture of the complete underwater and surface environment. It requires programmable high-capacity computers which have the ability to retrieve and handle vast amounts of data on a number of targets simultaneously, from a wide variety of sources, process that data and distribute it to a number of different destinations.

The best and most effective way of handling the data is undoubtedly the databus. The ability to have data passing round a system has enabled the multipurpose console to be developed which provides enormous flexibility and redundancy, each console being able to undertake a variety of different functions at the command of the operator, depending on the priority and nature of the requirement. Current command systems are therefore characterised by organising the various elements around a LAN (Local Area Network) which interconnects processors distributed around the system. Many systems rely on proprietary computers developed by the contractor, but this situation is now changing as Commercial-Off-The-Shelf (COTS) hardware and software technology becomes more acceptable and in many cases self-imposed due to financial considerations - a case of not reinventing the wheel.

This enormous potential and flexibility has enabled designers to develop and introduce the concept of the totally integrated combat suite for the submarine. This incorporates sensors, combat suite and weapon control in one total package. To treat these three prime areas as a single system is of considerable value as it overcomes many of the problems formerly experienced in interfacing different systems.

With the advent of the fully integrated combat suite and the extensive use of automation, designers are now integrating all command and control and weapon control functions within the confines of the submarine control room. This brings enormous advantages to the submarine commander who is now fully aware of the entire environment relating to the boat, its status and the threat situation.

The COTS revolution is already beginning to have a major impact on new combat systems. Even older technology, wherever possible, is being upgraded with COTS technology. Importing COTS technology is even more feasible in new generation systems where the advent of open system architecture is also revolutionising system development. Open system architecture allows easy upgrading of technology and capability and offers continuous growth potential throughout a system's life. Open system architecture, combined with COTS technology using the latest software available, means that combat systems can be easily modified to integrate the latest weapons, sensors and software. In the area of software this includes multi-sensor TMA, weapons control, tactical navigation, simulation, and, of increasing importance in view of ever decreasing assets both at sea and ashore, onboard training.

For the future the increasing ranges of sensors, growing ranges of weapons and the changing role and endurance of submarines are all areas that will have to be addressed within the context of an integrated combat system. The latest requirements to be embodied within the combat suite and relating to ISR will be the need for integrated intelligence (SIGINT and ELINT) and the rapidly growing need to command Autonomous Underwater Vehicles (AUVs) from submarines. Flowing from this will be the need to address the presentation of data to the command team, for new technologies will not only offer a much larger volume of processed data, but it will be handled at a much higher rate than hitherto.

The development and use of AUVs will revolutionise submarine operations. For the future these vehicles will enable the submarine to operate in a stand-off mode while the AUV performs its mission, whatever that may entail (reconnaissance, minehunting, deploying weapons, sensors and so on). This will require increased capability from the command system to both control and handle data relating to the operation of the AUV.

In addition new types of weapon already under development (anti-air missiles for example to counter ASW helicopters) will need to be integrated with the command systems.

UPDATED

Table VIII

Operational combat and weapon control systems

Systems	Manufacturer	Country	Installed on	Navy	Units
AN/BSY-1 (V)	Lockheed Martin	US	Los Angeles	USA	23
AN/BSY-2	Lockheed Martin	US	Seawolf	USA	2
CCS Mk 2	Raytheon	US	Los Angeles	USA	28
CCS Mk 2	Raytheon	US	Ohio	USA	16
DLA-2A		France	Galerna (Agosta)	Spain	4
DLT-D3	Thales Underwater Systems	France	Daphne (Hangor)	Pakistan	4
DLT-D3	Thales Underwater Systems	France	Daphne (Albacora)	Portugal	2
DLT-D3A	Thales Underwater Systems	France	Daphne (Delfin)	Spain	2
IPS-12 (Nibs)	Ericsson	Sweden	Sjoormen A 12	Singapore	4
IPS-17 (Sesub 900C)	Ericsson	Sweden	Näcken A 14	Denmark	1
IPS-17 (Sesub 900A)	Ericsson	Sweden	Västergötland A 17	Sweden	4
IPS-19 (Sesub 940A)	CelsiusTech	Sweden	Gotland A 19	Sweden	3
Isus	ATLAS Elektronik	Germany	Type 209/1300 (Sabalo)	Venezuela	2
Isus 83	ATLAS Elektronik	Germany	Type 209/1200 (Chang Bogo)	Korea, South	9
Isus 83-2	ATLAS Elektronik	Germany	Type 209/1400 (Preveze)	Turkey	4
Isus 90-1	ATLAS Elektronik	Germany	Dolphin	Israel	3
Isus 90-20	ATLAS Elektronik	Germany	Improved Sauro	Italy	4
KAFS	AMS	UK	Type 209/1400 (Tupi)	Brazil	4
Kanaris	Lockheed Martin	US	Type 209/1200 (Glavkos)	Greece	4
Mk 106		US	Tang	Turkey	2
Mk 117		US	Los Angeles	USA	51
MSI-70(U)	Kongsberg	Norway	Sokol (Kobben)	Poland	4
MSI-90 (U)	Kongsberg	Norway	Ula Type P 6071	Norway	6
MVU-110	RFAS	RFAS	Kilo	Algeria	2
MVU-110	RFAS	RFAS	Kilo	Poland	1
MVU-110	RFAS	RFAS	Kilo	Romania	1
MVU-110/119	RFAS	RFAS	Kilo	RFAS	11
MVU-119	RFAS	RFAS	Kilo	India	10
MVU-119	RFAS	RFAS	Kilo	China	4
MVU-119	RFAS	RFAS	Kilo	Iran	3
Sactis (V1)	SMA	Italy	Sauro Type 1081	Italy	2
Sewaco VIII	Thales Nederland	Netherlands	Walrus	Netherlands	4
SFCS Mk 1	Lockheed Martin	US	Type 209/1500 (Shishumar)	India	4
SFCS Mk 1	Lockheed Martin	US	Upholder	Canada	4
Sinbads	Thales Nederland	Netherlands	Type 209/1100 (Glavkos)	Geeece	4
Sinbads	Thales Nederland	Netherlands	Type 209/1300 (Cakra)	Indonesia	2
Sinbads	Thales Nederland	Netherlands	Santa Cruz TR 1700	Argentina	2
Sinbads	Thales Nederland	Netherlands	Type 209/1200 (Atilay)	Turkey	4
Sinbads M	Thales Nederland	Netherlands	Hai Lung	Taiwan	2
SLW 83	ATLAS Elektronik	Germany	Type 206A	Germany	12
SMCS	BAE Systems	UK	Swiftsure	UK	2
SMCS	BAE Systems	UK	Trafalgar	UK	5
SMCS	BAE Systems	UK	Vanguard	UK	4
Subtics	Thales Underwater Systems	France	Agosta (Khalid)	Pakistan	2
TACTICS	Terma	Denmark	Tumleren Type 207	Denmark	3
SCCS MK 2	Rockwell	US	Collins	Australia	5

Notes
TFCS Torpedo Fire-Control System

UPDATED

Australia

Launcher Control System (LCS)

Type
Weapon launch control system.

Description
Designed, developed and manufactured by BAE Systems Australia, under contract to Strachan & Henshaw of the UK, the Launcher Control System (LCS) provides weapon launch control for the Royal Australian Navy's Collins class submarines.

BAE Systems Australia has designed and developed both hardware and software for the LCS, to monitor depth, speed, air and hydraulic pressures, launcher door positions and provide executive control over the firing sequence. The LCS interfaces directly into the integrated ship's control monitoring and management system, providing details of launch system status, events, faults and weapons discharge. In consultation with the boat's combat system, the LCS assists in the selection of the most efficient weapon discharge characteristics.

Each submarine is fitted with two separate, independent LCS systems, each operating a bank of three torpedo tubes. Each LCS consists of a central launch controller, three local tube control panels and a local system operating panel.

The LCS uses a complete VME-based system developed from the high-level specification. Detailed electronic hardware design utilising 68000 processor technology and fail-safe analogue techniques was undertaken from the system design.

The full suite of mission-critical operating software was fully designed and developed using the Ada programming language in accordance with DoD-STD-2167A.

As part of the contract, BAE Systems has also developed an extensive ILS analysis covering FMECA, LSA/LSAR, RAM, MTBF and spares provisioning. Full system level EMIC testing and validation has been performed to ensure compatibility with other ships' systems.

The Company has also developed the associated simulators and set-to-work equipment for the functional testing of the system and for integration of the LCS into the land-based submarine Combat and Ship's Management System test facility.

Operational status
Production of six ship sets, together with spares, commenced in 1992 with final delivery in September 1994. Systems are now in operational service in 'Collins' class submarines.

Contractor
BAE Systems Australia, Sydney, New South Wales.

VERIFIED

Denmark

TACTICS

Type
Tactical data system for submarines.

Description
Developed in 1985, the Terma TACTICS is designed to meet the requirements of combat information systems for small submarines.

Functions performed include picture compilation, situation assessment, tactical manoeuvre calculations and weapons deployment. It provides a standard tactical datalink to exchange track and ESM information as well as plain text messages, utilising existing onboard radio equipment, but may also be supplied with NATO Link 11 or other customer-specified datalink.

The TACTICS supports the Terma Torpedo Fire-Control System (TFCS), which has its own processor cabinet and torpedo control panels. The system provides control of up to four wire-guided torpedoes simultaneously. It handles readiness status reports from the tubes and torpedoes, and controls run-up and firing as well as course and depth guidance when under way. The TFCS also supports fire-control solutions for straight running torpedoes.

TACTICS consists of the following basic modules which may be added in any number to suit the specific submarine type:

(1) the Graphic Display (GD), which is a 20 in high-resolution raster scan colour monitor, portrait oriented, the lower part being utilised for information readout. The GD can display three different types of picture:
   (a) General Operational Plot (GOP), which compiles and displays a complete situation picture with maps, tracks, ESM data, and an extended selection of tactical patterns and tools. The entire system relates to 'own ship's' navigational position and readout positions in latitude/longitude, colour grid, or true or relative bearing/range as desired. The GOP has a wide scale of editing tools, and may off-centre and zoom to view any local geographical position. Up to 250 tracks and attack plots are maintained for up to four torpedoes
   (b) Contact Evaluation Plot (CEP), which plots up to 40 contacts as a function of time and allows the system to produce a situation picture and an attack evaluation based on inputs from passive sensors
   (c) Attack Plot (ATP), which extracts information from the two above mentioned plots, and produces the local attack situation; it also includes all the necessary vector diagrams, forecasts and recommendations for torpedo attack on selected targets
(2) the System Terminal forms the man/machine interface with a keyboard containing a 'QWERTY' keypad and 60 dedicated function keys, and a high-precision rollerball
(3) Data Processing Unit (DPU), which serves as the main TDS data co-ordination unit and holds all interfaces to the internal TDS modules as well as external interfaces like navigational fix systems, ESM, communications, sonars, hydrophones, periscopes, radar and depth gauge
(4) Torpedo Guidance Unit (TGU), which is a processor that handles all calculations for launch, guidance and torpedo position determination. The unit interfaces torpedoes and tubes to the entire combat system, and also handles the interface of the Torpedo Fire-Control Panel, Tube Order Panel, and the Torpedo Distribution Unit, which are peripheral equipments to the TGU
(5) peripheral equipment includes tape cassette or disk recorder, printer and colour plotter. The online functions are the recording of all events within the system and the loading of maps for display. Offline the system may produce playback to the screens for lessons learned, and printed records of various selections and formats, such as track records or narratives
(6) The modules are housed in water-cooled cabinets, shaped to fit into the narrow space of the hull.

Operational status
In service with the Royal Danish Navy submarines of the Kobben class (3 boats).

Contractor
TERMA A/S, Tastrup.

UPDATED

France

DLT-D3

Type
Submarine torpedo fire-control system.

Description
The DLT-D3 torpedo fire-control system is used in French Navy submarines. All types of torpedo employed by the French Navy can be launched, including wire-guided. The system may also be expanded for anti-surface missile applications.

Target data are fed to the system from onboard sensors, which comprise fore and aft sonars, acoustic range-finder, and attack and surveillance periscopes.

The system employs a general purpose digital computer, associated with a CRT display terminal.

The following functions are performed by the system:

- updating of the tactical situation from the data delivered by the various sensor systems fitted and the navigation equipment
- assistance in calculating target components by the use of special recorded programmes
- weapon control; computation of the firing path, remote setting of torpedoes and firing sequence control. The system is designed for launching any type of torpedo
- maintaining a chronological record
- maintenance assistance using test programmes.



DLT-D3 submarine weapon fire-control system on board a Portuguese Daphné class submarine

Firing data can be computed in three ways: two separate paths for weapons; two torpedoes against a single target; or two torpedoes against separate targets. Firing data for two targets can be computed simultaneously.

The DLT-D3 operating programmes permit tracking of eight targets, simultaneous guidance of two wire-guided torpedoes and preparation of a third for launching. Each of the three monochrome displays of the terminal is dedicated to the presentation of the following data, in accordance with the programme implemented: tactical situation, firing path, and alphanumeric display of parameters (tote) and decoding of the designations and functions of the two common keyboards. Communication between the operator(s) and the computer is through the keyboards. Emergency launch of torpedoes is possible from either bow or stern station.

The system is designed to be manned by one or two operators at the operations centre, and one operator at the bow station with possibly another at the stern station. The equipment arrangement, typically, is one Iris 35M digital computer, a monitoring and control console (VIC), an azimuth relay (RZ), a true-bearing diagram (GZ) in the operations centre, a tube selection panel (PAT), and tube servicing station (PST) in the bow and/or aft torpedo tube compartments.

Operational status
The system is in service aboard the Daphne class submarines of Pakistan, Portugal and Spain.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

SAT

Type
Integrated submarine combat system.

Development
In December 1974, when the French government decided to re-equip its SSBN force with improved M4 strategic missiles, it was recognised that the submarines needed to upgrade their self-defence capability. Work on an upgrade was begun by CPM (now DCN Ingénierie, part of DCN International) in the early 1980s and led to the SAT (Système d'Armes Tactiques) that integrated the TIT (Traitement des Informations Tactiques) tactical data processing system, the LAT (Lancement Armes Tactiques) tactical weapons launching system and the DSM (Détection Sous-Marin) sonar system.

The advantages that SAT could offer the SSN force were also recognised and CPM began developing a SAT for the SSNs in the mid-1980s as a parallel development to the Rubis class Améthyste (AMElioration Tactique HYdrodynamique Silence Transmission Ecoute) upgrade programme. This SAT was similar to its predecessor, differing in that it incorporated COTS processors and an Ethernet LAN to improve the capability of the TIT element that was renamed TITAC (Traitement des Informations Tactiques et Aides au Commandement).

Description
The SAT system for the Rubis class is a federated system consisting of TITAC, LAT and DSM linked by two digital databusses. It is believed the system can track up to 20 targets automatically and 30 manually, while conducting TMA on four. Two torpedoes may be controlled simultaneously. The system features Digilog processing - Motorola 68000 processors and Ada-language software. It uses two improved Colibri consoles for TMA and the tactical situation plus a dedicated Digilog computer cabinet. The display systems have Motorola 68020 processors and VME base (although it is planned to move to PowerPC workstations as used in SUBTICS) while the MMI features two 48.26 cm raster scan displays with menus, a QWERTY keyboard and dedicated buttons.

The LAT system is the DLA 2B/3 while the DSM consists of the DMUX 20 a fully integrated passive low-frequency sonar with bow and flank arrays, complemented by the DUUA 2B support sensor covering 500 Hz and 2.5 to 15 kHz. Both sensors and the DUUX 5 (see DUUX 5 entry), share a pair of processing cabinets with Motorola 68020 for processing the acoustic data. The DSUV 62A/62C (commercial name Lamproie) is a very low-frequency 100 m long, 80 mm diameter, towed array at the end of a 400 m cable.

Operational status
In service with the French Navy Rubis class SSNs, and which has purchased or intends to purchase some 15 systems.

Contractor
DCN, Paris.

VERIFIED

SET

Type
Integrated submarine combat system.

Development
For the Le Triomphant class SSBNs the CPM/DCN companies further evolved the earlier SAT system to produce the Systeme d'Exploitation Tactique (SET) which retained the LAT and DSM elements but replaced TITAC by the SYTAC (Synthese Tactique et Aides au Commandement).

Description
SET is a federated architecture system which tracks up to 100 targets simultaneously and can control two wire-guided torpedoes and either two anti-ship missiles or one missile and a free-running torpedo.

The SYTAC uses up to six Colibri Mark II COTS ruggedised PC workstations based on IBM PowerPC with Barco displays (one or two for command/communications; one or two for fire control and the remainder for sonar and TMA).

The LAT is the DLA 4A and in the SET, the DSM consists of the DMUX 80 sonar suite. The workstations have two 48.26 cm raster-scan displays using POSIX/UNIX/IPX Window/Motif, ANSI, 'C' and 'C++' software. Track management using all sensors can be automatic (either automatic detection and tracking or automatic pulse tracking), semi-automatic (operator-initiated) or manual.

The DMUX 80 is an integrated sonar suite with spherical bow array, a polyvinyldifluoride flank array and a wide aperture array passive ranging sonar, an intercept and a low-frequency towed array. The Mustang range signal processing system is incorporated in the sonar suite.

Operational status
The SET entered service with the commissioning of *Le Triomphant* in September 1996 and will equip the remaining SSBNs of this class.

Contractor
DCN, Paris.

VERIFIED

SUBTICS®

Type
Submarine tactical integrated combat system.

Development
UDS International (Underwater Defence Systems) is a subsidiary of ARMARIS, developing and manufacturing submarine combat systems for the export market.

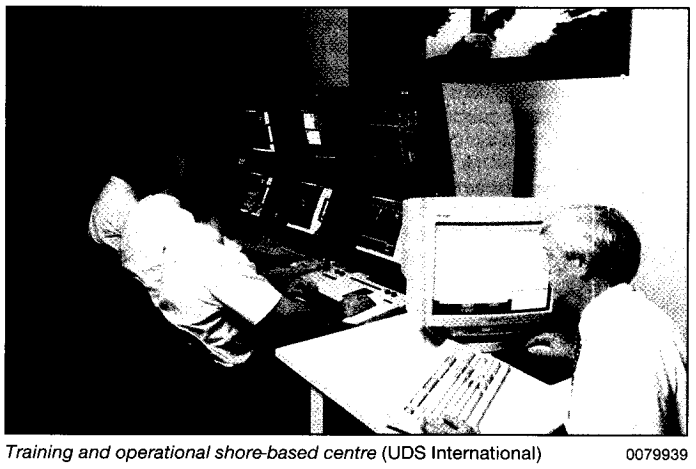
Using this expertise, UDS International offers the SUBTICS® (SUBmarine Tactical Integrated Combat Systems) range of systems which based on advanced sensors and weapons and which is adaptable to any type of submarine design including both refit and new building submarine programmes and engineered to meet not only present, but also future operational requirements.

Description
The main subsystems of SUBTICS® are:

- a comprehensive set of sensors which include: bow cylindrical or conformal arrays; towed arrays; flank; and distributed arrays that multiply the detection capacity of the submarine against silent targets
- all types of heavyweight wire-guided torpedoes and anti-surface submarine-launched missiles
- an integrated architecture which links both sensors and weapons to the system's communication and data handling core through the system network databus.

Integrating the various systems in the submarine SUBTICS® provides for:

- the processing of signals acquired by acoustic (sonar) and non acoustic (optical, optronic, ESM radar countermeasures) sensors for detection, tracking, localisation and identification of targets



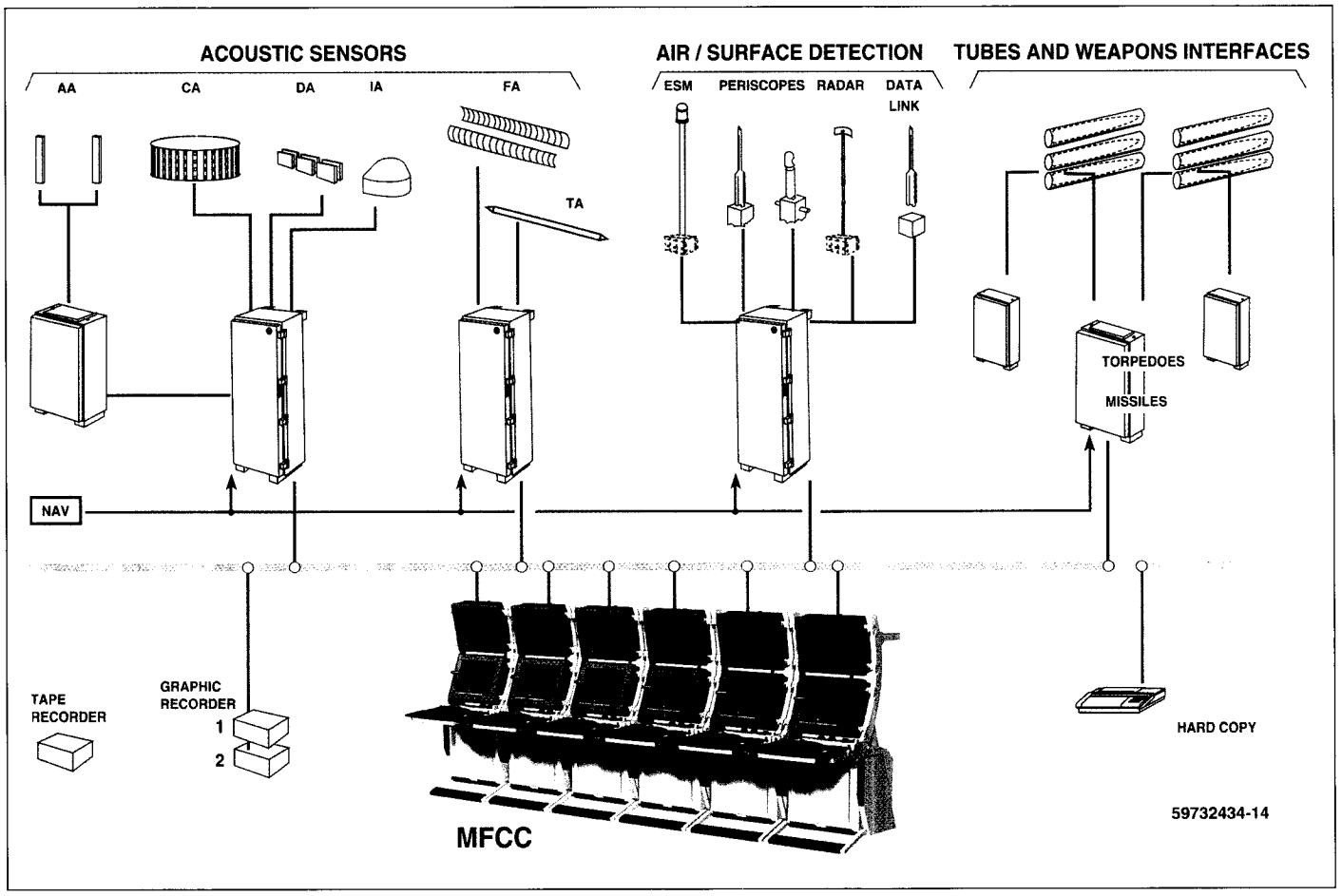
Training and operational shore-based centre (UDS International) 0079939

- the determination of the tactical situation (track association, fusion, synthesis, trajectory and management)
- the provision of assistance for tactical analysis, decision making and action management with respect to the geographical and tactical environment
- the engagement of targets and weapons command and control (choice of weapon, launch and guidance)

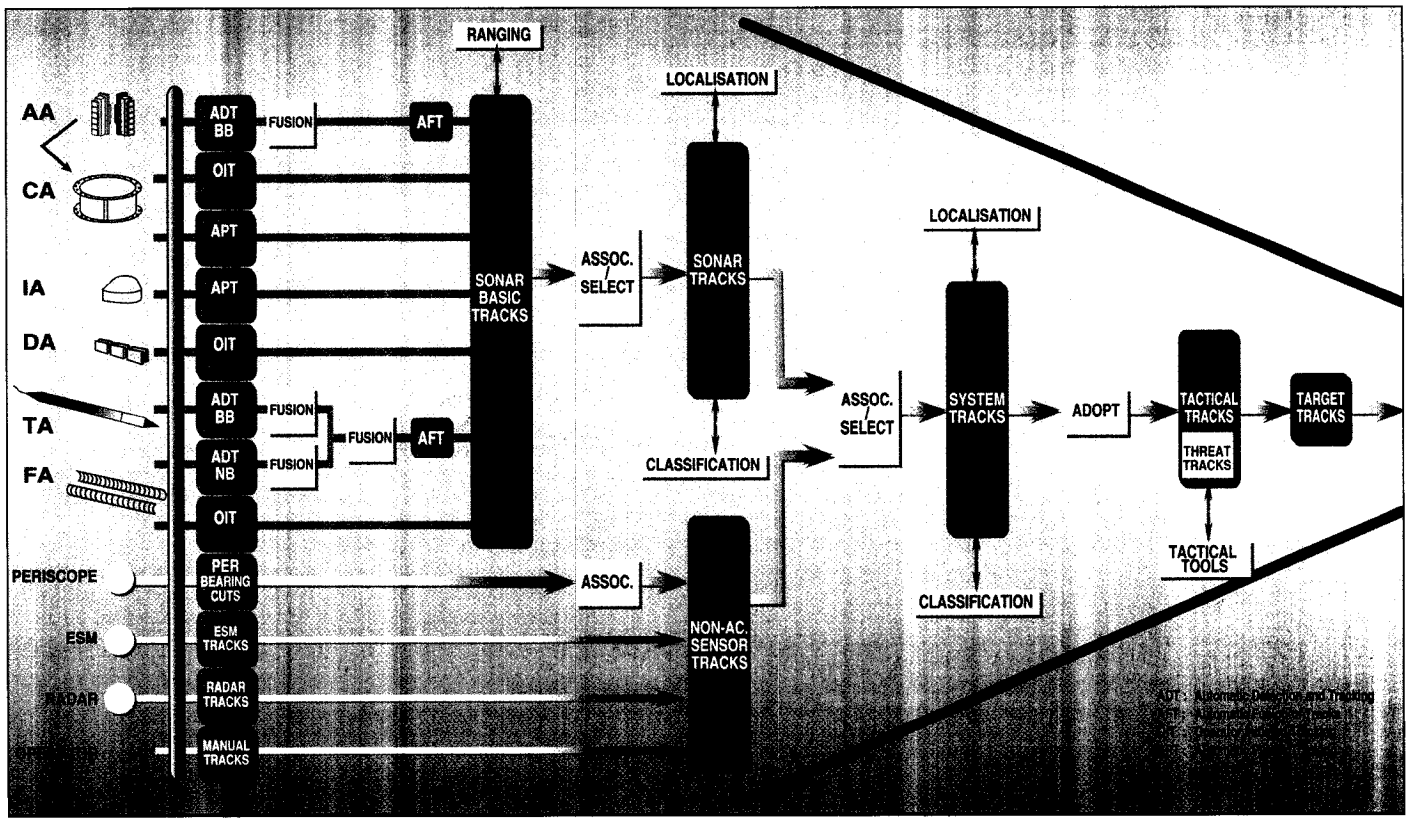
The basic components of the sonar subsystem include a set of acoustic arrays and appropriate detection (or transmission), tracking, and analysis and localisation processing modules, together with a set of common processing modules for TMA, classification, identification and track management using broadband, narrowband, demon and pulse (passive interception and ranging) processing channels.

The basic set of acoustic arrays includes a cylindrical or conformal bow array, an active array, a distributed array, an intercept array, a flank array, and optionally a towed array, an obstacle avoidance array plus self-noise monitoring hydrophones and accelerometers.

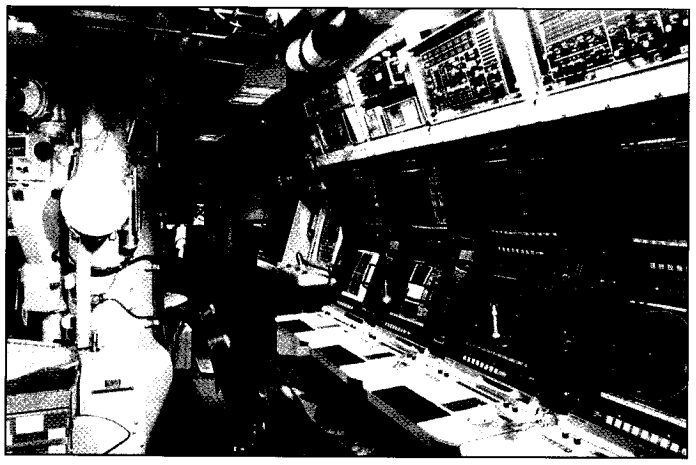
The TMA module includes automatic and interactive processing functions. The classification and identification module includes audio and spectrum analysis processing functions plus interactive hypothesis generation and verification functions. The track management module includes interactive association and fusion processing functions plus sorting of best representative acoustic track functions.



Typical SUBTICS® block schematic (UDS International) 0098846



Track management data flow of SUBTICS® (UDS International) 0079940



SUBTICS® on board an Agosta 90B submarine (UDS International) 0122932

The key features of SUBTICS® are:

1) Operational efficiency and long range performance achieved by:
- the use of up-to-date sensors (including flank and towed arrays) and capacity to launch missiles
- implementation of advanced automatic and interactive processing
- system manning based on functional integration and consistency, configuration flexibility and user-friendly MMI

2) Operational availability based on:
- functional and hardware redundancy and reconfiguration flexibility
- on line management of system status and performance
- the use of advanced standard technology
- easy maintenance

3) Reduced total life cycle cost due to a high level of hardware and software standardisation (leading to reduction of spare parts, training and cost of tools) and to functional integration (minimisation of crew training)

4) Adaptability and growth potential as a result of modularity of hardware and software architecture and to interface standardisation.

Signal and data processing is carried out using Power PC VME boards with multifunction consoles equipped with two 19 inch high definition colour monitors with ruggedised Power PC workstation. The architecture is based on an Ethernet redundant system network, and software standards include POSIX/UNIX, TCP.IP, X Window/Motif, ANSI C/C++ language. The DOD STD 2167 is used for software development.

SUBTICS® full integration also means that every operational function is coherently associated in a continuous track building process along which tracks are continuously summarised and displayed together with their associated localisation and classification attributes. As a result, clear and comprehensive tactical situation displays are presented allowing the command to take fast, accurate and correct decisions.

Operational status
Three systems were ordered in early 1995 for Pakistan's new 'Agosta' 90B submarines and have been delivered. The first combat system was successfully tested at sea and has been in commission since mid-1999. Two systems were also ordered in 1997 for the Chilean 'Scorpene' submarines. SUBTICS® is currently in series production.

Contractor
UDS International, Sophia Antipolis.

UPDATED

SYVA

Type
Tactical ASW system for frigates.

Description
SYVA (Synthise de la Vielle Acoustique) is a tactical ASW system for surface vessels integrating a suite of sensors (passive and active sonars and so on) and incorporating new-generation hardware and a specially developed software suite. The version installed as part of the modernisation of the French Navy Tourville class frigates features the SLASM VLF active sonar.

Initially developed for SLASM, SYVA is able to accept a variety of new and different interfaces to integrate different generations of sonars such as DSBV 61A, DSBV 62C and UTSS 1A currently operational aboard French Navy warships.

The system is easily tailored to the requirements of any naval force and can be fitted or retrofitted to all types of surface combatants. It provides digital interfaces with: navigation systems; active and passive sonars; environmental data acquisition systems; and command support systems.

As an ASW tactical decision making aid, SYVA helps duty officers by providing a comprehensive overview of the ASW tactical situation using three consoles based on Sun SPARC workstations for:
- tactical decision making toolkit
- target motion analysis using passive sonar detection (bearings and frequencies),
- acoustic environment analysis.

The target motion analysis tool allows: ranging measurements to be calculated using bearing and frequency rate measurements; interactive TMA which is based either on a maximum likelihood estimation process or Kalman filtering using, when available, operator inputs such as target course, range, speed and fundamental frequency; and operator TMA using simultaneous bearing/frequency deviations.

The acoustic environment analysis tool manages environmental data when this is available or statistical data such as sound velocity profiles, sea states, bottom depth and type and ambient noise. Sonar parameters and self-generated noise are also accessed to calculate the effectiveness of 'own ship' sonar within the environment. From this data, loss and range predictions are calculated.

An online database provides operational data on threats.

The tactical situation displays 'own ship' tracks and target tracks as detected by the ship's sonars (DSBV 61A, DSBV 62C, UTSS 1A or SLASM) which are then evaluated by the TMA function. The system also displays and plots tracks provided by the command support system or surface/air combat system (SENIT).

SYVA also provides an interactive, configurable control system and multitarget onboard simulation.

SYVA is based on an open architecture and distributed software configuration which allows different implementations to be designed to suit various operational requirements and associated with suitable equipment packaging (COTS, ruggedised, or full military specification) and can be configured from single workstation to complete system. The consoles used with SYVA are based on Sun SPARC workstations and C language software. The system uses three dedicated multifunction consoles for TMA tactical situation display and environmental data, while other consoles are used for specific sonar displays.

The SYVA software suite is based on industry software standards, including: Unix; C-language; X11/Motif; RISC graphic workstations; and Ethernet LAN.

All SYVA systems are designed around hardware featuring: commercial-off-the-shelf components; component repackaging to ruggedised requirements; full compliance with military specifications.

Operational status
The system is currently in service aboard seven French ASW frigates (two retrofitted with SLASM) and two shore-based training centres. The system is fully operational and the success achieved during sea trials of the first SYVA package led to a decision to retrofit all French ASW frigates irrespective of their sonar equipment configuration.

Contractor
ECA, Toulon.

VERIFIED

TSM 2072

Type
Submarine Tactical Data Handling System (TDHS) and Weapon Control System (WCS).

Description
The TSM 2072 results from the combination of the DLT-D3 (see DLT-D3 entry) and the M8 and SINBADS produced by Hollandse Signaalapparaten BV (part of the Thales Underwater Systems organisation). The system can be integrated into any existing or newly developed combat system.

The TSM 2072 is capable of managing a wide range of weapons (torpedoes and missiles) of various origins (for example, France, Germany, UK and the US). The system is capable of controlling simultaneously two wire-guided torpedoes and two other weapons (anti-ship missiles or an anti-ship missile and a free running torpedo).

The system functions include:

(a) MultiSensor Situation Elaboration (MSSE): providing management of tracks supplied by acoustic and non-acoustic (optical, optronic, ESM, radar) sensors, determination of the tactical situation using interactive multisensor localisation, identification and designation procedures

(b) Situation Threat Assessment and Planning (STAP): providing evaluation of the tactical situation and the production of navigation plans (route and tactics) and engagement plans (selection of weapons and optimisation of launch and guidance procedures)

(c) control of weapons interfaces and weapon guidance.

The system uses 68020 and 68040 microprocessors communicating across a standard VME-type bus and uses structured software developed in C and Ada. It uses a multifunction workstation with one or two high-definition 19 in colour monitors (COLIBRI or MOC console from Signaal or a COTS workstation).

Operational status
The operational status of the system is uncertain.

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED

Germany

ISUS 90

Type
Integrated combat system.

Description
ISUS 90 is an integrated submarine combat system designed to manage acoustic, electro-optic, EW, radar and navigation sensors and to process, analyse and display data from those sensors. It performs tactical data signal analysis, classification, TMA with presentation on a tactical situation display. The system also carries out weapon control functions and status for torpedoes, mines, missiles and decoys and carries out threat analysis and assessment. This interactive process leads from the display of raw sensor information to an easy-to-read display of the combat situation, providing the command team with optimum assistance in the decision making process.

The system integrates a wide variety of acoustic arrays including: cylindrical or conformal; flank; towed; passive ranging; cylindrical transducer; and intercept, as well as own noise hydrophones and accelerometers; Doppler and EM log; underwater telephone; radar; ESM; optic and optronic sensors and navigation sensors.

The ISUS 90, is an open architecture system based on a modular Ethernet databus linking DEC compatible computers with high-speed RISC signal processors, VME backplanes, Ada software and data transfer from sensors via a fibre optic link. The system supplied to the Dolphin class submarines incorporates eight multifunction consoles.

The system performs the following functions on data either sequentially by one operator or in a task sharing concept simultaneously by several operators: broadband detection over 360° with high bearing accuracy; sonar pulse detection over 360° in a very broad frequency band; detection of low-frequency spectral lines over a long range with high bearing accuracy; transient detection and storage; accurate range measurement in two 120° sectors; monitoring of own hydrodynamic and machinery noise; location of targets by single pulse active sonar; navigation; integration of periscope and radar displays into the multifunction common consoles equipped with two high-resolution raster scan flat screen displays; automatic and interactive tracking of targets (the target track is controlled by one main sensor and supported by auxiliary sensors); audio broadband and narrowband analysis (the analysis leads to computer-aided classification suggestion); threat analysis; launching suggestion for weapons; integration of the torpedo sonar information from wire-guided torpedoes; launching of underwater missiles; control of wire-guided torpedoes and display of the target/weapon situation.

The ISUS 90-20 is being fitted into the four Italian Navy Improved Sauro class submarines in place of the existing IPD-70S sonar suite, SACTIS command system and FCS Mk 2 torpedo fire-control system. The ISUS 90-20 will incorporate a fully integrated sonar suite, command and fire control equipment. The system is based on four multi-function consoles and two main electronic cabinets. The system can track more than 100 targets, performing TMA and threat assessment on 64 of these and simultaneous control of up to four wire-guided torpedoes.



Consoles of the ISUS 90 integrated combat system

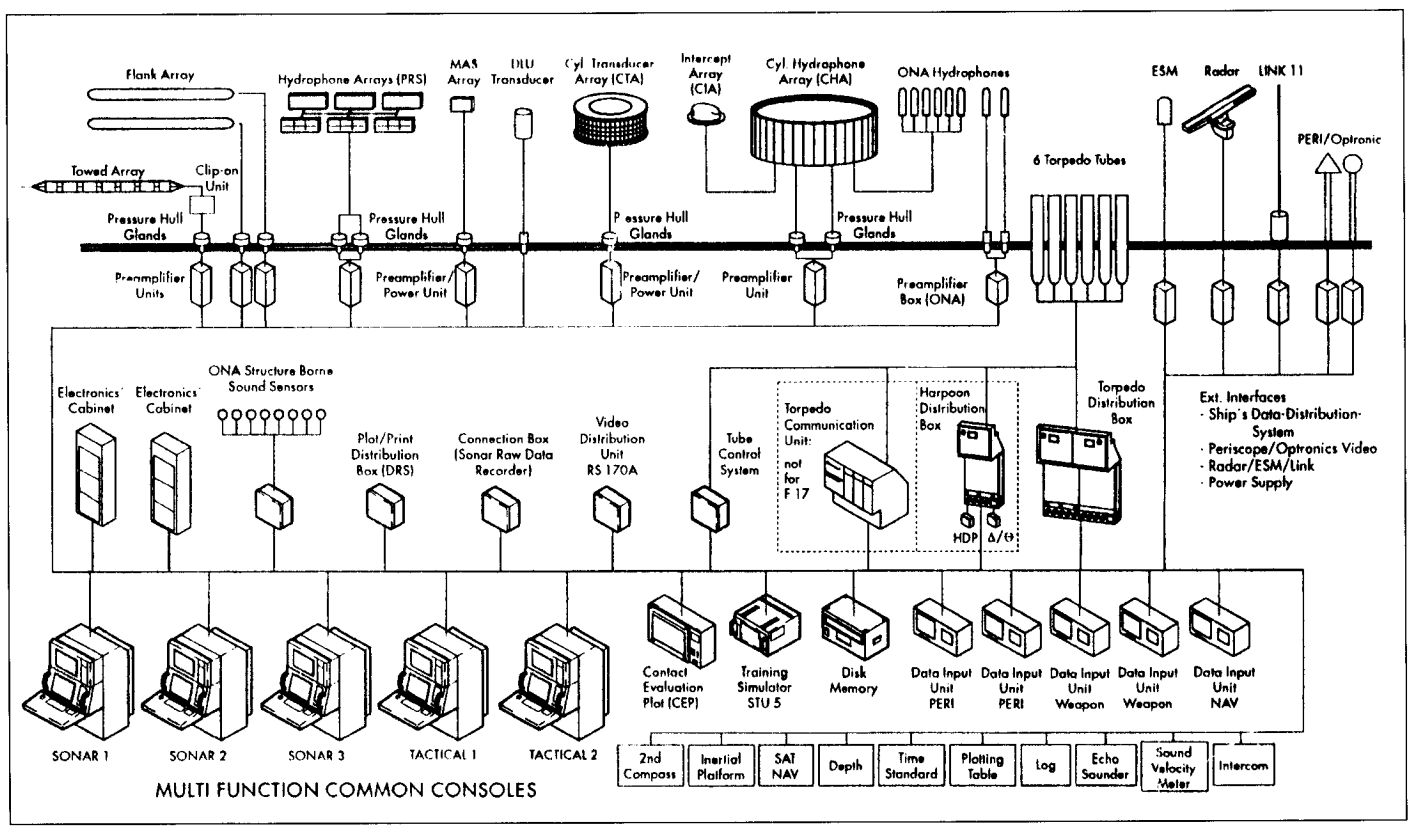
The sensor suite incorporates bow-mounted passive conformal array, bow-mounted active HF cylindrical array mounted over the conformal array, passive cylindrical intercept array and eight own noise analysis transducers for monitoring the level and frequency spectrum of self-generated noise.

The next ISUS 90 system to be delivered in 2004 will be a move away from specific dedicated hardware towards an emphasis on functional software using international open standards. This approach allows a high level of COTS integration into the system. Other features include new dual flat panel display consoles and digital arrays. In terms of sonars, a digital towed array sonar with a winch launching system will be added as well as an Intercept Detection and Ranging Sonar (IDRS) designed to detect intercept pulses from active sonars and torpedoes in the range of 1 to 100 kHz.

Operational status
Variants of the ISUS system are in service aboard the German 206A class, the Type 209 submarines of the South Korean (ISUS 83), Turkish (ISUS 83) and Venezuelan (ISUS 83) navies. It is also fitted in the Israeli Navy Dolphin class (ISUS 90) submarines and upgraded Italian Navy Sauro class (ISUS 90-20) submarines. The ISUS 90-20 will also equip the Type 212A submarines under construction for the German and Italian navies. Furthermore ISUS has been selected for the Type 209 submarines of the Turkish (ISUS 90) and South Africa (ISUS 90) navies and the Type 214 submarines of the South Korean (ISUS 90) and Greece (ISUS 90) navies.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED



Typical ISUS 90 configuration

International

ATS series control systems

Type
Torpedo control systems for aircraft.

Description
These systems are designed to allow remote selection, presetting and launch of the A244/S and/or MU90 Impact torpedo and other existing types of lightweight torpedo, from any type of helicopter or fixed-wing aircraft. The systems are normally supplied in one of three configurations: stand alone, semi-integrated and fully integrated.

In its stand-alone version, the airborne ASW system consists of the APS control panel and the APS computer unit. The links with the platform are limited to the power supply and the store release system's consent. Torpedo preset parameters as well as target data are manually input. The APS control panel is, in general, accommodated at the pilot/co-pilot post with the Mission Computer Unit at the rear of the platform. The computer unit is provided with a support tray and shock-absorbers.

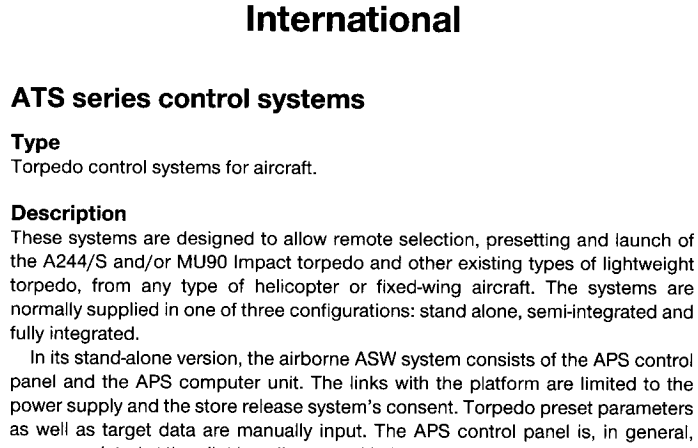
In the semi-integrated version, the APS computer unit is also linked to the ASW sensors of the aircraft (data log, dipping sonar or sonobuoy system or Link 11) through which the engaged target data can be automatically fed to the torpedo system resulting in automatic computation of the optimum torpedo firing solution, the associated hit probability, the recommended heading and time to drop.

In the fully integrated version, the airborne ASW system is represented by a 'black box', the Torpedo Control Unit (TCU). The TCU is connected to the aircraft's local network (double-redundant BUS 1553) and dialogues with the MCU as well as with the Store Management System (SMS). The control of the torpedo system is fully exercised by MCU console where a dedicated man-machine interface (MMI software) allows the data exchange between the ASW operator (TACCO) and the torpedo system.

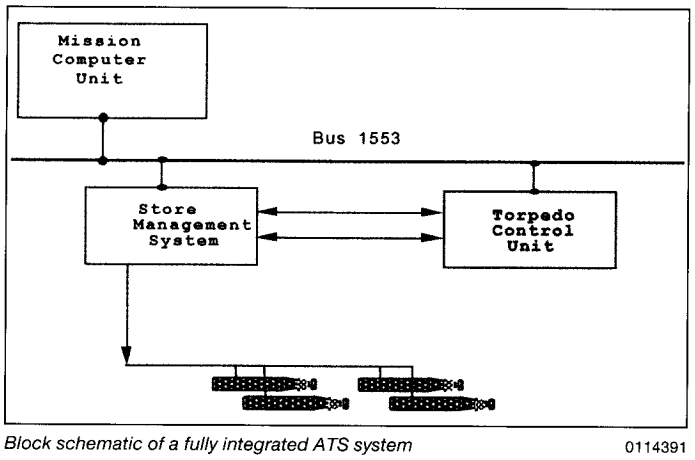
Through the local BUS the TCU receives the platform data log, target data, environmental data and, once the target is engaged, displays the optimised firing solution, the heading to release point, the time to drop and the relevant hit probability. The torpedo release order can be given automatically or manually. The torpedo release order, triggered by the MCU, is then generated by the SMS after the TCU has communicated the successful completion of the torpedo preset phase. The TCUs built-in self tests allow the functionality of the TCU and the selected store to be monitored.

Manual and degraded operational modes are also features incorporated in the system. Should both the BUSs be down, the TCU can provide the store with default preset parameters (casualty mode release) and the torpedo can still be serviced.

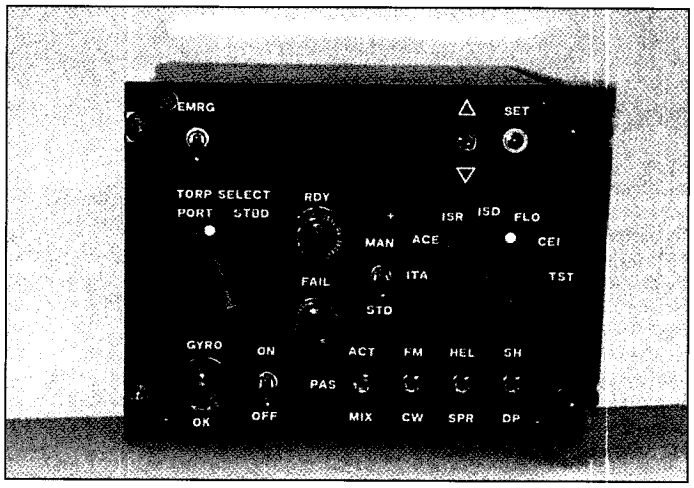
Operational status
In production and in service.



Block schematic of a stand-alone ATS system 0114390



Block schematic of a fully integrated ATS system 0114391



A typical APS control panel (Eurotorp) 0114392

Aircraft	ATS
AB212	A244/S, stand-alone
Alouette II	A244/S, stand-alone
ATL1	MU90/Mk 46, semi-integrated
ATL2	MU90, semi-integrated
Cougar	MU90/A244/S, stand-alone
EH101	MU90, fully-integrated
MI-14	MU90/A244/S, semi-integrated
NH-90	MU90, fully-integrated
Panther	A244/S, stand-alone
S2, Grumman	A244/S, stand-alone
Sea King A&B	A244/S, semi-integrated
Sea Lynx	A244/S, stand-alone
SH-3D	MU90/Mk 46 semi-integrated
Super Frelon	MU90, stand-alone
Super Frelon	A244/S, semi-integrated
Super Lynx	A244/S, stand-alone

Contractors
Eurotorp, Sophia Antipolis, France.
Whitehead Alenia Sistemi Subacquei, Livorno, Italy (production).
DCN, St-Tropez, France.

UPDATED

Kanaris

Type
Submarine fire-control system.

Development
This system was developed by Lockheed Martin Tactical Defense Systems in collaboration with the Hellenic Navy's Research and Development Centre (GETEN) for the first four units of the Greek Navy's Glavkos class (Type 209) submarines.

Description
Each system consists of a two-cabinet firing distribution unit and the main control unit with two consoles. The latter are the Lockheed Martin (formerly Unisys) Tactical Modular Displays (TMDs) which feature an embedded AN/UYK-44 computer using CMS-2M language software to process and display sensor data. The MMI comprises a 19 in raster scan display, with 1,024 × 768 pixel resolution, and a 12 × 40 character touch-sensitive display. In addition there are manual entry buttons and a roller ball in an operator console unit. Above each TMD is a sensor and peripheral unit, which acts as an interface with the sonar systems. It is also used to transfer launching data to two missile data processors for use with Sub-Harpoon. The firing and distribution unit conducts fire-control calculations as well as selecting, presetting and guiding torpedoes, permitting the system to control up to four weapons (Mks 37-2, 37-3, NT-37C/D, SUT and SST torpedoes or Sub-Harpoon missiles) simultaneously.

Operational status
The system entered service in May 1993 aboard the submarine *Triton*. The remaining three boats of the first four Type 209 boats of the Greek Navy have subsequently been refitted with Kanaris, the last in 2000. Five systems are operational: four for shipborne use and the fifth as a land-based training unit.

Contractors
Lockheed Martin, Syracuse, New York.
GETEN (Hellenic Navy Research and Development Centre.)

UPDATED

SPS115

Type
Surface vessel torpedo launching system.

Description
The SPS115 is developed and manufactured by Whitehead Alenia Sistemi Subacquei (Italy) and marketed by Eurotorp (a French/Italian consortium between DCN International, Thales and Whitehead). The pre-setting system is capable of managing a large spectrum of lightweight anti-submarine torpedoes such as the MU90 Impact, A244/S (Mod 0, Mod 1 and Mod 3) and Mk 46. The system is capable of handling a mix of weapons.

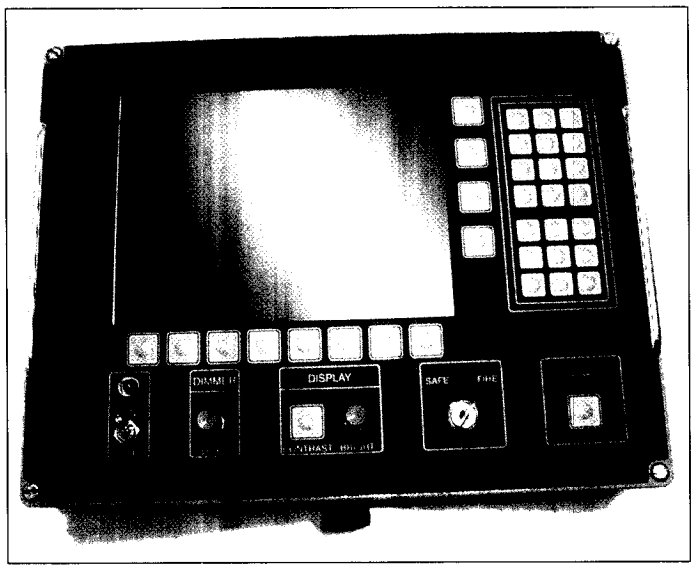
The SPS115 comprises a set of electronic units (SIP, SCE and TIU), which implement all the tasks related with interfacing the on-board combat system and with the launching tubes.

The launching network may operate both with the B515/3/2/1 and Mk 32 triple launching sub-units, and is composed of three interconnected electronic units and one interactive operator's display unit.

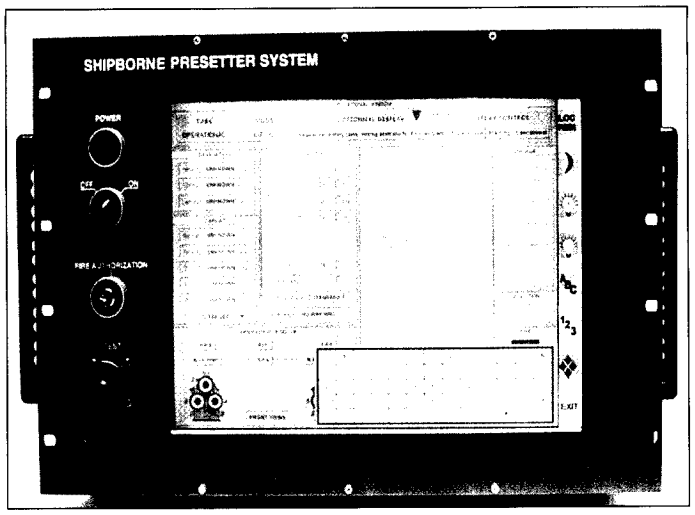
Specifications
(for SCE and TIU)
Length: 520 mm
Width: 335 mm
Height: 380 mm
Weight: 37 kg

Contractors
Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy.
Eurotorp G.E.I.E., Sophia Antipolis, France.

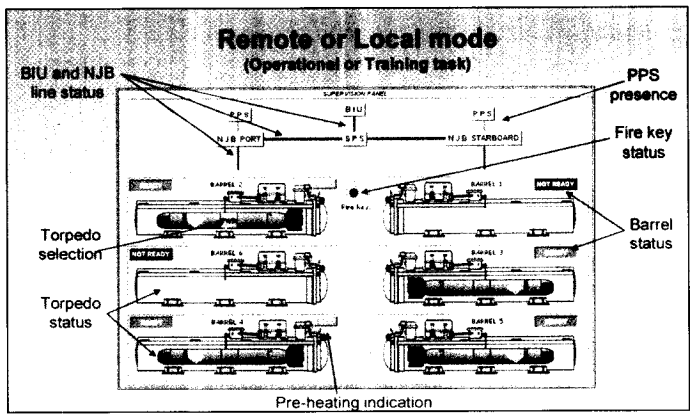
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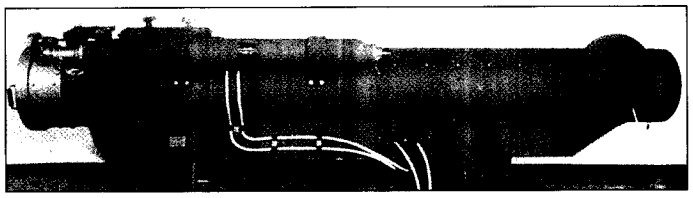
Control panel of SPS115 (Whitehead Alenia Sistemi Subacquei) ***NEW***/1022768



The dual MU90/Mk46 torpedo shipborne presetter (Eurotorp) 0114389



The shipborne presetter MMI block schematic (Eurotorp) 0114387



A single fixed B515 torpedo tube (Eurotorp) 0114388

STS series control systems

Type
Shipborne torpedo control systems.

Development
The STS system was developed in the late 1970s to meet the requirement for torpedo preset and firing capabilities for the Mk44 torpedo (the Mk44 is no longer in service). The STS family has technologically and performance-wise evolved in parallel with the capabilities of the new generations of lightweight torpedoes and surface vessels' combat systems structures. The aim has been to achieve a comprehensive torpedo launching system featuring multisystem capabilities, outstanding safety as well as being compliant with the most demanding environmental situations.

Hardware and software is of modular construction allowing the system to be configured for the control, preset and firing of the MU90, the A244/S (any model) and Mk46 (any model) torpedoes, as well as a combination of different systems (dual torpedo system capability).

Description
In its standard configuration the STS consists of a shipborne presetter (SPS) connected to the port and starboard Torpedo Launching Stations (TLS) through Torpedo Interface Units (TIU). Temperature Alarm Panel (TAP) and Torpedo Tubes' Air Charging Stations (CHS) are also provided.

In this configuration the SPS is linked to the vessel's LAN so that the torpedo system is fully remotely operated through the ship's multifunction consoles in the command centre. Training and degraded operational modes, defined as 'local' and 'emergency' modes, are built-in features of the system.

When operating in local mode, the touchscreen display of the SPS features an operator-friendly MMI suitable for monitoring the status of each torpedo (in each tube), the status of the tubes and the status of any of the links with the ship's combat system. Ship's data log and target data fed through the link with the LAN are processed by the SPS to define the optimum torpedo firing solution as well as the relevant hit probability circles associated with the engaged target. When operating in remote mode, all data computed and available at SPS level are provided to the multifunction consoles to allow same MMI and extended planning functions.

The TIU (one for each TLS) provides the electrical interface between the SPS and the torpedo/tube. According to the system configuration, the TIU accommodates the relevant torpedo hardware interface. The TIU is linked to the SPS via a digital serial line.

The standard deck-mounted TLS is the trainable triple-barrelled B515 (see B515 entry). The B515 is an upgraded version of the former ILAS-3 torpedo launcher. Of modular design, the B515 can also be configured as a fixed single tube or mounted side-by-side in a twin tube configuration for external use or for torpedo magazine applications.

When required, navy-owned TLS such as the Mk 32 (any model) can be easily integrated with the lightweight STS. According to the type of selected weapon, the Mk 32 torpedo launcher can be upgraded with a low-cost modification kit to achieve multitorpedo capability.

Operational status
The lightweight STS family is in service with a number of navies all over the world, see table below.

Country	STS	TLS
Abu Dhabi	A244/S	Mk 32/9
Argentina	Dual A244/S-Mk 44	ILAS-3
Colombia	A244/S	ILAS-3
Denmark	MU90	B515/2
Ecuador		ILAS-3
France	MU90	B515

Country	STS	TLS
Germany	MU90	Mk 32/5
India	A244/S	ILAS-3
Indonesia	A244/S	ILAS-3
Italy	Dual MU90-Mk 46/2	B515/3
Libya	A244	ILAS-3
Malaysia	A244/S	B515/3
Nigeria	A244/S	ILAS-3
Peru		ILAS-3
PR of China	Dual A244/S-Mk 46/2	ILAS-3
Singapore	A244/S	B515/3
Sweden	A244/S	B515/1
Venezuela	A244/S	ILAS-3

Contractors
Eurotorp, Sophia Antipolis, France.
DCN St Tropez, France.
Whitehead Alenia Sistemi Subacquei, Genoa, Italy (production).

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Italy

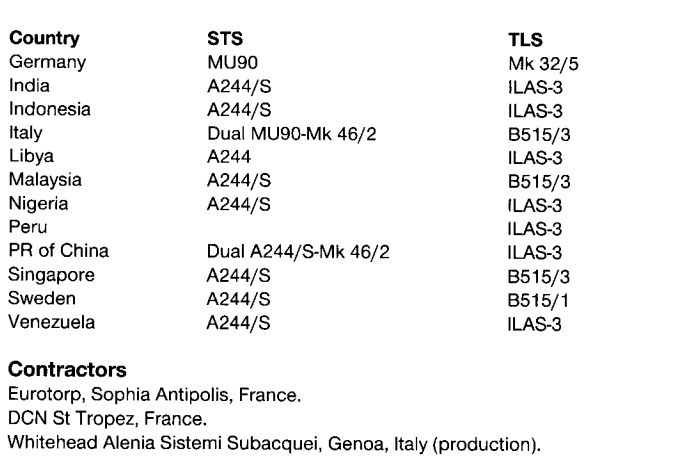
FCS Mk 3

Type
Submarine command and control systems.

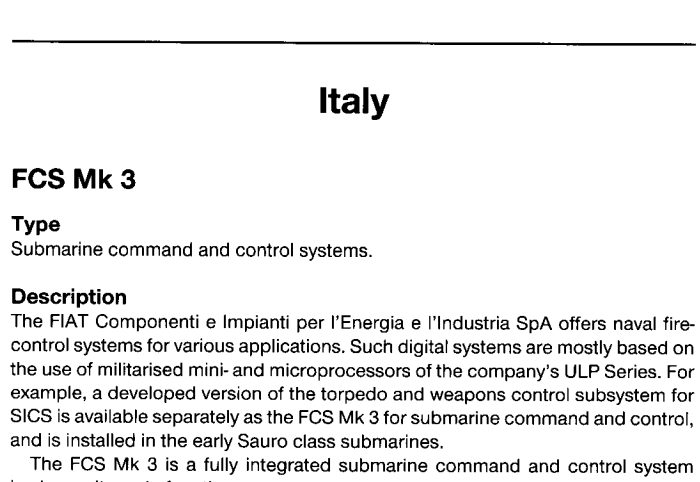
Description
The FIAT Componenti e Impianti per l'Energia e l'Industria SpA offers naval fire-control systems for various applications. Such digital systems are mostly based on the use of militarised mini- and microprocessors of the company's ULP Series. For example, a developed version of the torpedo and weapons control subsystem for SICS is available separately as the FCS Mk 3 for submarine command and control, and is installed in the early Sauro class submarines.

The FCS Mk 3 is a fully integrated submarine command and control system having as its main functions:

- acoustic sensor performance prediction
- prediction of counter-detection range
- target motion analysis
- threat evaluation
- target designation for attack
- weapons control (torpedoes and missiles)
- countermeasures control.



Consoles for the SEPA FCS Mk 3



Schematic diagram of FCS Mk 3 for submarines

Sensor inputs to the system include radar, navigation and attitude information, periscope and acoustic data from the integrated active/passive sonar system.

Target and 'own ship's' data from these sources are used to calculate and display target positions and target vectors, impact point predictions, tactical situation, a launch and guidance display, and wire guidance signals. The local control and switching box connects the signals from the FCS to the selected torpedoes, provides launching tube control, and feeds electric power to torpedoes in the tubes. Within the torpedo, the electronic control unit carries out wire signal interfacing, torpedo steering in accordance with FCS commands, computation of target data from the torpedo acoustic head, and torpedo homing.

Inputs to the system include: active and passive sonar data, navigational information, radar and ESM/EW sensors, and periscope. Weapons controlled include torpedo tubes for A184 weapons, which are connected via a local control and switching box.

Operational status
No longer in production or supported by manufacturer. In service aboard the two oldest Italian Sauro class submarines and four Type 209 boats of the Peruvian Navy.

UPDATED

MM/BSN-716 (SACTIS)

Type
Submarine action information system.

Development
SACTIS is the abbreviated title given to the submarine action information system developed for Italian Navy Sauro class submarines.

Description
In both versions the principal functions include:

(a) automatic data acquisition from all sensors (for example, hydrophone, sonar, passive ranging system, search and attack periscopes, radar, ESM, navigation system, depth-sounder)
(b) manual data input
(c) real-time computation of ship's position and target position (from bearing data only)
(d) data display (raw and processed) with five different presentations: unfiltered situation; tactical situation; time/bearing display; acoustic propagation display; tactical operation tabular evaluation
(e) calculation and display of data for typical manoeuvres such as screen or barrage penetration, evasion, target interception or collision course, approach and divergence routes, Closest Point of Approach (CPA)
(f) data and event recording
(g) playback for training and analysis.

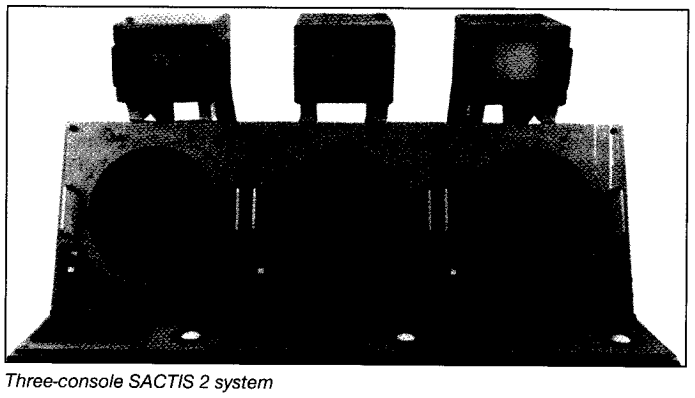
The hardware comprises: two or three display groups which have vertical CRT displays and keyboards for data input and system management, with separate alphanumeric 'tote' displays above the situation display CRTs; a central processor unit based on a Rolm MSE 14 digital computer; disk memories; a printer; a specially designed interface unit for input/output between SACTIS and the various sensors. The displays are arranged side-by-side to form an operating console and up to 30 separate targets can be displayed, from which individual track histories can be selected for examination and 10 of them presented as filtered targets. Main sensors connected to the system include the BPS-704 radar, IPD-70S sonar system and the Thetis electronic warfare system.

The later SACTIS 2 version includes provision for connection with the submarine's A184 torpedo fire-control system, inclusion of the ELT/810 sonar prediction system and connection to a Link 11 receiver. There is also extended computer capacity and a third operator position at the SACTIS console.

Operational status
The two oldest Italian Sauro class submarines are fitted with the MM/BSN-716 system.

Contractors
Datamat Ingegneria dei Sistemi SpA, Rome (software).

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Three-console SACTIS 2 system

TBI

Type
Torpedo board interface.

Description
The TBI is a family of products designed to interface heavyweight torpedoes with the control systems of submarines using advanced redundant serial communication (Ethernet).

The TBI is of modular design, which enables it to be readily adapted to the combat management systems of different kinds of submarines and different types of heavyweight torpedoes. It makes extensive use of available COTS hardware and software. Dual Ethernet interfaces are provided to the control system and it features online BITE and extended off-line test capability. Redundant design and flexibility with low power consumption and small cabinet dimensions are additional features.

The TBI family currently includes three different versions developed for the Type 212A; Sauro and Scorpene class submarine designs.

The main functions carried out by the TBI are:
- handling data communications between the command system consoles;
- handling data communications to/from the torpedo;
- executing torpedo pre-launch check, launch, wire guidance tests and so on;
- torpedo firing in emergency conditions;
- managing on-board torpedo tube related functions;
- testing and monitoring the battery of each stowed torpedo;
- managing the audio channel for torpedoes;
- monitoring the battery and heating for up to six torpedoes when in the launch tube;
- sending digital data exchanged in the communication link to a recording system.

The system architecture is based on dedicated and independent modules for each tube and a supervisor system with redundant capabilities. In addition the system can include dedicated modules for: stowed torpedoes; closed loop tests for maintenance purposes; local firing panel; and torpedo simulator. The simulator was developed in the SW version primarily for training purposes and in the HW/SW version primarily for integration and testing purposes.

The main components of the TBI comprise:
- Control unit (supervisor);
- Torpedo interface (Modulo Gestione Siluri - MGS);
- Stowed torpedo interface (Modulao Test Armi in Stiva - MTA);
- Local firing panel/display (LFP);
- Closed test module (Apparato Test TBI - ATT);
- Torpedo simulator (TRAS).

The control unit interfaces the TBI to the redundant Ethernet communication bus with the control system. Command and data received from the combat system are sent to the torpedo interface module or other dedicated autonomous TBI modules. In the same way, data from the torpedo is collected and sent to the combat system. The module contains two sections to enable it to guarantee a redundant performance and to maintain the submarine's launch capabilities. In case of combat system failure or under operator selection, the control unit interfaces the local firing panel/display, allowing an emergency launch with some reduced wire guidance capabilities. The control unit includes some dedicated functionality, typical of the torpedo to be launched, such as hit evaluation and attack and pre-setting optimisation, data correlation between the torpedo and sonar system. The control unit can simultaneously manage different torpedo interface modules in a mixed load.

Each of the torpedo interface modules allows complete management of one tube/torpedo. The module transforms the high level information emanating from the control unit in signals to the torpedo, allowing complete management of the umbilical cable and the wire guidance cable. In the reverse way data received from the torpedo is converted in high level and sent to the control unit. Interface with signals from the torpedo tube ensures safety requirements. Typical torpedo functionality and computer-controlled guidance can be performed for more than one torpedo.

The stowed torpedo interface module, which is similar to the torpedo interface module, allows torpedoes to be checked while still in the stowage rack using a standard command received by the command system via the control unit. A special battery monitoring status is continuously available on request.

The local firing panel/display allows the TBI to work in local mode, without any connection to the command system. The main functions performed are emergency launch, local check and display of certain information for the operator in the torpedo tube compartment. This module can be included on the TBI cabinet or installed as a separate item.

The closed test module provides maintenance and checking of the functionality of the system at torpedo tube level. As with the local firing panel it can be included on the TBI cabinet or installed as a separate unit.

A software version of the torpedo (a simulator) is included in the TBI, allowing the operator to carry out a simulated launch and displaying on the combat system console the launch results. A more complex version, including hardware simulation, is available, mainly for integration and test purposes. A simplified scenario is internally defined; a connection to an external general scenario generator is foreseen. The torpedo simulator can be included in the TBI or installed as a separate item.

Operational status
Developed and produced in various versions for the Sauro class, Type 212A, and Scorpene design.

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

TCU102

Type
Surface vessel torpedo launching system.

Description
The TCU is connected to the Milas launching system by means of a data bus MIL-STD-1553B, by two lines, each one in double redundant configuration, and with the torpedoes by means of hard lines and bi-directional RS-422 serial lines. The TCU is capable of managing up to 12 MU90 Impact torpedoes on the missile at one time.

Operating functions include:
- Off-line test (requested test)
- On-line test (parallel test)
- Tactical item engagement
- Presetting for launching the torpedo

Specifications
Length: 520 mm
Width: 335 mm
Height: 380 mm
Weight: 37 kg

Contractor
Whitehead Alenia Sistemi Subacquei SpA,, Livorno.

UPDATED

Netherlands

SEWACO VIII (Gipsy)

Type
Submarine data handling and weapon control system.

Description
SEWACO VIII (one of the family of SEWACO combat systems, also referred to as Gipsy) is an automated data handling and weapon control system designed for the Walrus class submarines of the Royal Netherlands Navy. The system forms the link between the submarine's sensors and its weapons and consists of seven identical multifunction Display and Computer Consoles (DaCCs). The built-in computer is of the SMR-MU type; the 16 in (406 mm) Plan View Display (PVD) provides a high-load, synthetic picture together with compressed radar video or sonar video, and the control panel is a multipurpose unit. The use of identical DaCCs offers maximum flexibility.

A Central Control Unit (CCU) is used to regulate the mutual data transfer between the DaCCs and the sensors and weapons. For this function two SMR-MU computers are provided, one active and the other a hot standby machine. The large amount of data from the sonars is handled by two extra SMR-MUs, also housed in the CCU. Three types of sonar are fitted (towed array, flank array and circular array), and other sensors and data sources include a noise analyser, ESM facilities, radar, periscopes and position-finding equipment.

The weapon control system can control a mixed load of weapons for subsurface and surface engagements, and the ship's launching system consists of two mutually independent sections, each of which is controlled from a Launching System Control Panel (LSCP). The interface with the weapons (modern subsurface missile) is formed by two identical distribution cabinets and for each pair of torpedo tubes (four are fitted in the Walrus class) incorporating the Mk 67 handling/launching system. All hardware necessary for the integration of these weapons is included in the distribution cabinet, avoiding the necessity for additional equipment.

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The main functions of SEWACO are:

(a) sonar display and control. This makes it possible to omit the original sonar displays and controls
(b) contact evaluation. This entails displaying information obtained from all sensors in a time/bearing format
(c) classification, where ESM, ASM and noise information is compared with cassette tape stored libraries to provide a rapid classification of the target
(d) contact motion analysis. Modern tracking filters are used for the automatic determination of target movements
(e) tactical plot and general plot functions, giving an up-to-date survey of the tactical and/or navigational situation or an historical situation survey
(f) weapon control, whereby the weapon systems are provided with the requisite aiming data
(g) simulation and test to verify the system's operability and to aid in operator training for the functions (a) to (f).

Additional functions can be inserted easily because the system is highly software oriented.

Operational status

No longer in production.

Four systems have been delivered and equip the boats of the Walrus class of the Royal Netherlands Navy. A more basic system has been supplied for shore-based training.

Contractor

Thales Nederland, Hengelo. ***UPDATED***

SINBADS

Type

Submarine integrated battle and data system.

Description

Developed in the 1970s, SINBADS (Submarine INtegrated Battle And Data System) is a compact data handling and weapon control system which supersedes the Thales Nederland M8 Series of torpedo FCSs for submarines. The computer used is the Thales Nederland SMR-MU, a fourth-generation general purpose machine, and the complete system combines the weapon control and data handling functions.

The processing cabinet incorporates two SMR-MU processors to handle TMA, track compilation and navigation. The display and control consoles are each provided with an SMR-MU processor to handle raw video or raster display of sonar data. The MMT comprises a software-controlled keypad, two handwheels and a rollerball.

The two weapons electronic cabinets each have an SMR-MU processor to manage and control the weapons.

The data handling function covers sensor display and sensor selection for track initiation. The raw sensor data of all sensors can be displayed. Each individual sensor is indicated with a unique label. The development of SINBADS is based on the application of modern passive sonars, capable of automatic tracking of targets. The tracking algorithm is based on Kalman filtering techniques and the tracking system includes as its main mode of operation a 'bearing-only' analysis which, however, also accepts other inputs of target information. The complete tracking system functions as an interactive system in which the command can intervene in the tracking process. For this purpose there are four display formats available.

SINBADS can handle five targets and three torpedoes simultaneously. These can be guided, unguided or a mixture thereof. The system also includes data recording for on and offline use, weapon simulation for training, online failure monitoring, and an emergency mode for which hand controls are provided to enable torpedoes to be set, fired and controlled in case of a computer or display failure. SINBADS can also be interfaced with the SUB-HARPOON anti-ship missile.

Operational status

No longer in production.

In service with the navies of Argentina (two TR 1700 type); Greece (four Glavkos class); Indonesia (two Cakra class); Peru (two Angamos class) and Turkey (four Atilay class). The SINBADS M version is fitted in the two Taiwanese Hai Lung class.

Contractor

Thales Nederland, Hengelo. ***UPDATED***

Norway

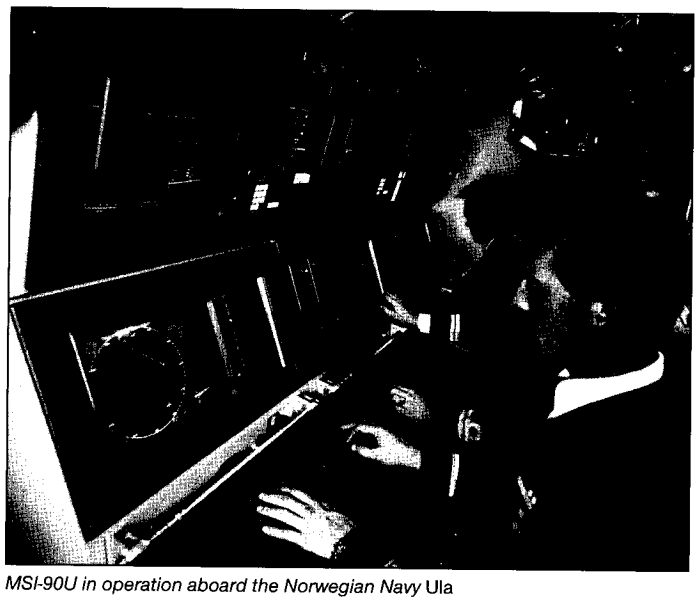
MSI-90U

Type

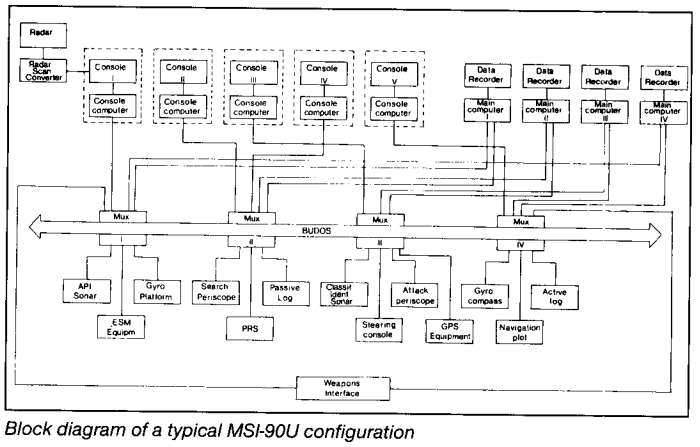
Submarine basic command and weapons control system.

Development

The MSI-90U has been designed to comply with the requirements of the Royal Norwegian Navy and the German Navy for their next generation of submarines, the Norwegian Ula class and German U212 class.



MSI-90U in operation aboard the Norwegian Navy Ula



Block diagram of a typical MSI-90U configuration

The basic design philosophy has been to achieve high, all-round capabilities, system flexibility and availability, with limited support costs through a structured design to the functional parts of the system. The basic design highlights the importance of redundancy and independent operation to the different subsystems.

The MSI-90U has undergone an extensive technical and operational test programme as part of the Royal Norwegian Navy's test of the Ula class.

Description

The MSI-90U is a software-based command and weapons control system which uses distributed processing, a high-capacity serial data transmission system (LAN), and multifunction operator consoles to achieve a high degree of capability, flexibility and availability. The main features of the system are:

- distributed data processing using the 32-bit KS-900 general purpose computer designed for real-time processing, based on the commonly used Motorola 68020/68040 range of microprocessors. The modular KS-900 is designed for programming in Ada, C and Pascal
- a high-capacity Local Area Network (LAN) is used for data communication between subsystems of MSI-90U, between MSI-90U and sensors, and sensor to sensor communication
- multifunction operator consoles allowing every operator to have access to all information in the system as well as permitting the number of operators to be adjusted to suit the current tactical situation. This means that one operator can operate the complete system with one console in, for example, a patrol situation. In the standard MSI-90U configuration four identical multifunction operator consoles are used, which can be configured for different console (work) modes. The number of consoles can be adapted to customer requirements
- built-in redundancy allowing subsystems to operate separately in graceful degradation fallback mode.

The LAN, named BUDOS, is based on Ethernet, and can interface sensors/subsystems via Ethernet, RS-422 or NATO STANAG 4156. Via BUDOS, any subsystem can communicate with any other connected subsystem. Connection of new subsystems can easily be made by means of spare interfaces on the existing BUDOS multiplexers, or by adding more multiplexers.

Four KMC-900 multifunction operator consoles (each with its own console KS-900 computer), three main KS-900 computers and two or three KS-900 weapon computers (depending on weapon type and customer requirements) ensures adequate redundancy.

Information is presented on two high-resolution colour raster scan displays. The man/machine interface is via a programmable entry panel (a plasma display with touch-sensitive overlay matrix), trackerball with associated control buttons and a standard alphanumeric keyboard. The MMI concept of the system, including layout of display pictures, has been subject to extensive MMI studies and trials in co-operation with the Royal Norwegian Navy and the German Navy.

The system is designed to carry out sensor integration covering target motion analysis, classification and identification, threat evaluation and weapons assignment and control. A number of supplementary facilities is also provided, such as: tactical evaluation and navigation, engagement analysis, preprogrammed movements, sound trajectory calculations and presentations, predicted sonar ranges for own ship and hostile ships, presentation of geographical fixed points and areas, data recording, and simulation for training purposes and so on.

The system is capable of tracking up to 25 targets simultaneously and controlling up to eight torpedoes and four missiles in different salvo combinations simultaneously.

Operational status
The MSI-90U is now operational on board all six Norwegian Ula class submarines and the Polish 'Sokol' (ex-Norwegian Kobben class). The MSI-90U is currently undergoing a joint German/Norwegian upgrading programme. Series deliveries of the MSI-90U for the German Type 212A, as well as upgrading of the systems on board the Norwegian Ula class, are under contract and are being undertaken until 2005. The system has also been contracted for the Italian Navy Type 212A submarines. Series deliveries will take place between 2002 and 2004. The system may also be acquired for the new Spanish submarines when they are ordered.

Contractor
Kongsberg Defence & Aerospace, AS, Kongsberg.

UPDATED

MSI-90U Mk 2

Type
Submarine command and weapons control system.

Description
The MSI-90U has been designed to comply with the requirements of the Royal Norwegian Navy and the German Navy. The MSI-90U Mk 2 command system is a modified derivative of the system developed for, and fitted in, the Norwegian 'Ula' class submarines and on order for the German Navy Type 212A submarines.

The MSI-90U Mk 2 is based on COTS technology using the new MFC-2000M multifunction console with UltraSPARC processors and NEC active matrix thin film transistors and high-resolution (1,280 × 1,024 pixels) colour LCDs with backlight. The software is also based on COTS including POSIX, Open GL, X-Windows, OSF/Motif, digital maps, audio-video modules and asynchronous transfer mode (ATM) network protocol.

The Mk 2 is capable of interfacing with the DM2A4 and Type 184 Mod 3 torpedoes and with UGM-84 Sub Harpoon and SM 39 Exocet submarine-launched missiles. In addition it is planned to interface the Sub-Polyphem fibre-optic guided anti-ship/anti-helicopter/land attack missile with the fire-control system. Optionally the system can also interface with the SST4, SUT, Mk 37, F17, L5 or other torpedoes.

The MSI-90U Mk 2 is said to be capable of simultaneous automatic and operator interactive TMA computation on up to 25 targets, with firing preparation and guidance of up to eight torpedoes, and preparation and control of up to four missiles.

Operational status
The MSI-90U Mk 2 is being offered for the Spanish Navy's potential plans to acquire Scorpene class boats. The main prospect for the MSI-90U Mk 2 remains the Scandinavian Viking project.

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

UPDATED

MSIFC

Type
Tactical picture compilation and weapon designation system.

Development
MSIFC (Multi-Sensor Integrated Fire Control) (formerly known as the MSI-2005F) is a new system which incorporates experience gained with MSI-90 and SENIT 2000 to produce an anti-submarine warfare system which will be integrated with the Lockheed Martin Aegis system for the Fridtjof Nansen class frigates scheduled to enter service in 2005. It was developed from 1998 to meet the Undersea Information and Sonar (Unison) programme in a project team led by the Norwegian Defence Research Establishment (FFI). The system is also likely to be offered to export customers of Aegis in association with Lockheed Martin to provide the anti-submarine combat element instead of the AN/SQQ-89 system. The system is also capable of operating as a stand-alone system providing a complete range of warfare capabilities except AAW. The technology may later be applied to submarines.

Description
MSIFC is primarily an ASW system with a torpedo alarm facility which is based upon three consoles linked by an Asynchronous Transfer Mode (ATM) based local area network and accepts data from the Spherion MRS 2000 hull-mounted and the CAPTAS Mk 2 towed array sonars. There are four MFC2000C twin screen consoles (three for ASW and one for ASuW) which are also designated SC3200.

The MSIFC links to the Aegis part of the Fridtjof Nansen combat management system via a dual redundant gateway, in other words a computer with interface cards.

Operational status
Hardware development of the system has been completed and factory acceptance testing for the first system was completed in December 2003. Delivery of the first shipset was accomplished in June 2004. Then remaining systems will be delivered between 2004 and 2007. Five MSI-2005F systems have been ordered for the Fridtjof Nansen class frigates.

Contractor
Kongsberg Defence & Aerospace A/S, Kongsberg.

UPDATED

Russian Federation

Uzel & Murena

Type
Submarine digital weapon control system.

Development
The Uzel system was Russia's first digital computer system and entered service with the Project 641B Tango class diesel-electric attack submarines from 1973.

Description
It is reported that these weapon control systems consist of at least three MVU-110EM digital computers operating at 100 kbps. The systems weigh about 2.8 tonnes and have a volume of 3.5 m³, while power consumption is 3 kW. The MMI comprises two single-operator consoles, one with a sonar display and the other with switches and buttons. The weapon control element of the system can simultaneously track five targets of which two can be tracked automatically with ballistic data entered manually and ballistic solutions produced automatically for the other three. The system also controls the automatic weapon reloading system. In the tactical data-handling role an additional three targets may be tracked manually.

Operational status
Operational aboard Project 877 (Kilo class) submarines.

UPDATED

Sweden

NEDPS (NIBS)

Type
Submarine action information and fire-control system.

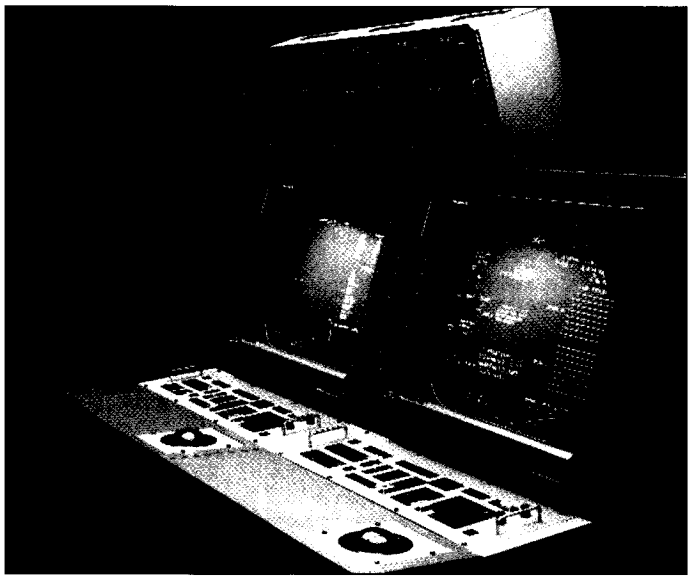
Description
The NEDPS (Näcken Electronic Data Processing System (in Swedish, NIBS)), was developed for use in the Näcken class submarines of the Swedish Navy.

The fully integrated system is designed to acquire, process and display information for tactical evaluation forming a basis for decisions regarding selected targets and torpedo guidance. The system includes complete hardware and software for controlling wire-guided homing torpedoes. Also included is computer control and monitoring of ship's functions, such as propulsion, steering, depth keeping, trim and storage battery condition.

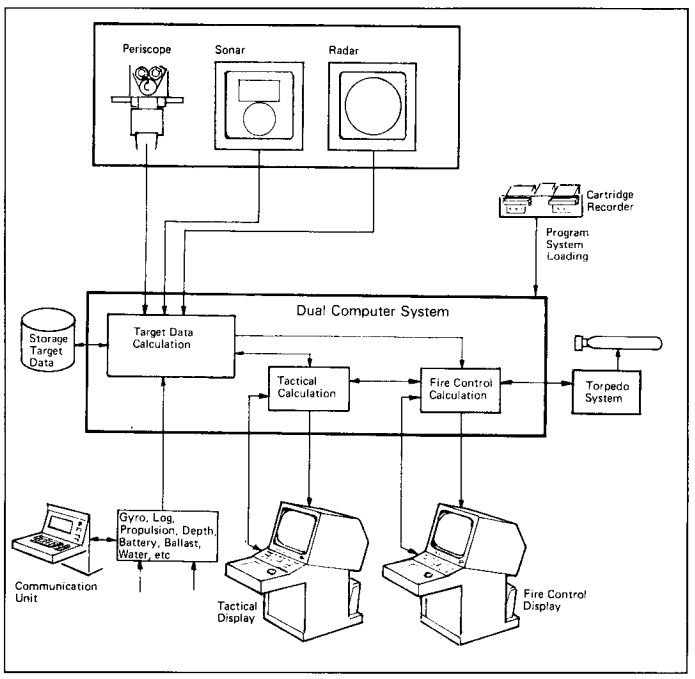
The system has a dual-computer configuration, the information being gathered through an extensive data collecting system from the different surveillance and weapon systems, as well as from the navigation system. The information is presented to the operators on two separate displays, each of which is equipped with input facilities in the form of special keyboards and trackerballs. Each operator console incorporates three weapon panels in the upper part of the console, together with an alphanumeric display which presents supplementary information such as datalink messages and ESM data. After target acquisition the tracking is carried out automatically and relevant fire-control data are calculated continuously. Torpedoes are normally controlled fully automatically after firing with graphic and alphanumeric presentation of all relevant information. Manual override of the tactical and fire-control displays is available at all times. The operational plot provides an extensive range of supplementary information, including own submarine operational area; own submarine movements together with navigation



The Mk 2 action information/fire-control system fitted as part of the mid-life update on the Sjöormen class submarines



The Mk 2 action information/fire-control system consoles as fitted in the Västergötland class submarines



NEDPS Mk 2

reference points and times; operational areas for other submarines; minefields; coastal radar stations with radar parameters. The plot also displays up to 50 internal labelled targets, 10 target channels for TMA; 240 external (via datalink) targets with target numbers and identities; and 32 ESM lines.

The tactical plot is used for the passive sonar TMA calculations on up to 10 targets simultaneously. On the Näcken class this plot is manned by the executive officer who supervises the fire-control operator as well as the sonar, radar and ESM operators. He also handles the periscope observations made by the commander.

Operational status

The NEDPS Mk 2, which uses software developed from the earlier Mk 1 version, with a single multifunction console, is in service with the four Västergötland class submarines, and has been retrofitted to the Näcken class submarine *Kronborg* now in service with the Danish Navy. One system has also been installed in a training simulator at Berga Naval College. The Sjöormen class boats being transferred to Singapore also carry the NEDPS system. The system is no longer in production.

Contractor

SaabTech AB, Järfälla.

VERIFIED

Sesub 940A

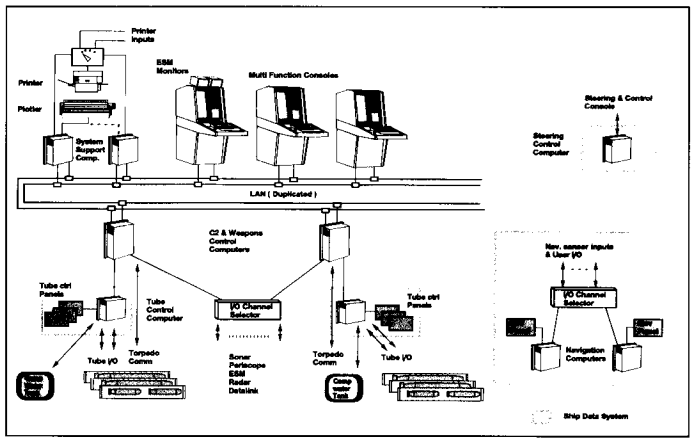
Type

Submarine combat system.

Description

The combat system in the Gotland class is a derivative of the SaabTech 9SCS Mk 3 based on a distributed configuration using duplicated LAN and a series of intelligent nodes which provide access for various subsystems into the databus. The system is designated Sesub 940A by the Swedish Navy. Sesub 940A uses Ada software which is based extensively on software already developed for the 9LV Mk 3 operational in the Anzac class frigates of Australia and New Zealand and other vessels of the Danish, Finnish and Swedish navies. The suite is based around three Terma-built Type IID multifunction consoles providing command and control, communications and weapons control functions. Each console can manage up to 50 tracks with 3,000 vectors, 250 symbols and 500 labels. The complete system has a capacity of 95 tracks. The system is connected on a dual Ethernet copper wire LAN. There are also three consoles for the STN ATLAS CSU90 sonar suite, which interface with the system, as well as two torpedo interface units, the sonar suite being capable of tracking some 250 targets simultaneously.

The system features multisensor Target Motion Analysis (TMA) and simultaneous control of all torpedoes. TMA is calculated based on passive sonar



Block schematic of the 9SCS Mk 3 (Sesub 940A) submarine combat system 0007218



The combat system aboard a Gotland class submarine 0007217

bearings only, with optional supplementary target data from other sensors such as periscope and radar.

The system has been upgraded to enable it to handle the new Tp 62 torpedo.

Operational status
In service aboard the Swedish Navy's Gotland class submarines.

Contractor
SaabTech AB, Järfälla.

VERIFIED

United Kingdom

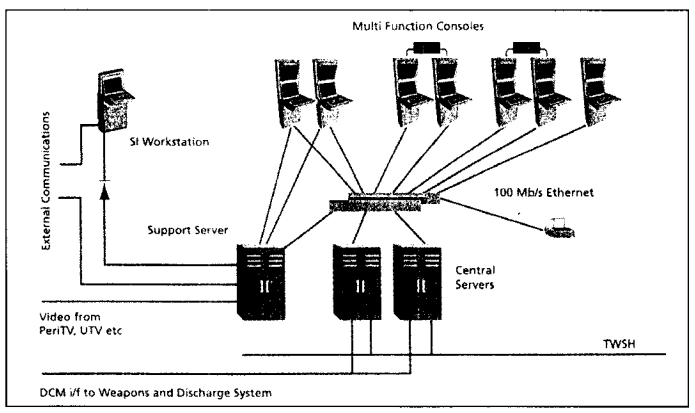
ACMS

Type
Astute Combat Management System (ACMS).

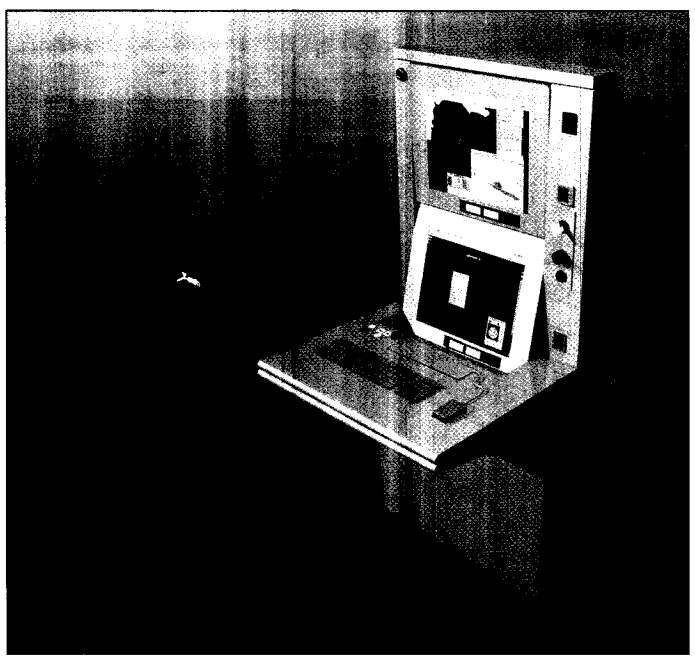
Development
The ACMS has evolved from the SMCS currently in service in all classes of UK submarines. SMCS was designed from the outset for evolution, which has enabled applications proven on earlier variants of the system to be transferred back into the ACMS design.

Description
ACMS combines three separate combat system requirements in a single system:

- SMCS functions for the command and control system using new applications and new display graphics developed for the updated Trafalgar class. This ensures user familiarity and continuity in operator training
- The command support system. Logicon's standard product for the recognised maritime picture is embedded in ACMS and is accessible from all console positions
- The command workstation system in which two consoles are capable of displaying video images from the optronics masts and other sources.



ACMS system architecture (AMS Ltd) 0524685



A graphic of the console to be used with the ACMS (AMS Ltd) 0129735

ACMS will be a distributed system capable of handling the growing volume of information available in modern nuclear submarines and of controlling current and future sophisticated underwater weapons. New consoles, each possessing two large LCDs, have been designed for ACMS. Over 95 per cent of the hardware in ACMS is commercial, including modern powerful processors that have allowed a dramatic reduction in the number and types of cards. The new system has resulted in significant savings in space, weight, electrical consumption and cooling requirements.

The modern system architecture allows the introduction of third-party applications and ensures that new requirements can be accommodated easily as they emerge. Its design ensures that processing speed and reliability of mission critical elements will be preserved.

The ACMS comprises seven multifunction consoles each with two 18 in LCD panels, a keyboard and mouse. The consoles will all be mounted in the control room, six on the tactical side and one on the sonar side.

An eighth console with a single LCD display is housed in the EW office and is used for handling special intelligence information.

Two central servers provide processing facilities for functions such as TMA and the track database. They operate in a master/slave configuration for resilience. They also handle the interfaces to external equipments and weapons and provide a host environment for third-party applications that need to be resilient, such as the improved acoustic model oceanography package.

A support server contains video processing cards and takes inputs from various video sources such as the optronics masts, underwater TV and so on and from the external communications system. The server also contains a processor for third-party applications and hosts Logicon's ICS product, which makes the recognised maritime picture available to all consoles.

The servers and nodes are connected by a star configuration Fast Ethernet (100 Mb/s) LAN using fibre optic cables. There are two LANs for resilience, each with its own switched hub. Video is provided to two consoles by direct links.

Processor cards are variants of Sun's Sparc 2 family running the Solaris 8 Unix operating system. The open system architecture and spare capacity mean that additional terminals, whether PCs or Sun workstations, can easily be added and additional third-party applications incorporated without necessarily needing additional hardware resource.

Operational status
On order for the Royal Navy Astute class submarines. Operational software achieved factory acceptance in July 2002.

Contractor
AMS Ltd, New Malden, Surrey.

UPDATED

KAFS

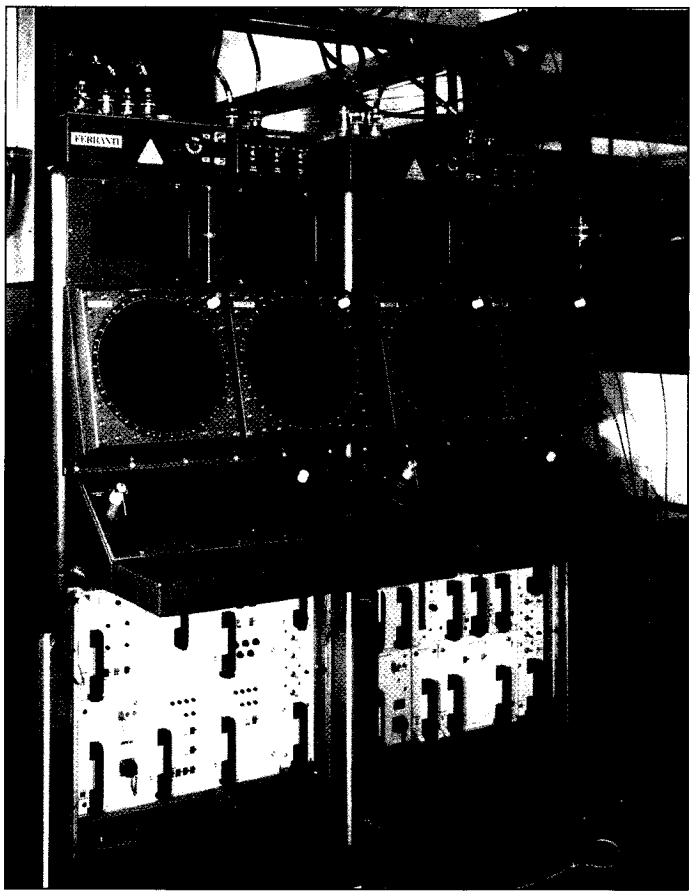
Type
Submarine combat information and fire-control system.

Development
KAFS was a commercial development of Outfit DCC (see separate entry) and reflects Ferranti's experience in submarine combat information and fire-control systems, gained from the development of Outfits DCA, DCB, DCC and DCH for the Royal Navy.

Description
KAFS is suitable for conventional submarines of all sizes. The system uses modern processing techniques and software algorithms to provide a wide range of operational facilities including sensor data handling, target motion analysis, picture compilation, fire control, tactical calculations and data recording. A comprehensive onboard training facility enabling training in both combat information and fire-control procedures to be carried out in harbour or at sea, is also included. The system hardware and software has been specifically designed in a compact, modular manner to provide a range of facilities which can be adapted or expanded as necessary to meet individual customer requirements.

The equipment configuration is a console in the control room linked by a MIL-STD-1553B databus to the weapon control equipment in the torpedo room. The torpedo room equipment comprises a local control panel, which provides common services together with two weapon interface units and two tube switching units. The weapon interface and tube switching units are provided one each side to port and starboard, so that in the event of a failure in the equipment of one side the other remains operational. Data from the sonar, search and attack periscopes, ESM, radar and navigation sensors is also passed to the system via the databus.

The control room console provides two identical operator positions mounted above two electrical sections that house the FM 1600E central computer and all the associated electronics. Full combat information and fire-control facilities are provided at each console operator position and either operator can control the whole system, thereby allowing one position to be shut down in patrol state. Each console position has two CRT displays, two command data panels, and a weapon control and system status panel. The two display areas provide the operator with a label plan, time/bearing or vertical section display and a tote display providing pages of data and selections to enable them to interact with the system using a light pen. Track data, intercept alarms and tube and weapon status are displayed on the combat information and fire-control command data panels. Tube and weapon



KAFS console

preparation orders are passed to the torpedo room using the weapon control and system status panel. Weapon guidance is fully automatic, although KAFS also has facilities for manual guidance post-launch and system control, as well as status indications.

The weapon control equipment in the torpedo room, which is microprocessor-based, provides the interfaces to the tubes and weapons. Tube and weapon status is displayed on the local control panel which also provides weapon discharge and control facilities in fallback mode, independent of the central processor, and facilities for weapon battery heating together with monitoring to detect hazardous conditions. The weapon interface and tube switching units apply switch settings and power supplies to the tubes and weapons during the preparation and launch phases. After launch, guidance commands are also routed to the weapons via these units.

Operational status
1984 - the Brazilian Navy ordered two systems for Type 209 submarines and a shore training system.

1987 - Brazil ordered a further two systems for Type 209 submarines.

The last two systems were built under subcontract by SFB Informatica in Rio de Janeiro and have been delivered to the Marinha do Brasil.

Contractors
AMS, Camberley, Surrey.

SFB Informatica, Rio de Janeiro.

UPDATED

Manta

Type
Submarine tactical data handling system.

Development
Manta is a tactical data processing system developed and built to support the command systems in submarines. Originally developed to enhance the existing command system capability on selected Royal Navy submarines, the system is currently in service with the Royal Navy as DCG(R), a four-position variant of Manta (see DCG(R) entry). Manta exploits commercially available computing units to achieve performance, portability and reliability with a low lifetime-cost and short procurement lead times.

The system replicates the full functionality of its precursor system, DCC, including its interface to the command-system computer.

Description
The system provides a high-level software environment that is used to integrate and co-ordinate a suite of existing and proven tactical applications which allow the command to optimise deployments including:

- tactical picture compilation, display and management
- data fusion, classification and TMA tools
- navigation quality charts to enhance the tactical picture
- oceanographic and environmental data analysis, prediction and exploitation
- weapon command tactical aids
- navigation and mission planning facilities
- online operational and engineering information

These functions combine to enable the command to maximise platform effectiveness and minimise risk of detection. By subjecting the data to rigorous and intensive analysis Manta is able to produce a more accurate picture of the tactical situation.

Manta provides a distributed open systems processing environment, based on networked COTS Sun SPARC workstations running under UNIX. The network is easily reconfigurable to provide inbuilt redundancy and to deliver high system availability and reliability. Flat-panel colour display technology is used to minimise the impact on platform space and power requirements. The high screen resolution displays offer high-performance colour graphics in a compact unit. Combined with the use of Windows and point-and-click user interaction this provides a powerful yet easy to use operating environment.

The software design includes a substantial suite of existing and proven tactical applications and incorporates a high-performance, object-oriented track database.

The system can be configured to interface to any automated data source including command systems, sensors, communications equipment and weapons through a range of industry standard interfaces. Alternatively manual data entry capability enables Manta to be used as a stand-alone system.

The open architecture configuration also includes substantial expansion capability permitting future inclusion of new control room facilities either as integrated functions with access to tactical picture data, or as stand-alone functions running within the overall environment. This gives the system great potential for supporting the implementation and trials at sea of prototype software and technology demonstrators.

Operational status
Available for acquisition.

Contractor
AMS, New Malden, Surrey.

VERIFIED

OSDI

Type
Own Ship's Data Interface (OSDI).

Description
OSDI is a dual-redundant data distribution, processing and interface unit. It provides an intelligent interface between the navigation systems and sensors and the tactical weapons systems highway.

OSDI interfaces with the following subsystems:

- Inertial Navigation Systems (INS)
- Ship's Navigation Automated Processing System (SNAPS)
- Global Positioning System (GPS)
- Depth sensor
- Electromagnetic Log (EM Log)
- Frequency Standard 'E' (FSE)

OSDI distributes the following data:

- Ships' reference and rates messages (attitude, speed, attitude rates and associated validity) indications
- Navigation reference messages (position, polar position, velocity vectors including drift and their associated validity indications)
- The Time Synchronisation Message (UTC time and a rolling count for use as a timestamp)

The OSDI hardware consists of two identical dual-redundant processing cabinets and one shared Own Ship Data Display (OSDD) which provides depth, speed and heading.

Operational status
Under contract for development and initial production of equipment as part of the tactical weapon system in the Royal Navy's Trafalgar class submarines.

Contractor
BAE Systems C4ISR, Christchurch, Dorset.

VERIFIED

SMCS

Type
Submarine command system.

Development
Advances in both submarine design and sensor technology have led to significant increases in the quantity and diversity of tactical data available to the combat team



SMCS console 0007219

of a modern submarine. To manage the increased data processing, SMCS (SubMarine Command System), was selected by the Royal Navy as the new command system for fitting or retrofitting to the Vanguard, Trafalgar and Swiftsure class submarines. SMCS has been designed to allow it to evolve taking advantage of the latest technology which can be incorporated without disturbing the vast amount of complex application software using COTS hardware and software.

Description

SMCS is a high-capacity open architecture distributed processing command system based on a dual-redundant fibre optic Local Area Network (LAN). SMCS interfaces to the submarine's sensors and tactical weapons, providing the control of the weapon discharge systems and functions to support the full range of combat system management tasks. The functions include: Track Motion Analysis (TMA); tactical picture compilation; oceanographic data analysis; weapon management; weapon command tactical aids; onboard training; data recording and replay.

The capacity of SMCS for handling and storing data is very large. Track processing has been specially developed, taking full advantage of many years of experience in this area. Many simultaneous TMA solutions can be handled. An important consideration in the functional design has been to automate as much of the routine of track management as possible, leaving operators free to concentrate on the more critical aspects.

Operator interface is by high-resolution colour graphics displays at a number of MultiFunction Consoles (MFCs), with interactive plasma panels and 'pucks' (similar to a mouse). Secondary workstations are also available where space is particularly limited.

SMCS technology is based on recognised and widely used commercial components, ruggedised to suit the submarine environment. The use of commercial standards ensures widespread and long-term availability and support for the key components, as well as ease of upgrade. The main processor is the Intel 80386/486. In the major server nodes these have been replaced by Intel Pentium processors, with the possibility of upgrading as this family of processors is enhanced, while fast processing is performed by Inmos transputers, which can also be upgraded. The system architecture allows this substantial processing power to be easily increased, if necessary, to accommodate future requirements, and there is sufficient spare physical capacity to do so.

SMCS software is written in Ada, while Occam is used for the transputers. This approach yields a highly modular system, which facilitates enhancements.

Fundamental to the SMCS architecture is the high bandwidth, dual-redundant, fibre optic Local Area Network (LAN) based on the IEE 802.5 token passing protocol, with built-in self-healing. The LAN has a 3 MHz bandwidth, of which 2 MHz is available. To the LAN are connected the processing nodes and the MFCs, which also contain processing capability.

An important feature of SMCS is its inherent resilience to failure. All processing nodes are duplicated, with one in use and the other on standby and the MFCs are identical. The standby nodes are automatically switched into use in the event of a failure being detected in the other.

A number of key features of SMCS include:

- a high degree of flexibility and expandability
- a substantial increase in usable processing power
- improved operability, to ease the growing burden on the crew in the modern submarine environment
- improved reliability to provide a 'non-stop' system
- the capability to match envisaged and likely improvements in weapons and sensor technology.

The flexibility of the basic system architecture has been demonstrated, not only by the different submarine fits being produced, but also by the adoption of SUCCESSOR-based systems for the Royal Navy's surface ships, where the detailed operational requirements are very different.

Versions of SMCS can be readily produced to suit almost any type of submarine, to form the key central element of the combat system. For the 'Trafalgar' Update II programme, new displays have been developed using high-performance graphics packages that conform to the X-Windows® standard. They run under the general purpose UNIX operating system using Sun SPARC processors.

Operational status

In service since 1992 and fully operational aboard Royal Navy Vanguard, Trafalgar and Swiftsure class submarines.

Contractor

AMS, Frimley, Surrey.

UPDATED

SMCS-NG

Type

Submarine Command System - New Generation (SMCS-NG).

Development

SMCS-NG began as a technical demonstrator programme to prove the feasibility of the technology, commencing with the software. Once the technical solutions had been approved work progressed onto hardware and system engineering aspects, which included the development of a prototype console suite. A functioning prototype system was installed in the BAE System Submarine Systems Integration and Support Centre in early March 2003. Because SMCS was designed from the outset to evolve, this has enabled applications proven on earlier variants of the system to be transferred to SMCS-NG.

Description

SMCS-NG (Submarine Command System - New Generation) resolves several obsolescence issues in the current version of SMCS that currently exist or will soon become extant. The new technology will release a significant volume of space and processing power. Giving more scope for third party application to be hosted within the SMCS system environment. The design draws heavily on developments made by AMS for the combat management systems for the Astute class submarine and Type 45 destroyer.

The core requirement for SMCS-NG is to take information from the sonars and other sources and, through advanced algorithms and data handling, to display in real time a picture for the command team. SMCS is a distributed system capable of handling the growing volume of information available in modern nuclear submarines and of controlling the sophisticated underwater weapons currently in service and expected to enter service in the future.

SMCS-NG transfers applications proven on earlier variants of SMCS to a new modern system architecture that uses PCs to provide the computer processing with Windows 2000 as the software operating system. The design includes a reconfigured LAN, four new multifunction consoles and internal modifications to the three system cabinets. Portions of the existing command console equipment will be updated to SMCS-NG configuration and a smaller terminal in the sonar area will also be updated.

Two central servers provide the processing facilities for processes such as TMA and the track database. They operate in a master/slave configuration for resilience. The servers and nodes are connected by a Fast Ethernet (100 Mb/s) LAN using fibre optic cables. The system is based around two LANs to provide redundancy in case of emergency.

New devices have been introduced to convert between the TCP/IP communications used by SMCS-NG and the bespoke protocols used in the legacy Tactical Weapons System Highway and weapons interface equipment. They are mounted in separate racks so that the PC processors remain in a commercially available configuration to keep costs low. A support server contains a processor for third-party applications such as NECTA.

SMCS-NG uses COTS equipment throughout the system. In particular the PCs will be either standard office-quality towers or ruggedised 19 in rack-mounted machines. The use of COTS technology offers greater systems openness, enabling new capabilities to be added more quickly and easily in the future.

The system features four multifunction consoles each with two large 18 in flat LCD panels as the main displays in a configuration very similar to that developed for the Astute class combat management system. The graphical user interface is also very similar to the 'Astute' system, so that training will be common for the two classes.

Operational status

SMCS-NG is due for installation in HMS *Torbay* early in 2004 and negotiations with the MoD are underway for a contract for a full production-standard kit for installation in HMS *Torbay* together with shore kits to support software development and combat system integration.

A further contract is anticipated for SMCS-NG kits for the remaining three Trafalgar class boats in the Final Phase of the S&T Combat System Update.

AMS is now conducting a study to investigate the feasibility of retrofitting SMCS-NG to the Vanguard class SSBNs and to the remaining in-service SSNs.

Contractor

AMS, Frimley, Surrey.

NEW ENTRY

SWIM

Type
Weapon interface equipment.

Description
The purpose of SWIM (Submarine Weapon Interface Manager) is to route and monitor command and control signals between various elements of the combat and tactical weapon system.

SWIM facilitates the interfacing of the 'Astute' Combat Management System (ACMS) and the Tomahawk Tactical Weapon Command System (TTWCS) with the new generation air turbine pump discharge gear and weapons. Weapon capability includes the heavyweight torpedo Spearfish and the Tomahawk land attack missile with retained features for the Royal Navy Sub Harpoon Block 1C missile.

The system's advanced design includes monitoring functions and redundancy features, which facilitate high system safety, reliability and availability.

SWIM applies COTS technology to offer significant reduction in size and in number of line replaceable units, enhanced maintenance features, significant expansion capability, and lower cost of ownership in comparison with older systems.

Operational status
SWIM is ready to be fitted in the Royal Navy Astute class submarines.

Contractor
Ultra Electronics Command and Control Systems, Loudwater, Buckinghamshire.

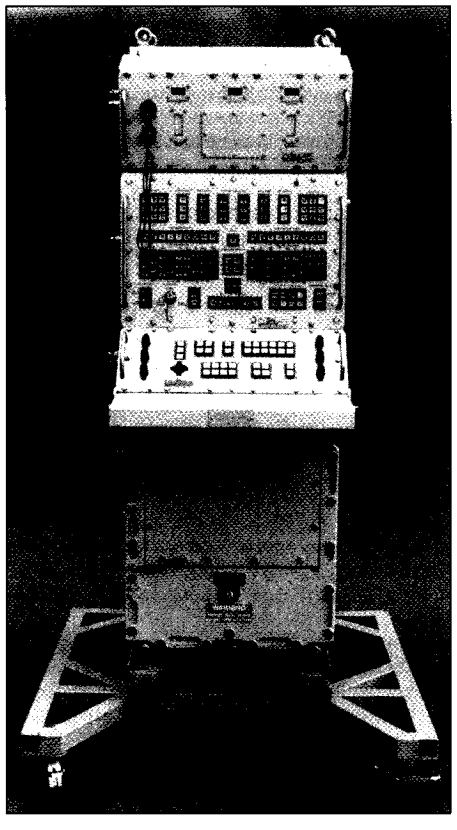
UPDATED

Torpedo launch controller

Type
Electronic launch controller for submarine discharge systems.

Description
The launch control processor is a part of the Vanguard class weapon handling and discharge system, which is manufactured by Strachan and Henshaw. The launch control processor is a microprocessor-based system, which monitors and controls the torpedo firing sequences from loading to discharge. It also links the discharge instrumentation system with a comprehensive set of self-diagnostics and provides fault tolerant interfaces to each torpedo tube. The system allows remote control and monitoring of the torpedo tubes from the control room, without operator assistance, and has built in fault recognition to speed diagnosis.

The tube operator console, which also forms part of the Strachan and Henshaw weapon handling and discharge system, provides similar facilities in the Canadian Victoria class. The tube operator console which houses the launch control processor, features an operator interface and provides the drive profile for the weapon discharge air turbine pump.



Torpedo launch controller is installed in Strachan & Henshaw tube operator console aboard the Canadian Victoria class submarines

Operational status
Launch control processor in service in Vanguard class submarines (UK) and tube operator console operational aboard Victoria class (Canada).

Contractor
Ultra Electronics Command and Control Systems, Loudwater, Buckinghamshire.

UPDATED

United States

AN/BSY-1(V)

Type
Submarine combat system.

Development
The BSY-1(V) totally integrated combat system has been developed as a result of restructuring the SUBACS programme. As part of the redesigned SUBACS, the fibre optic databus distribution system was replaced by the traditional copper cable together with already developed hardware in order to accomplish data distribution. The system is designed to equip the Los Angeles class attack submarines.

Description
The system is the first submarine combat system in the US Navy to integrate navigation, sonar and weapons system data for improved target detection, classification, localisation, combat control and weapons launch. The BSY-1(V) integrates the medium- to low-frequency bow-mounted Submarine Active Detection System (SADS) sonar used for the detection and fire-control solutions on hostile subsurface to surface targets. This operates over 360° in long-range search, and provides a passive listening mode. The system also integrates the high-frequency, active Mine and Ice Detection Avoidance System (MIDAS) mounted in the sail and which is used for close-range detection of mines and polar navigation. Finally the system integrates two towed passive arrays: the TB-16 and the lightweight, long thin-line TB-23 towed array, the latter providing long-range submarine target detection. The TB-23 can be reeled into the submarine's ballast tanks.

The integrated combat system carries out target motion analysis and calculates a fire-control solution for Mk 48 Adcap torpedoes, Harpoon and Tomahawk cruise missiles. It uses the UYK-7 and UYK-44 computers as its central processing elements.

The system is designed to improve data processing and management capabilities using new and more capable computers, new data displays and additional software and increased automation in areas such as surveillance, detection and tracking of targets. This will enable operators to perform multiple tasks and handle multiple targets simultaneously. The aim is to reduce the response time between initial detection and launching of the weapon.

The distributed processing architecture system comprises 117 units, including 64 general purpose and 35 specialised processors, digital beamformers, signal conditioners, displays and disk storage devices. Some 3.6 million lines of tactical software code are used in this system.

Operational status
The first unit designated to receive the BSY-1(V) system was the Los Angeles class submarine *San Juan.* The system was installed during the summer of 1987. Coincident with the first system going to sea, the US Navy commissioned a shore trainer. Since then, 21 submarines have received the system and all 21 of the acoustic subsystems have been upgraded with the Navy's new standard AN/UYK-43 computer (which will replace the old AN/UYK-7). The latest version of the system, referred to as 'ECI-010 Level', which incorporates the latest version of the Tomahawk fire control and acoustic improvements, completed certification at the contractor's facility in September 1993. As of August 1995, 19 submarines have been upgraded to the ECI-010 level. A total of 25 AN/BSY-1 systems were ordered, including a number for non-shipboard use (training and so on).

All 25 AN/BSY-1 sets have now been delivered, including a Maintenance Trainer. In addition, two Team Trainers and four Weapons Launch Systems Operator Trainers have been delivered. Boats currently fitted with AN/BSY-1 are *San Juan, Pasadena, Albany, Topeka, Miami, Scranton, Alexandria, Asheville, Jefferson City, Annapolis, Boise, Springfield, Columbus, Montpelier, Santa Fe, Hampton, Charlotte, Hartford, Toledo, Tucson, Columbia, Greenville* and *Cheyenne* (in order of completion).

Contractors
Lockheed Martin Naval Electronics & Surveillance Systems, Undersea Systems, Manassas, Virginia (production).

VERIFIED

AN/BSY-2

Type
Advanced submarine combat system.

Development
The BSY-2 combat system was instituted after the SUBACS programme was cancelled in FY86. It was developed for the new SSN-21 'Seawolf' nuclear-powered attack submarine of the US Navy. The development of BSY-2 is considered to be one of the largest computer software efforts ever undertaken for a submarine. Considerable effort was devoted to developing and integrating a massive amount of software involving some 5.5 million lines of code, the majority of which is written in Ada. Responsibility for developing the software was shared among seven development organisations under the direction of the prime contractor. Four of these form part of the prime contractor and three are subcontractors.

Description
The BSY-2 is an integrated sensor and fire-control system combining active sonar, passive flank array sonar, passive towed array sonar and combat control system with an advanced computer system which is designed to detect, classify, track and launch weapons at enemy subsurface, surface and land targets. The boat's sensors include a wide aperture array (BQG-5), long thin-line towed array (TB 29), a hemispherical transmit array, a standard towed array (TB-16D), a Mine and Ice Detection Avoidance Sonar (MIDAS BQS-24 HF active array), and large spherical array. Other hardware includes a tactical situation plotter, transmit group, a large vertical display screen and a large horizontal display screen, multifunction combat system display consoles, weapon launch system and multi-array conditioner.

The BSY-2 also integrates the BQG-5 wide aperture array (installed on the submarine USS *Augusta* and USS *Cheyenne*) offering significant performance improvement over existing sensors.

The system has been developed to counter the submarine threat of the 21st century, and as such is being designed to enable the submarine to: detect targets in a much shorter time than is currently possible; allow operators to perform multiple tasks and handle multiple targets simultaneously; and to greatly reduce the time between detecting a threat and the launch of weapons.

The new UYS-2 acoustic processor, which has several times the capacity of the UYS-1 is used, and the BSY-2's distributed architecture is specifically designed to cope with the increased processing requirements of the acoustic array suite. The system comprises 92 Motorola 68030 32-bit processors which carry out the various functions within the combat suite. The design specification requires the processors to be grouped in four task areas: acoustics, command and control, weapons and display. Redundancy is provided in various ways. In the weapon cluster a designated back-up spare will be available for each of the four processors. Thus, if any processor fails it will be automatically replaced by its spare, providing 100 per cent redundancy. The remaining three clusters will not, however, achieve the same level of redundancy. For these, various back-up support options will be available should one or more processors in a cluster fail. At the first level of redundancy six spare processors will be available for electronic substitution in the event of failure. As a second line of defence, other processors in the affected cluster can be available for use as spares, if they are not being used for their own function at the time. Finally, if all available processors are in use and failure occurs, then the system will suffer gradual degradation with some loss in operational capability. If operational capability is lost a prioritised list of functions will be implemented, assuring that minimum defensive functions (self-protect functions) are maintained at all times. These will afford the submarine protection against hostile threats, but will not provide it with the full capability required to carry out an attack mission. Finally, should a cluster begin to lose operational capability, then spare processors carried on board can be manually inserted into the system, but this takes time which in certain threat situations may not be available.

The system features six data displays and 11 consoles.

Operational status
Contract for full-scale development and production was awarded in March 1988. Total development and procurement costs for four BSY-2 and two BQG-5 systems was US$1.7 billion. Integration and testing of the system took place between 1989 and 1994, the first system has been delivered to *Seawolf*. It is unlikely that more of these systems will be built, as a new combat system has been selected for the Virginia class.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

UPDATED

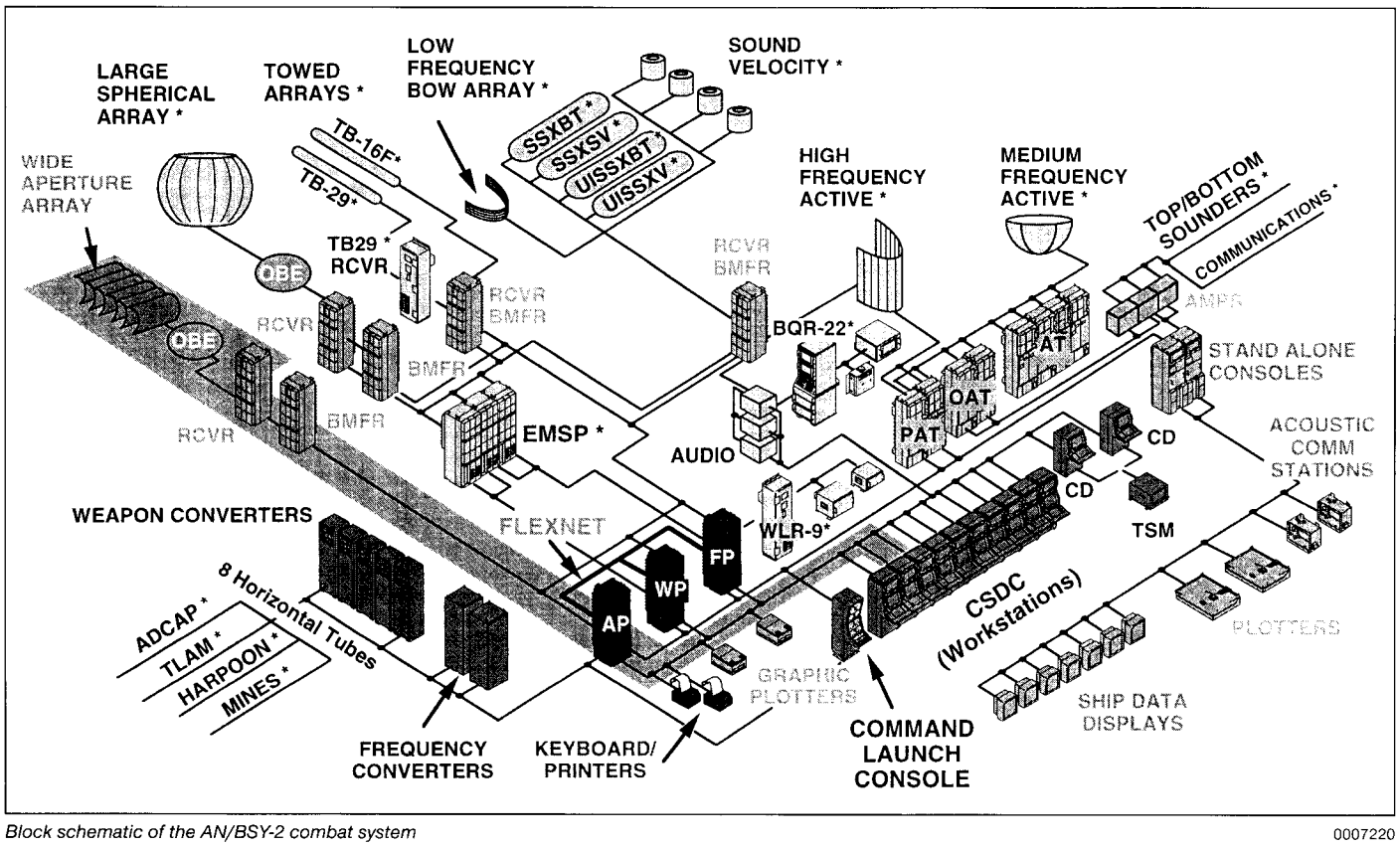
AN/SQQ-89

Type
Surface ship Anti-Submarine Warfare (ASW) combat system.

Development
The US Navy recognised in the early 1970s that, despite improvements in the performance of ASW fire-control systems such as the Mk 116, the effectiveness of ASW warships in the face of quieter and higher-performance submarines was limited. Towed array sonar systems were being developed with more sophisticated signal processors which made detection at longer ranges possible, while the development of the LAMPS (Light Airborne MultiPurpose System) Mk III helicopter improved the capability for localisation and engagements of targets beyond the horizon.

It was clear that the best solution would be to create an integrated ASW combat system, which would incorporate the Mk 116 as well as data from all the shipborne and airborne sonars. Research and development of the system, later designated AN/SQQ-89 Surface Ship ASW Combat System, began in 1976. The initial system technical evaluation trials were conducted in 1982 on board the Spruance class destroyer *Moosbrugger* (DD 980). The first production system, AN/SQQ-89(V)2 was installed in the Oliver Hazard Perry class frigate (FFG 7) USS *Curts* (FFG 38) in 1985.

The SQQ-89 was also selected for the later Ticonderoga class cruisers (CG 47) and the first SQQ-89(V)3 was installed in the USS *San Jacinto* (CG 56) which was commissioned in January 1988. The first SQQ-89(V)1 was installed in the Arleigh Burke class destroyer *Arleigh Burke* (DDG 51) in July 1991. Every Arleigh Burke



Block schematic of the AN/BSY-2 combat system

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class destroyer after DDG 51 (DDG 52 through to DDG 78) will have the SQQ-89(V)6.

Two companies have supplied the AN/SQQ-89 ASW combat system to the US Navy. In 1990 and 1992, Northrop Grumman won competitive contracts for the production, logistics support and design agent activities. In 1991 and 1996, Lockheed Martin won competitive contracts for the same activities.

Description

The SQQ-89 is the US Navy's premier surface ship ASW combat system designed to detect, locate, track and engage submarine targets. It transmits and/or receives acoustic signals using a variety of sensors to provide target classification, as well as performing and controlling Target Motion Analysis (TMA) and controlling the setting of 'own ship' ASW weapons. In addition, it provides multisensor track correlation, track management control and forwards track data to the ship's combat direction system or command and decision system.

The system is an integrated combat system, which consists of two or three sonar sensors, which interface either with the Mk 116 fire-control system or a Weapons Alternate Processor (WAP). This integration provides maximum operational effectiveness while requiring the minimum manpower to operate the equipment. The SQQ-89 permits the sharing of display consoles when multiple sensors are in use, with the system using between two and six consoles. One or two of these consoles are usually for the Mk 116 system and the remainder are for the sonar systems, with OL-190 acoustic data converters interfacing the consoles with the computers. The AN/SQQ-89(V)1, 3, 5 and 8 have a total of five display consoles, while the (V)4, 6 and 7 have six. There is no Mk 116 in the SQQ-89(V)2 system aboard the Oliver Hazard Perry class ships. Two display consoles are used for the acoustic sensors in the FFG 7s.

The sensors integrated in the SQQ-89 are the AN/SQS-53B/CD hull-mounted sonar, the AN/SQR-19 TACtical Towed Array Sonar (TACTAS), the AN/SQQ-28 LAMPS Mk III Sonar Signal Processing System (SSPS), all supported by the AN/UYQ-25 Sonar *In situ* Mode Assessment System (SIMAS). The fire-control equipment is the Mk 116, except for the FFG 7 class which uses the WAP. In addition to the operational equipment, the SQQ-89 includes an OnBoard Trainer (OBT), the AN/SQQ-89(V)T. The OBT provides realistic training and front-end stimulation of SQQ-89 ASW and AN/SLQ-32(V) electronic warfare sensors. It features a trainer console, LAMPS helicopter navigation simulator, signal generator/processor and various peripheral systems.

The AN/SQR-19 is a passive, long-range omnidirectional computer-aided system for detecting, classifying and tracking surface and submarine targets. The computer-aided detection features provide operator alerts and optimised search and classification displays allowing operators to handle high-density, multiple contact situations. The SQR-19 is a digital system providing high reliability and low maintenance. The OA-9056/SQR-19 towed array group consists of an 82 mm diameter array which is towed on a 1 n mile (1.7 km) cable to depths of 365 m. The two other major subsystems are the Ship-based Electronic Subsystem (SES) and the OK-410/SQR-19 Handling and Stowage Group (H&SG). Early versions of the SQR-19 use the AN/UYK-20 data processing system, but systems produced from 1992 onwards can use the AN/UYK-44-based Signal Data Processing Unit (SDPU).

The SQQ-28 SSPS was originally designed as the shipboard processor for the LAMPS Mk III weapon system. It processes raw data from sonobuoys linked from the SH-60B Seahawk ASW helicopter to the ship via the AN/ARQ-44 radio link and received by the AN/SRQ-4. The SH-60 LAMPS Mk III helicopter and SQQ-28 provide a long-range sensor capability along with a long-range offboard weapons delivery system. The SQQ-28 processes all active and passive sonobuoy data. A secure two-way datalink between the helicopter and ship contains acoustic or radar and ESM data along with helicopter command and control communications. LAMPS Mk I acoustic data is received by the AN/SKR-4B(V) receiver. Modifications to the SKR-4 interface allow LAMPS Mk I and LAMPS Mk III interoperability. LAMPS Mk I/III interoperability kits are installed in Ticonderoga class cruisers beginning with the USS *San Jacinto* (CG 56) and in all of the Arleigh Burke class destroyers (DDG 51). When SQQ-28 is installed in ships with the SQR-19, it shares the UYK-44-based Signal Data Processing Unit (SDPU). In older, stand-alone configurations, it uses the AN/UYK-20 DPS.

The AN/UYK-25 and associated SIMAS provide a computer-based capability for monitoring the environmental sensors for providing sonar *in situ* performance predictions and mode selection to provide the most effective SQQ-89 system performance in various environmental conditions. The system receives environmental data (water temperature versus depth, windspeed and so on) and computes the expected acoustic propagation conditions. Based on these predictions, SIMAS provides sensor setting recommendations to optimise sensor performance. The UYQ-25 is hosted in a commercial-off-the-shelf (COTS) processor and display system. The UYQ-25A(V)2 is associated with all SQQ-89 variants with the exception of Ticonderoga class cruisers (CG 47 to CG 54). The updated system is the AN/UYQ-25B(V)1.

The Mk 116 ASW Command control System (ASWCS) (see separate entry) is a computerised system that integrates acoustic sensor data and non-acoustic data to perform multiple contact management, contact correlation, and contact localisation through the use of automated TMA techniques. The Mk 116 directly interfaces with shipboard acoustic sensors (SQS-53C, SQR-19 and SQQ-28), non-acoustic sensors (radar, ESM) and receives offboard sensor data via datalink and the ship's combat direction system. The Mk 116 provides ASW weapon control functions for the Vertical Launch ASROC (VLA) weapon system and shipboard torpedo tubes and generates fire-control solutions for targets of interest.

The OBT provides integrated shipboard training in port or at sea, generating target scenarios and directly stimulating the acoustic sensors to provide operational ASW team training.

The AN/SQQ-89 surface ship ASW combat system is a fully integrated combat system. The individual subsystems (SQS-53C, SQR-19 and so on) are, however, capable of stand-alone operation. Each subsystem can be installed alone or in various combinations, depending on each set of ship requirements and various combinations have been sold to foreign countries (see separate entries for individual elements).

In April 2004 a contract was awarded to General Dynamics for improvements to the system. These will feature improvement technologies associated with automated torpedo detection, sonar performance prediction, active sonar, active displays and integrated training and logistics.

Operational status

Over 135 SQQ-89 systems have been ordered and the system is still in production. A new variant, the AN/SQQ-89(V)15, is being introduced beginning with the Flight IIA Arleigh Burke class destroyers.

Class	Variant	Hull Numbers
CG Ticonderoga (CG 47)	(V)2	CG 54-55
	(V)3	CG 56-61, 63-64
	(V)12	CG 62, 65
	(V)6	CG 68-73
	(V)7	CG 66-67
DD Spruance (DD 963)	(V)5	DD 963-966, 968, 970, 971, 975, 980, 981, 991
	(V)6	DD 967, 972, 973, 978, 982, 984, 985, 987-989, 997
	(V)12	992
	(V)8	DD 969, 974, 976, 977, 979, 983, 990
DDG Arleigh Burke (DDG 51)	(V)4	DDG 51
	(V)6	DDG 52-78
	(V)10	DDG 79-84
	(V)14	85-90
	(V)15	91-107
FFG Oliver Hazard Perry (FFG 7)	(V)2	FFG 7-9, 11-13, 15, 28, 29, 32, 33, 36, 38-43, 45-49, 53, 55-61
	(V)9	FFG 14, 37, 50-52, 54

The V(3) in Ticonderoga class cruisers is being upgraded to the V(12) variant.

Contractor

Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

UPDATED

CCSM

Type

Submarine combat system.

Development

In May 1996, Lockheed Martin Federal Systems received an initial US$159 million contract from the US Naval Sea Systems Command to develop the command, control, communication and intelligence system for the US Navy's New Attack Submarine (NSSN) Virginia class. Development is being implemented in three increments to allow for additional technology insertion without impacting on the overall test and integration schedule.

Development and subsystem level testing for sonar and architecture will be completed at Lockheed Martin Federal Systems' Manassas site, while combat control development and subsystem testing will be completed by Raytheon Company at Portsmouth, Rhode Island. Other members of the team led by Lockheed Martin include Northrop Grumman and Digital Systems Resources.

Description

The full combat suite solution will encompass sonar, combat control and architecture major subsystems, plus the integration of all additional combat suite electronics on board the 'Virginia'. These include ESM, radar, external and internal communications, submarine defensive warfare systems, navigation, total ship monitoring, periscope/imaging, navigation sensor system interface, tactical support devices and special purpose subsystems.

The design will make maximum use of COTS and adopt an open system architecture, which will facilitate future technology integration and performance improvements. COTS equipment will account for 78 per cent of all system hardware and 76 per cent of software code.

The architectural approach provides a loosely coupled federated architecture environment for each subsystem. Processed data and information is shared via a hierarchy of fibre optic networks implemented using asynchronous transfer mode communications, while sonar sensor data is distributed to processing hardware via fibre optic fibre channel standard technology. Standardised interfaces at the configuration item (drawer level) allow for technology upgrades without major system-level impact.

A flexible design approach to the software enables software already developed, tested and installed in other applications to be reused in the new application as well as developing new software which itself can be re-hosted in other programs. Much of the processing software is common with the CCS Mk2.

The open system architecture will be built around the AN/UYQ-70(V) (Q70) computing and display infrastructure, TAC-X computer technology and

asynchronous transfer mode networking technology. The combat system will also be fully compatible with the Joint Maritime Command Information System (to allow the Virginia class to interoperate with other ships, submarines, aircraft, ground units and command activities) and the Advanced Tomahawk Weapon Control System.

The AN/UYQ-70 Colour Common Display Console will form the common workstation for all combat departments including command and control, sonar, photonics, ESM, external communications and defined special-purpose applications. A command workstation configuration provides a deck-mounted stand-alone capability, while vertical and horizontal large-screen displays will provide a group viewing and planning facility. All UYQ-70 versions specified for 'Virginia' will use a 100 MHz Hewlett-Packard single-board 6U VME processor and run on HP-UX or HP-RT operating systems.

The CCSM is based on a modular isolated deck structure that provides a benign operating environment for all the electronics. Each of the total 15 subsystems will be installed in structurally isolated enclosures assembled off-board to make up the CCSM. Following build and testing the entire CCSM is then end-loaded into its prefabricated hull module.

Operational status

Inter-subsystem integration is being performed at Lockheed Martin's Manassas facility, moving to the command and control system module off-hull assembly and test site at General Dynamics' Electric Boat in Groton. The command and control system module is being assembled off-hull, with individual subsystems installed in structurally integrated enclosures before being end-loaded into the module's prefabricated hull section.

Currently being installed on first two Virginia class boats.

Contractors

Northrop Grumman Corporation Oceanic and Naval Systems, Annapolis, Maryland.
Lockheed Martin Federal Systems, Manassas, Virginia.
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

UPDATED

CCS Mk 2

Type

Submarine integrated weapon control system.

Development

The CCS Mk 2 (Combat Control System Mark 2) is a major US Navy upgrade that reduces to four the many submarine combat control system variants currently in the US fleet.

In late 1988, Raytheon won the competition to develop and manage the CCS Mk 2 upgrade. The first system became operational in 1995. As prime contractor for much of the currently deployed CCS Mk 1 system, Raytheon used its experience to retain approximately 80 per cent of the CCS Mk 1 functionality in the CCS Mk 2 system.

The CCS Mk 2 provides commonality across combat systems on the Los Angeles class attack submarines and Ohio class ballistic missile submarines. The system integrates data from advanced submarine sensors and controls weapon targeting and launch. The system incorporates significant potential for growth to handle additional submarine mission requirements. This growth potential was realised through the incorporation of a distributed network and open system architecture subsystems in the Block 1 upgrade, which is operational.

The CCS Mk 2 programme also implements a common in-service support programme for both the Los Angeles and Ohio class platforms. Through the adoption of common systems, CCS Mk 2 has significantly reduced support costs.

Description

The upgrade programme is a major step toward the US Navy goal of evolving fire-control equipment systems into comprehensive combat control systems. The system consolidates the functions of sonar, target motion analysis, tactical displays, weapon order control and submarine navigation and communications.

The improvement provides common equipment and software in the Ohio class and Los Angeles class submarines, including those with vertical launch capability. The upgrade will also be installed aboard new Los Angeles class submarines equipped with the AN/BSY-1 sonar system in 1996.

With the installation of CCS Mk 2, the many different combat systems currently in the fleet have been reduced to four variants, which achieve nearly complete hardware and software commonality. In replacing the AN/UYK-7 standard computers used in older combat control systems with the AN/UYK-43 model, Raytheon provided increased processing performance with reserve capacity for future enhancements. In addition, the CCS Mk 1 OTH processor was replaced by the AN/UYK-44 and a parallel processor. The parallel processor provides a significant increase in responsiveness for the track/correlation function.

The CCS Mk 2 also includes an upgrade of all cursive displays to modern raster displays. Based on commercial technology from Silicon Graphics Inc, the display system includes a sophisticated graphics engine and a high-speed display processor. With a local processing capability of eight million instructions per second (Mips), the display processor decreases dependency on the central processing unit by more than 50 per cent, providing significant processing reserve for future fire-control system enhancements.

The design of the tactical system has been paralleled by the development of a common logistics and in-service support programme. This support programme has realised efficiencies and reduced the overall cost of the support programme. Due to the commonality of combat systems and the common support programme, training programmes for the submarine crew have been combined and streamlined.

The latest upgrade (Block Ic) to the CCS Mk 2 includes integration to an open system architecture, modifying the consoles to enable them to manage other sub-systems such as the Advanced Tomahawk Weapon Control System and Joint Maritime Command Information System and moving from a monochrome display to full colour using COTS technology.

Operational status

Raytheon Company won a US$405 million competitive contract for the system upgrade in September 1988 from the US Navy's Naval Sea Systems Command. Additional functional improvements and other contract changes have increased the contract's value to over US$500 million. As prime contractor, Raytheon leads the programme's management and technical effort, which includes a major software upgrade. The company's Marlborough, Massachusetts, facility is providing the raster displays. The CCS Mk 2 is currently installed aboard some 14 'Los Angeles' and all 5 Ohio class submarines. It is planned that all improved Los Angeles class submarines will be fitted with CCS Mk 2. The first CCS Mk 2 Block Ic has been installed on a Los Angeles class submarine. A variant of the CCS Mk 2 has been ordered by the Australian Navy to upgrade the Collins class submarines. The lead submarine will be fitted with the CCS Mk 2 in time for trials to begin in mid-2006. The system has also been retrofitted to the Egyptian Romeo class submarines.

Contractor

Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

UPDATED

FFISTS II

Type

Tactical decision aid.

Description

FFISTS II is a tactical decision aid that gives shipboard commanding officers and Anti-Submarine Warfare (ASW) commanders an automated set of tools to assist in planning, environmental support and contact localisation. The system combines measurements of the *in situ* sensor performance of active and passive sonar systems in deployed platforms and allows commanders to assess the overall ASW situation.

FFISTS II is hosted on the Sun 4-based US Navy standard Desktop Computer II (DTC II) and is written in the C programming language under the UNIX operating system. The system communicates with other sensors and onboard computers via an Ethernet Local Area Network (LAN). This allows a number of operators to use the system simultaneously while sharing computer memory space. The system is designed to:

- assess 'own ship' sonar performance for a given type of target and a given operating environment
- automatically acquire tactically relevant data on course, speed
- closest point of approach, latitude/longitude, threat, own forces and shipping
- provide display of patrol areas, weapons envelopes and planned tracks.

The FFISTS II geographic display provides three types of operational support. Command and control support includes various datalinks, navigation interface and geographic maps and overlays. Environmental support includes active and passive sonar, active reverberation and real-time noise monitoring. Finally, localisation support includes target motion analysis used to predict the movement and location of platforms as well as multiple algorithms with corrections.

Contractor

EDO Combat Systems, Chesapeake, Virginia.

VERIFIED

ISCWS

Type

Integrated sonar, command and weapon system.

Description

ISCWS is based around a distributed architecture providing high availability of all system capabilities which will allow it to meet changing requirements well into the 21st century. The distributed architecture features dual redundant high-speed databus, redundant processors, multifunction operator consoles and a standardised set of modules.

Logistics and maintenance are simplified by the use of the same hydrophone and preamplifier in all passive arrays. The ISCWS also integrates all the submarine's other sensors and functions including ESM, radar, navigation, communication and weapons to result in a completely integrated submarine combat system.

The system features lightweight fibre optic cabling for interconnections which reduces weight and increases reliability. In addition, a common system processor cabinet is used for all signal and data processing which improves Mean Time Between Failure (MTBF). Three types of computer resources are used in the system. The digital processing unit uses both system and array processors, while workstation processors are used in the operator consoles.

There is considerable scope for enhanced capabilities which would be available through future upgrades.

Contractor
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

Mk 98

Type
Submarine-launched strategic missile fire-control system.

Development
General Dynamics Defense Systems (formerly General Electric, then Martin Marietta, then Lockheed Martin) is a key supplier for the Trident strategic weapons system.

Description
The fire-control technology serves the primary purpose of preparing the missile guidance system for flight and controlling the missile launch sequence.

Support equipment consists of: guidance system test equipment for shore-based activities and nuclear submarine strategic weapons facilities; guidance system containers and handling equipment; and equipment to support fire-control and guidance operations including a new digital fire-control computer. In addition, Defense Systems provides the equipment which controls the strategic weapons Trident training facilities.

Operational status
The system is in service aboard the Ohio class SSBNs and SSGNs of the US Navy.

Contractor
General Dynamics Defense Systems, Pittsfield, Massachusetts.

VERIFIED

Mk 116

Type
ASW fire-control system ASWCS.

Development
The Mk 116 was developed as an underwater fire-control system in the early 1980s. The concept resulted in a significant approach to performing fire-control functions in a separate computer interfaced with the Combat Direction System (CDS)/ Command and Decision System (C&DS) computer. Previous Mk 116 configurations were resident in the CDS/C&DS computer processor. The ASWCS modifications to previous versions of the fire control came in anticipation of further improvements in submarine quieting technologies. These modifications, incorporated in the AN/SQQ-89 surface ship ASW combat system, are known as Mods 5, 6 or 7. Classes equipped with the Mk 116 Mods 5, 6 or 7 include Ticonderoga class cruisers, and the Arleigh Burke and Spruance classes of destroyers. The Mk 116 ASWCS is not incorporated in the Oliver Hazard Perry class frigates, SQQ-89 variants (V)2 and (V)9. Fire-control functions are performed by the weapons alternate processor in those variants.

Description
The Mk 116 ASWCS is a mainframe computer system which is designed to provide battle planning, threat evaluation, tactical data processing, contact management, target engagement processing, and weapon fire control. It is organised into two subsystems: the Computer Processing Subsystem (CPS); and the Weapon Control and Setting Subsystem (WCSS). Data is received from a number of external sensors and distributed around the system by an integral switchboard or data converter. The system directly interfaces with shipboard acoustic sensors (typically AN/SQS-53, AN/SQR-19 and AN/SQQ-28), radar, ESM, and receives offboard sensor data via datalink.

The CPS provides displays of tactical data, computes and stores track data, calculates weapon control firing solutions for selected targets and generates weapon recommendations and launcher orders. Most systems are based upon a three bay AN/UYK-7 computer and AN/UYA-4 family OJ-194 display console. The UYK-7 has a memory of 256,000 32-bit words and an optimum processing power of 667,000 operations. The newest systems have two AN/UYK-43B computers and, from the AN/UYQ-21 family, the OJ-452 display console. The UYK-43B has two central processing units each with a memory of 2,560,000 words and an optimum processing power of 3,002,000 operations. The software in both systems is in the US Navy's own CMS-2 language and Mod 7 has 215,000 lines of code.

Before the Mod 6 version, the WCSS is basically the same in all the Mk 116 systems. It consists of the Mk 329 weapon control panel which selects the fire-control mode, the sensor/weapon pairing, launcher, and torpedo presetting. It is located close to, and operates in conjunction with, the OJ-194 display system except in the Mod 5 and later versions which use the OJ-452 consoles.

Other WCSS equipment includes the unmanned Mk 330 missile and Mk 331 torpedo setting panels for selecting, presetting and launching ASROC/torpedo attacks. The Mk 330 is not used in the Mk 116 Mod 4 systems installed in the Ticonderoga class cruisers CG 52-55. There are two Mk 332 weapon status and approval panels to provide command level display of ASROC weapon selection and launcher rail status. Also, on the bridge is the Mk 333 bridge display panel.

The external sensors all include an electromagnetic log and the Type F wind indicator. The other sensors and the data distribution units are as shown below:

Science Applications International Corporation is to develop software for the computer-aided dead reckoning tracer project for the Mk 116.

Operational status
A total of 75 Mk 116 ASWCS had been produced by January 1994 and it remains in production for incorporation into the AN/SQQ-89 as shown above:

Class/Type	Hull numbers	Mk 116
'Kidd'	DDG 993	Mod 2
'Ticonderoga'	CG 47-53	Mod 4
AN/SQQ-89 ship classes		
'Ticonderoga'	CG 54-64	Mod 5
	CG 65-73	Mod 7
'Arleigh Burke'	DDG 51-78	Mod 7
'Spruance'	971	Mod 6
	963, 964, 975, 982, 984, 985, 987-989	Mod 7
	965, 967, 968, 970, 973, 980, 981, 991, 992	Mod 8
	974, 976, 979, 983, 990	Mod 9

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

VERIFIED

SOAS (Submarine Operational Automation System)

Type
Submarine command support software programme.

Description
The demand to process and present the growing volume of constantly changing data provided by current and next-generation advanced sensors, covering both the tactical and ocean environment as well as the mass of data on own ship systems, and the increasingly lower acoustic signatures generated by modern submarines, is constantly increasing. To meet this demand the US Defense Advanced Research

Mk 116

Mod	Sonar SQS-53	Switchboard	Data converter	Gyros	Bathytherm	Fathometer
1	A	Mk 70	—	Mk 19	—	—
2	A	Mk 70	—	Mk 19	—	—
3	C	Mk 34	—	Type 11	AN/BQH-7A-SSQ-61	AN/UQN-4
4	A	—	Mk 18	Type 11	AN/BQH-7A-SSQ-61	AN/UQN-4
5	A	Mk 59	—	Type 11	AN/BQH-7A-SSQ-61	AN/UQN-4
6	B	Mk 59	—	Type 11	AN/BQH-7A-SSQ-61	AN/UQN-4
7	C	—	OL-191	Type 11	AN/BQH-7A-SSQ-61	AN/UQN-4
8	B	Mk 59	—	Type 11	AN/BQH-7A-SSQ-61	AN/UQN-4
9	A	Mk 59	—	Type 11	AN/BQH-7A-SSQ-61	AN/UQN-4

Projects Agency (DARPA) is studying software requirements for the next generation of submarine command systems.

Referred to as SOAS (Submarine Operational Automation System), the initial phase of the programme involved the development of a series of prototype software programs. These formed the key element in the next generation of software architecture for use in submarine command systems designed to provide highly integrated information and data management to assist the commander in tactical and ship control decision making. Using advanced computer hardware designs based on a series of parallel computers capable of carrying out millions of calculations simultaneously, and incorporating neural networks and artificial intelligence-based programs, SOAS will integrate signature and vulnerability management, ship monitoring and control, situation assessment, tactical planning, and the ship-crew interface.

Unlike the development of the BSY-1(V) system which was designed to meet a specific set of operational requirements, SOAS adopts a 'system extension' approach in which operational requirements are added as development of the system proceeds.

To meet this requirement, General Electric was awarded the contract to develop software prototypes in which programs are developed to satisfy an increasingly demanding tactical scenario. The first prototype, P1, completed in December 1990, covered the requirement for a submarine to carry out surveillance of hostile forces and reconnaissance in an area of low hostile activity. A land-based test system was established at General Electric's facility at Moorestown, where elements of the software undergo tests to prove the concept and where new concepts are evaluated and successful prototype designs are then integrated with the established architecture.

Subsequent developments envisaged a scenario where the number of contacts is significantly increased and incorporated stealth signature management programs being developed at the Applied Physics Laboratory of Johns Hopkins University.

At the end of FY93, DARPA declared a proof of principle completion on the SOAS programme. Subsequently, Lockheed Martin Advanced Technology Laboratories, Camden has adapted technologies developed under SOAS into multiple programmes. Examples include: knowledge-based correlation to Rotorcraft Pilot's Associate (Army); knowledge-based correlation and scene understanding to Electronic Warfare Advisor (DARPA); scene understanding and event monitoring to AEIWS Studies (Navy); contract management risk reduction to AN/BSY-2 (Navy); Case-Based Response Planner and Advanced Ship Self-Defense Combat Systems (Navy); primary man/machine interface, test simulation and primary communication substrate to Submarine Defensive Warfare System (Navy).

Operational status
Phase 1 contracts for development plans and demonstration of capabilities were awarded to General Electric, Lockheed-Georgia, McDonnell Douglas and Martin Marietta in January 1989. In February 1990, General Electric won the Phase 2 development contract, the design phase for which was completed in May 1991. Software coding was completed during the Summer of 1991 and full software integration was achieved in October/November 1991. Demonstration of the integrated P1 and P2 software architectures was conducted in December 1991 and the programme was completed in 1995.

Contractor
Lockheed Martin Advanced Technology Laboratories, Camden, New Jersey.

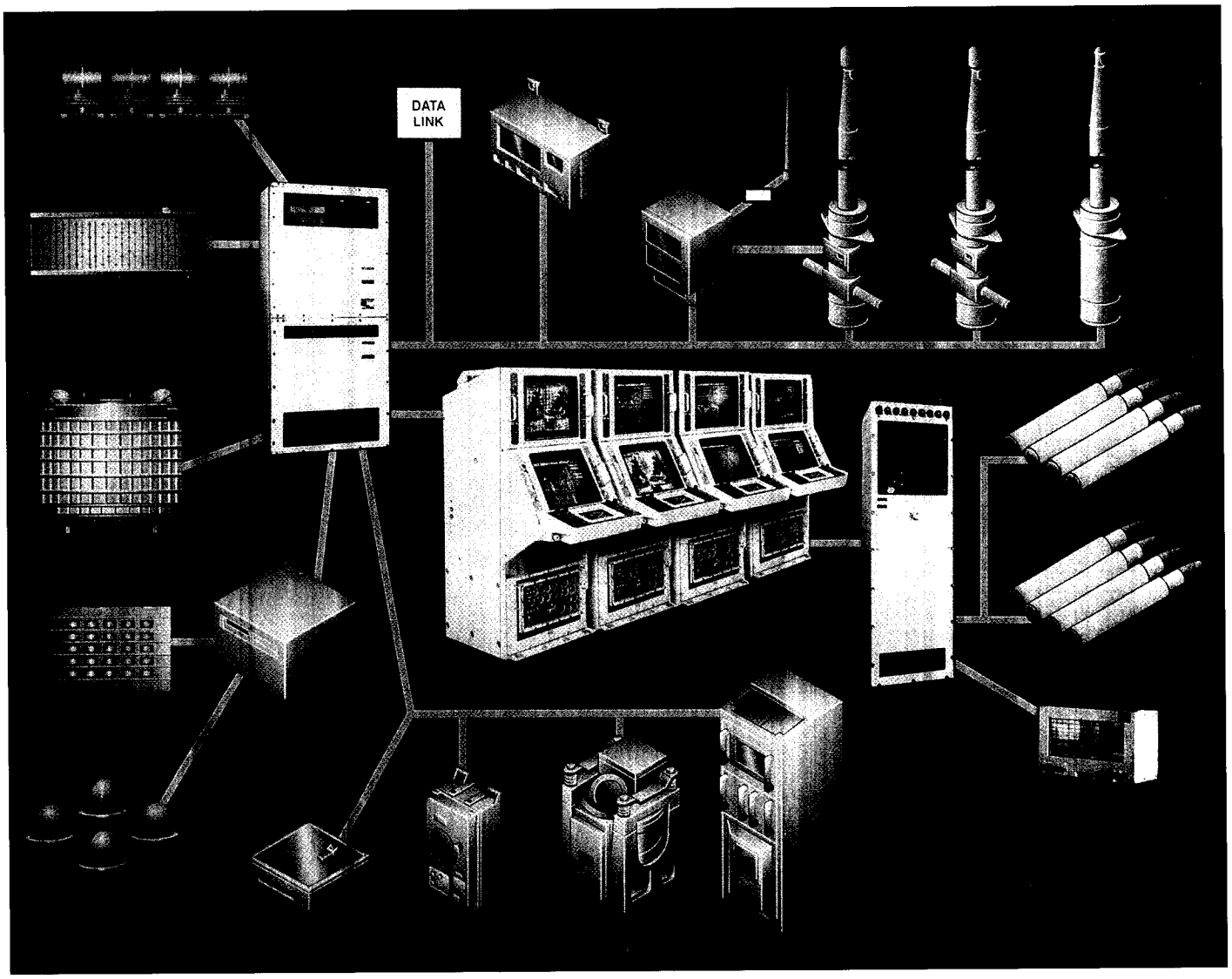
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SUBICS 900

Type
Submarine combat control system.

Development
The SUBICS 900 (SUBmarine Integrated Combat System) is an evolution of the Mk 1 Mod 0 delivered to the RAN in 1978 for the Oberon class submarines; the Mk 1 Mod 151 for the Indian Navy delivered in 1983; and the Mk 1 Mod C delivered to Canada in 1987 for the Oberon class. Architecture from the Virginia class has also been taken and migrated into SUBICS 900 for the SSK market. The system is designed to integrate sonars/sensors designed and developed by L-3 Communications ELAC Nautik, which are currently operational on diesel-electric submarines.

Description
SUBICS 900 is a totally integrated combat system that meets multimission requirements for modern diesel-electric submarines. The tactical functions



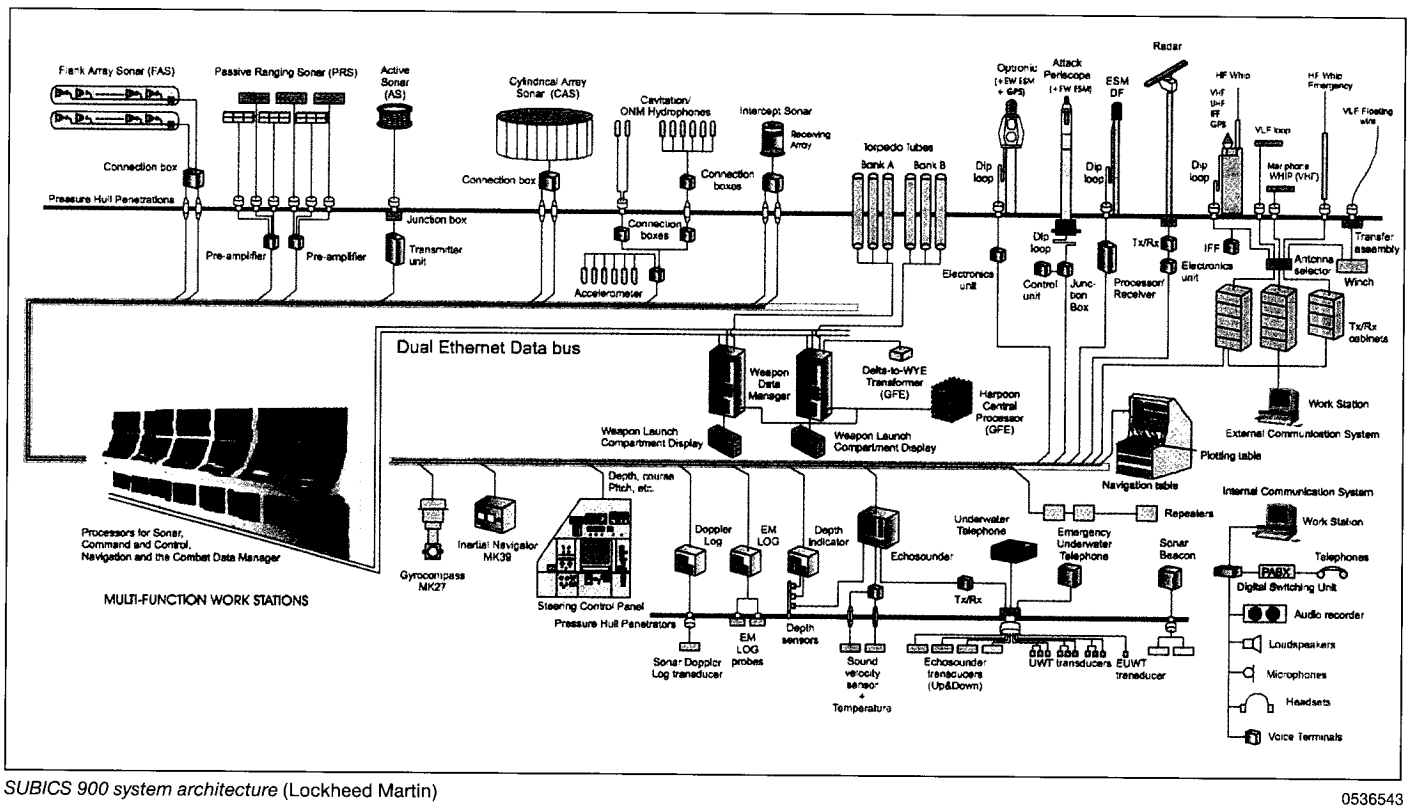
Block schematic of the submarine integrated combat system SUBICS 900

provided for are: tactical evaluation and planning; integrated surveillance and threat prosecution; and combat navigation. Using these functions the combat system performs: threat identification and enables tactical evaluation and planning to be performed; evaluates possible responses; gathers data and processes this to provide contact information in the form of a tactical display; performs torpedo/missile control functions; and displays for the command the geographical situation with navigation functions and alerts the command to approaching hazards.

To carry out these functions the combat suite integrates acoustic (flank array, cylindrical array, passive ranging, intercept, and active ranging sonars and cavitation and self-noise monitoring equipment), electromagnetic (ESM, surface search radar and communication datalink), and electro-optic (search and attack periscopes) sensors with the capability to track 68 targets simultaneously. Threat prosecution is carried out against four targets simultaneously using three wire-guided torpedoes and a salvo of underwater-launched missiles. Optical sensors provide search/attack TV images showing up to eight tracks. Via datalink 120 contact reports can be maintained, together with up to eight tracks. The combat navigation capability provides the display of navigation charts (the system can input ECDIS), own ship position fixing, dead reckoning, recommended course and speed manoeuvres based on the tactical situation, and automatic alerts to natural and manmade hazards. It integrates Transit/Omega/GPS navigator, inertial navigator, gyrocompass, electromagnetic log, echo-sounder and navigation plotting table.

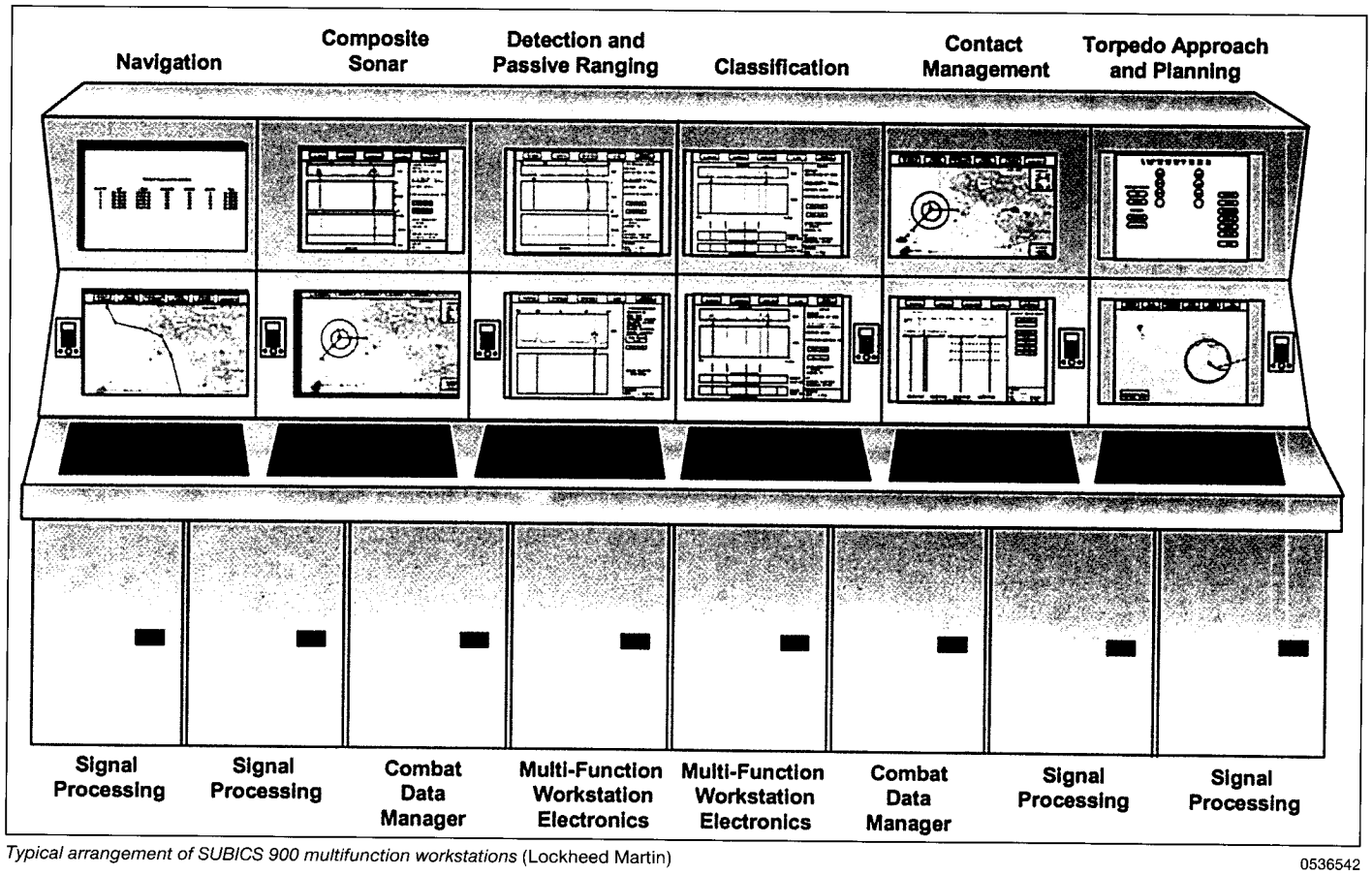
The combat system is centred around a Combat Data Manager; four multifunction consoles; and a Weapon Control Manager. These elements are used to: integrate sensor data; convert it into contact information; identify threats; and control weapons as required. The combat/weapon control equipment comprises an open system architecture Combat Data Manager, VME-based multifunction consoles, a Weapon Control Manager and an Emergency Weapon Control Display. The system uses the latest COTS Internet technologies such as Java, C++ and CORBA together with high speed Ethernet LANs to provide high combat efficiency.

The Combat Data Manager combines data from the navigation sensors, acoustic sensors, electromagnetic sensors and optical sensors and processes it into



SUBICS 900 system architecture (Lockheed Martin)

0536543



Typical arrangement of SUBICS 900 multifunction workstations (Lockheed Martin)

0536542

contact information. The unit also provides audiotape recording and distribution of acoustic and electromagnetic audio and periscope video to the multifunction consoles.

The multifunction consoles provide the operators with interactive displays for combat navigation, tactical planning, integrated surveillance, threat prosecution, performance monitoring/fault localisation, onboard training and logging/retrieval. Information is displayed on two 19 in diagonal, 1,280 × 1,024 picture element resolution, 60 Hz refresh rate, touch interactive colour monitors.

The Weapon Control Manager provides automatic threat prosecution to aid operators in the control of torpedoes and missiles. Operators can set torpedoes and missiles before launch, control their launch, and monitor and guide torpedoes after launch. The launch tube interface includes switching circuitry for interfacing with either torpedoes or missiles in each of eight launch tubes. The processing computes trajectories for three torpedo attacks and one missile salvo of one to four missiles simultaneously. Post-launch control includes telemetry from the torpedoes and automatic and interactive guidance commands to the torpedoes.

SUBICS 900 can be customised to operate UUVs.

Operational status
Developed and available for installation into diesel electric submarines.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems - Undersea Systems, Manassas, Virginia.

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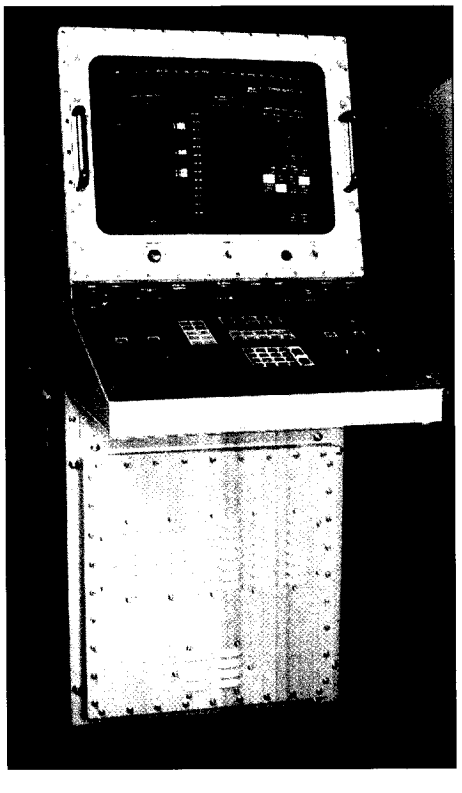
USFCS

Type
Submarine combat information and fire-control system.

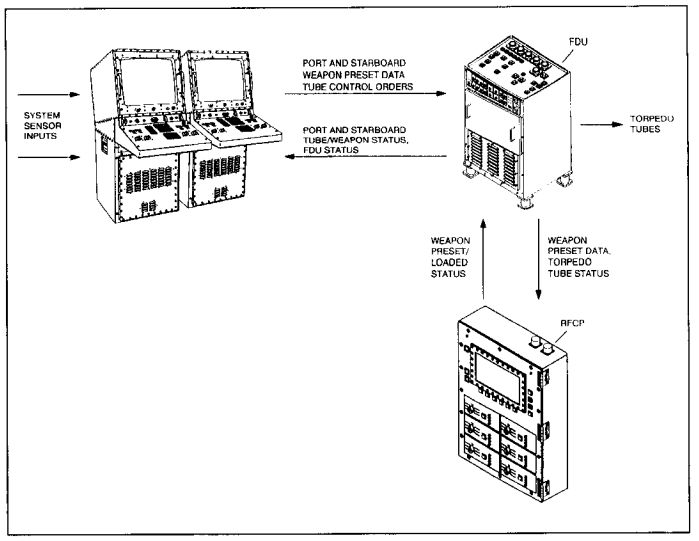
Development
USFCS (formerly known as Pisces) was developed by Lockheed Martin Tactical Defense Systems (formerly, Unisys Government Systems Group) to enable today's modern submarines to exploit their advantage of stealth by allowing for the rapid collection and analysis of data of either tactical or strategic importance. This, in turn, allows the submarine to accomplish its primary purposes of intelligence gathering and weapons employment against potential adversaries.

This is the third-generation submarine combat information and fire-control system developed by Unisys. It is the culmination of 30 years of experience in the development of submarine combat and fire-control systems. It was produced using the Unisys design philosophy of open systems and open architecture design. To support this philosophy, it incorporates the latest in proven leading-edge technologies such as VME bus structure, Motorola 680X0 processors, RISC processors, UNIX, Vx works and C.

Description
The USFCS tasks, in support of the overall submarine mission, involve processing data gathered by 'own ship' tracking sensors (sonar, radar, ESM, CCTV and periscopes), navigation system sensors (speed log, gyrocompass, GPS and Inertial Navigation System (INS)) and communications systems (datalink, RDF and IFF).



The MMC for USFCS



Block schematic of USFCS

This data is then recorded, analysed and manipulated by operators to assess potential adversary capabilities and co-ordinate manoeuvring of the submarine and deployment of its weapons.

The system consists of two Modular Multifunction Consoles (MMCs), Firing Distribution Unit (FDU) cabinet and the Remote Firing Control Panel (RFCP). The main control station is located typically in the submarine attack centre and consists of two identical MMCs. The MMCs are the primary operator stations for the collection, manipulation and recording of data from the combat system sensors. In addition, the MMCs are the primary stations for weapon selection, preset orders generated, testing, launching and guidance functions. The FDU, which is typically located in the torpedo room, provides data conversion and launch for the applicable submarine's weapons. The RFCP, also located in the torpedo room, provides the man/machine interface with the FDU and the torpedo tubes for tube load status, local weapon presetting, launching and guidance control, as well as for system offline diagnostics.

The system is capable of managing and tracking in excess of 200 tracks from multiple sources using automatic and manual Target Motion Analysis (TMA) techniques, while the weapon launch and control portion provides simultaneous control of multiple weapon types in virtually any mix (including salvos of the same weapon) for use against a single or multiple threats. Weapons that USFCS supports include: NT-37 torpedo versions C to F, V56 ASUW, VA53 ASUW, V53 ASW, SUT, SST-4, Mk-37 Mods 0-3 torpedoes and the Federated Harpoon Missile. In addition to track management and weapon capabilities, USFCS provides a data extraction and playback function for recording of mission-critical data for later replay and analysis, system training function to maintain system operator proficiency, piloting and prediction functions to aid in the manoeuvring and navigation of the ship, environmental/oceanography functions to aid in determining ship operating environment and an optional overlay/cartographic function.

Operator console

Two Modular Multifunction Consoles (MMCs) provide the primary control. Both MMCs are the same, each maintaining identical but independent system databases through the use of an intercomputer channel and redundant communication paths to the remainder of the combat system. In the event of a casualty, one MMC will meet all system requirements. Each MMC is capable of displaying multicolour radar video, CCTV data and high-speed graphics such as tracks and other tactical symbology. It also displays line segments, status reports, system alerts and other alphanumeric data. The MMC consists of a monitor assembly, a processor unit and an Operator Entry Panel (OEP).

Monitor assembly

The monitor assembly presents tactical video, graphic and alphanumeric data on a militarised, high-resolution, 19 in, 1,024 × 1,280 pixel, raster scan, colour Cathode Ray Tube (CRT). The monitor assembly also provides Finger On Glass (FOG) touchscreen capability interfacing with the graphics/display processors, which are components of the MMC processor unit.

Processor unit

The processor unit is a self-contained, self-cooled unit capable of operating independently of the other units of the MMC. The processor unit houses the graphics processor, display generator, applications processor and external I/O interface, each of which is described in the following paragraphs.

The applications processor provides the processing necessary for program loading, scheduling, data management, I/O control, target tracking, weapons calculation, weapons control, 'own ship' navigation, environmental data processing and online maintenance.

The graphics/display processor provides the processing necessary for display request management, display initialisation and termination, as well as periodic display management and operator action management processing.

The external I/O interface provides the interfaces to the combat system's sensor subsystems. The external I/O interface unit is controlled by the applications processor. External I/O interfaces are provided on Euro-Card VME bus plug-in modules in a section of the VME chassis reserved for application unique functions. Interfaces supported include:

Synchro
RS-232C
RS-422

MIL-STD-1397 A to E
MIL-STD-188
MIL-STD-1553
SAFENET
IEEE 802.3.

Operator Entry Panel (OEP)

The OEP is the primary device for operator control. The OEP provides momentary action push-buttons for target selection, mode and weapon control, a numeric keypad for numeric data entry and four trackballs, for entering variable/encoder data. The OEP can be tailored to meet customer requirements.

Firing and Distribution Unit (FDU)

The FDU provides the interface between the weapon/tubes and the remainder of the system. The FDU provides data conversion and control of weapon data flow for all ship weapons. Weapon orders are transmitted from the FDU to the weapon, and read-back data returns from the weapon to the FDU. The FDU is divided into two identically functional sides (port and starboard), each communicating with one of the MMCs using non-redundant cables. In addition, each functional side of the FDU can communicate and control up to four weapons using identical but redundant interface electronics and cabling channels. Each side of the FDU communicates with the Remote Firing Control Panel (RFCP).

Remote Firing Control Panel (RFCP)

The RFCP provides the man/machine interface with the FDU and the torpedo tubes. It also provides an emergency firing capability when the interfaces with the MMCs have failed or at command discretion. The RFCP provides the operator with the capability of weapon/tube selection and system monitoring during normal modes of operation. In the emergency mode, the RFCP provides the operator with the capability to preset, fire and guide the system torpedoes and Harpoon missiles. In addition, the RFCP provides the FDU diagnostic interface.

Operational status

No longer in production. Four systems were ordered, produced and accepted by the Egyptian Navy for the Romeo-C Submarine Modernisation Programme. All four systems have been successfully installed and integrated with the other combat system equipment.

Contractor

Lockheed Martin, Naval Electronics & Surveillance Systems - Undersea Systems, Manassas, Virginia.

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SONAR SYSTEMS

Introduction

This section covers all types of sonar used for ASW and deployed by surface ship, submarine and helicopter, as well as sonobuoys, airborne acoustic processing systems and static sonar systems. Shipborne sonars used for naval hydrographic purposes, training systems and simulators are described in the Oceanographic and equipment hydrographic survey section.

In carrying out ASW, sonars are assigned to the following tasks: detection long-/medium-range passive; classification - medium-range active/passive using high-speed, highly accurate signal processing, Doppler correlation and digital analysis; localisation - shorter range active/passive for tracking and final computations for controlling/directing weapon deployment.

Despite the great variety of available systems, employing the latest technology in sound detection and data processing, the detection of a hostile submarine is still an extremely difficult, complex and slow process and ties up large numbers and forms of ASW assets.

Although great strides have been made in the design of transducers and other sensing devices, the major developments in conventional sonars in recent years have been those related to the processing and display systems and their integration into a combat management system. The advent of digital computers, microprocessors and even more sophisticated electronic components, has meant that large amounts of information can be extracted from relatively weak signals. This is then processed at high speed and presented in a carefully arranged display from which rapid assessments and decisions can be drawn concerning the next stage in the operation.

Both hull-mounted and variable depth sonars are used for passive and active detection while towed arrays are employed for longer-range passive surveillance. Active towed arrays are now deployed in an effort to overcome the increasing use of stealth technology in submarine design that is making it very difficult to carry out initial detection of a target. The towed array has many advantages over the hull-mounted system in that it is deployed a considerable distance behind the ship and is thus not affected by any noise emanating from the towing vessel. Towed arrays also achieve very long detection ranges by operating at very low frequencies where propagation losses are lower, enabling the low-frequency sound emanating from propeller cavitation and machinery of a hostile boat to be detected. The towed array does, however, suffer from a number of disadvantages, including: being unable to determine the range of a contact (when operating in passive mode); ambiguity in bearing; directional uncertainty because of sideways movement of the array and the towing cable; flexing of the hydrophone array; and a number of other physical factors. These factors have been the subject of intensive research and development in recent years and have now been largely overcome. A further important factor to be considered in towed arrays is flow noise. This affects the hydrophones in the array as pressure fluctuations. Flow noise on an array is created in two ways:

- vibrations in the array or cable strumming resulting from vortex shedding and vibration of the tail caused by the instability of the wake
- turbulence-induced noise on the hydrophones resulting from the turbulent boundary layer around the wall of the cable.

Vibrations are, to a degree, damped by vibration isolation modules mounted in the array. In addition, a large winch and handling gear is required to deploy the array. This is not a major problem on surface ships (except from a weight point of view), but is impractical in all but the larger classes of submarines.

In some cases the array has to be clamped on as the submarine leaves harbour and removed just before re-entering, making the boat extremely vulnerable when this operation is being carried out. Some submarines overcome this problem by stowing the array on the side of the hull. However, despite its disadvantages the towed array is of immense value in long-range detection and a considerable amount of development effort is currently being devoted to the design of thin line towed arrays to provide a much lighter and easier to handle system.

During the next five to ten years increasing use will be made of new Low Frequency Active Sonar (LFAS) systems by surface ships and systems are under development in France, Germany, the UK and USA to meet operational requirements.

The primary airborne detection system is the sonobuoy which is produced in its tens of thousands for deployment from fixed-wing aircraft and helicopters. Since they are expendable, sonobuoys have to be relatively cheap to manufacture but reliable in operation. Large numbers of these devices are in current service and include both passive and active buoys, directional and non-directional, large size and small size, all of which transmit information back to the aircraft for processing and display.

Apart from sonobuoys, the other major acoustic detection system deployed by helicopters is the dipping sonar. With emphasis now on littoral operations a new range of capabilities has had to be developed to counter the harsh environmental conditions in this region, which can seriously affect acoustic propagation. It is a fact that in the littoral region detection ranges increase as frequency decreases. To extract the maximum advantage out of this phenomenon dipping sonars are now being developed operating at frequencies between 1 and 6 kHz. At these frequencies the range of the dipping sonar almost doubles from 6 to 1 kHz. At short ranges the performance of the dipping sonar is primarily a function of frequency dependent boundary interaction. This can create enormous problems for the sonar, but this is being addressed. At longer ranges, performance is affected by volume attenuation and propagation path effects.

The advent of bistatic and multistatic operations integrated within the framework of network centric ASW, demands that the dipping sonar has a centre frequency and bandwidth that is compatible with surface ship platforms for it to be interoperable under these conditions. Furthermore it must have the processing capability to handle multistatic operations with frequency compatible sonobuoys. The dipping sonar must also be compatible with LF active towed array sonars if is it is to be fully capable of providing interoperability in multistatic ASW operations.

Finally, requirements for dipping sonars must take into account volume and weight constraints of both the helicopter and the surface platform. The size and weight of a sonar system has a major bearing on its performance characteristics, and generally speaking the larger the system the lower the operating frequency. This in turn has a major impact on the size of the helicopter, and hence the size of the platform from which it can operate.

The large static systems moored on the ocean bed have been operated mainly by the United States and Russia, while a number of other countries installed less sophisticated systems, specifically to protect vulnerable areas in the littoral region. In the past static systems tended to be used in the most strategically important and sensitive areas and in particular at choke points. These are areas which are limited in width by land masses, but which serve as entry and exit lanes for submarines and in particular the strategic missile submarines. Attack submarines also patrol these areas to detect hostile submarines and neutralise them. Should a hostile submarine escape this first line of defence, it must then be detected and attacked by a second line of defence, such as surface ship and aircraft using towed array, hull-mounted or variable depth sonar, dipping sonar, sonobuoys, magnetic anomaly detectors and wake detection systems, torpedoes and depth charges.

Another underwater threat that is of increasing importance is the free swimmer and small submersible. Harbours and offshore platforms are particularly vulnerable to this form of attack and a number of static sonar systems have been developed to detect such intruders. The sensors of these systems are usually bottom or cable moored and connected to data processors and displays in a shore-based centre. In many cases an integrated system using a variety of radar, acoustics, electro-optical and/or TV-based sensors is employed. To counter this threat, an increasing number of small static and portable detection systems are being developed.

Detection problems

Passive sonars rely for detection on flow noise and cavitation caused by movement in the water of hull and propellers which creates noise over a wide frequency band; on regular low-frequency sound created by machinery; and on hostile active sonars.

Active sonar is bound by the same physical laws which affect passive sonars, except that the effect is doubled, for the sound has to travel in two directions - out and back - before signal processing can be undertaken. Active pulses also lose energy because of the increased distance they have to travel and by absorption in the hull of the target. Active sonars therefore suffer high propagation losses and their effective range is not as great as a passive sonar.

The range problem can be overcome by transmitting a low-frequency pulse (typically 1 kHz with a wavelength of approximately 1.6 m), but it is difficult to focus the beam accurately down a single point bearing. The spread of the pulse at low frequency also reduces accuracy by which range can be determined. Range can be improved by increasing transmitting power, but the relation is not linear. Advantages are that low-frequency pulses can penetrate anechoic coatings. It is also more difficult to detect low-frequency pulses at great distances (typically in the order of hundreds of miles).

LF active sonars (LFAS) offer good, long-range propagation and operate at frequencies below the critical frequency at which current anechoic tiles absorb acoustic energy. However, LFAS do suffer from excessive false alarms emanating from the effects of reverberation. This problem is being addressed with new transducer design, advanced signal processing and operator classification aids.

Factors affecting detection

Sonars are all affected by the same environmental factors; for example, temperature, salinity, pressure and seasonal variations in these factors as well as the geographical area in which operations are to be conducted. In addition, efficiency depends on whether one is operating in passive or active mode. All ships create self-generated noise from their movement through the water (cavitation) and from their machinery, as noted above. Own ship machinery-generated noise is more of a problem when the sonar is operating in passive mode, while cavitation tends to dissipate the energy of the transmitted pulse. In active mode, effectiveness can be curtailed further by temperature variations, which may restrict range capability.

These problems can be overcome in two ways, either singly or combined, depending on the requirements. One is to increase the transmitting power. This requires increased volume and weight capability in the ship together with the necessary generating power and a larger transducer array. The second solution is to mount the transducer as far away from noise sources as possible; for example, it would have to be a towed, variable depth or bow-mounted array. Bow arrays also suffer disadvantages, for it is not unknown for ships to be manoeuvred forgetting the extra projection at the bow, resulting in damage to the protective cover and even to the array itself. To further improve the efficiency of the sonar it is necessary to ensure that the ship be as quiet as possible. This can be achieved by providing a self-measuring noise diagnostic system which will enable the signal processing to cancel out self-generated noise frequencies.

Solutions to temperature variations and self-generated noise in passive mode are overcome by using variable depth sonars and the latter by towed arrays. All sounds possess their own very distinctive characteristics or 'footprints', for example frequency, amplitude and so on. Classification of targets can therefore be greatly aided if received echoes can be matched against a known library of sounds.

Taking advantage of the various properties of the medium, through which the sound passes in order to extend and improve the capabilities of the sonar, requires various ancillary systems, which can measure environmental factors and provide propagation predictions. Using this equipment, an operator can decide how best to use the sonar to obtain more accurate and positive results. For example, under the right conditions, range can be extended by use of bottom bounce, but it suffers in that the beam cannot be refocused after reflection and hence scattering and divergence occur.

Alternatively, the convergence zone mode of operation can be used which does not require so much power, but which may not always give such an extended range. The mode of operation is selected according to conditions and the tactical situation, but smaller sonar sets may not have the capability to operate in the bottom bounce mode.

Sonars usually operate on a variety of frequencies. For example, some older types of sonar work on a short range of about 2,750 m using two narrow beams with phase shift covering the 17 to 30 kHz band. Medium-range sets use a wider beam and operate at a lower frequency to overcome the problem of attenuation and so increase range. The latest very low frequency active towed array sonars operate on a frequency below 3 kHz. A number of research systems have been built over the last 15 years and very low frequency active towed arrays are beginning to enter operational service.

Modern sonars use electronic scanning to provide a panoramic picture (except for the small area round the stern which would be blanked by propeller noise). These are usually low-frequency sets with very high power to achieve long-range detection. Torpedo detection is now an essential and vitally important function of any sonar, for without it a ship is virtually defenceless against torpedo attack. Torpedo alert function can be provided by a dedicated intercept sonar or integrated into a passive sonar array. Such detection systems are now being integrated with active torpedo countermeasures to provide part of a layered underwater defence.

With all types of sonar, littoral operations result in increased levels of false alarm, which seriously degrade the system's overall effectiveness. One way of overcoming this problem is to use broadband active sonar systems, which will help to improve both detection and classification in the reverberant shallow water environment. Not only is this problem being addressed by the surface and submarine communities, but also by the torpedo community.

Data handling

On the data processing side there has been a significant increase in automated detection, classification, tracking and so on and the presentation of data in synthetic form. Processing power is available in abundance to cope with the demands that will be made on it in the future. The problem will be knowing what to do with the vast amount of information gathered in order to process it in the right way, to present the command with the right type of picture best suited to particular functions and from which accurate assessments can be made as to future tactics.

In the future, command systems must be fully integrated, which includes the sonar plot. This integration can be achieved in one of two ways:

- by passing fully processed data on all contacts to the command system for evaluation, a task which will require the application of artificial intelligence
- by relegating some functions of the command system back to the sonar processing system so that the command system receives heavily processed track data via a distributed system.

Future developments

Probably one of the most difficult areas for sonar operations in the future will be the littoral zone where depths generally are in the order of 100 fathoms (600 ft/183 m) or less. Here the effect of surface waves, high density of surface traffic, a disproportionate effect of bottom absorption, scattering and reflection – depending on the composition of the seabed – all combine to create enormous problems for the sonar designer and operator. In this scenario, only active sonars offer any certain possibility of detecting the latest ultra stealthy SSK and these, generally, can only reliably offer detection ranges in the order of 5 n miles. This problem is now beginning to be addressed with the development of special LF active sonars designed to take advantage of the shallow water channel. However, there is always a trade-off. While the detection probability factor can be increased, the classification factor is diminished.

A whole range of new technologies will have to be examined at the forefront of which will be the need for extensive application of fibre optic technology.

Another area to be addressed will be the use of AUVs and UUVs deploying sonar systems away from major platforms. Using AUVs in an autonomous operation will enable forces to covertly gather undersea information in shallow water without the need to project large manned submarines and Special Forces into an area.

Satellites are now providing, to an increasing number of forces, detailed information on environmental conditions including wind, waves and currents. It will soon be possible for satellites to provide continuous monitoring of the ocean environment, providing a wide range of data of incalculable value to forces operating in littoral scenarios. These new technologies, together with the increasing demand for more information to be made available to all units operating in the littoral scenario, where the time available for reaction is continually being reduced, is driving the need for what is now being termed Rapid Environmental Assessment. Without this tool, naval forces will not be able to effectively engage in Network Centric Warfare and in particular conduct effective undersea warfare.

Developments aimed at overcoming these problems centre on what are termed multistatic sonar systems. This concept involves the use of the whole range of sonar systems available – surface vessel (hull, VDS, TAS), submarine and sonobuoy. A typical multistatic LFAS system, for example, may include at least one towed active source and several towed LFAS receivers, which may include submarines and surface ships to perform bistatic detection. Multistatic systems can also be based around a field of sonobuoys which provide a multistatic receiver element while the transmitting element is provided by an active buoy, UUV, helicopter dipping sonar or towed LFAS.

Detections from all the various sensors are then fused, correlated and processed and re-distributed to the entire ASW task force. In essence Network Centric ASW. Such a concept will require a much higher degree of automation in the entire ASW process than is currently available. A greater degree of adaptive beam forming and processing will also be required in order to speed up correlation and enable a vast area of the ocean to be insonified to provide a complete sonar map of the area under surveillance. To achieve this, not only will the above have to be addressed but also communications – both above water and underwater – to ensure that the maximum amount of data can be handled effectively between the various involved platforms.

It is now appreciated that using a single ASW platform is not the answer to detecting the modern submarine, SSN or SSK and even more so SSK with AIP. Network Centric ASW will be the only effective way forward in the future to counter the submarine threat, particularly in the littoral zone. For NCASW (Network Centric ASW) to be effective it will be essential to develop effective multistatic sonar systems. In these, a variety of sonar sensors of different types, distributed around a number of different types of platform (air, surface and subsurface) are dispersed over a wide geographic area to operate as a single sonar system organic to the battle group, rather than as a number of disparate individual systems. Within this concept of a distributed sonar system, detection is automatic, beam forming is adaptive and the sonar in effect 'maps' the ocean automatically.

To work efficiently, multistatic sonar systems rely implicitly on effective, real-time communications links. In simplified computer terminology the battle group is, in essence, a large open architecture system with a large number of nodes (the platforms) each of which has access to all the data from all the sensors and which itself feeds its own sensor data into the bus (the communications link) connecting all the nodes together.

A number of trials are already under way to test the viability of the multistatic concept, but it may be some years before it reaches the fleets in an effective operational form.

As to the sonars themselves, frequency is vitally important, and for shallow water operations needs to be optimised both to overcome limitations caused by reverberation and to achieve acceptable detection ranges – which requires a trade off – or the deployment of a multistatic system. For classification of targets on or near the bottom in shallow water HF sonars are required.

Sonars also need to be able to take advantage of the best propagation depths, which requires them to be able to operate at various depths, sonobuoys with various depth settings, VDS, submarine sonars and sonars mounted on AUVs.

Lobe configurations are also critical – good resolution and classification performance results from the narrowest possible lobes. This can be further enhanced by the correct choice of pulse type and length according to prevailing conditions and circumstances and the use of sectorial transmission and receiving and a variable source level – even down to very low levels. All these, correctly used, help to limit the problems created by reverberation, ambient noise and other sonar propagation problems associated with operations in shallow water.

The US is addressing a number of the aspects of littoral ASW in Future Naval Capability programmes. In FY03 emphasis will be directed towards broadband and environmentally adaptive active sensing algorithms, the development of a common tactical picture of the undersea battlespace, and shallow water autonomous nodes arranged in a barrier. In FY04 a lightweight multistatic active system deployable by multimission helicopters and an airborne non-acoustic sensing system will be studied, together with deployment of an acoustic array to develop passive signal processing algorithms. In FY05 a deployable LF multistatic active sensor system and HF broadband array for submarines will be studied with a common environmental picture of the underwater battlespace. Fields of autonomous shallow water nodes for the detection of quiet submarines will also be developed. In FY06 a compact LF deployable receiver and technology for the detection of incoming torpedoes will be developed. In FY07 a compact LF deployable acoustic source for tactical use and an effective capability to detect, localise, and classify torpedo threats will be developed. This will be supported by a fused common tactical and environmental picture that will take into account the uncertainties associated with environmental measurements and models.

UPDATED

SURFACE SHIP SONAR SYSTEMS

Table IX

Operational surface ship sonar equipments

System	Frequency	Type	Manufacturer	Country	Installed on	Navy	Units
1 BV	HF	HM	L-3 Communications ELAC	Germany	Thetis	Greece	5
AN/SQR-18	LF	TAS	EDO	US	Cheng Kung	Taiwan	7
					Knox	Taiwan	8
					Knox	Thailand	2
					Takatsuki	Japan	1
			EDO/NEC	US/Japan	Shirane	Japan	2
AN/SQR-19	VLF	TAS	Northrop Grumman	US	Arleigh Burke I/II	USA	28
					FFG 7	USA	33
					FFG 7	Spain	6
					FFG 7	Poland	2
					Spruance	USA	10
					Ticonderoga	USA	27
AN/SQR-501	LF	TAS	Computing Devices	Canada	Halifax	Canada	12
AN/SQS-17	HF	HM	EDO	US	Bayandor	Iran	2
					Ctd Riviere	Uruguay	3
					Parvin	Iran	3
AN/SQS-23	MF	M	Raytheon/Sangamo	US/Japan	Gearing	South Korea	3
					Gearing	Taiwan	7
AN/SQS-26	MF	HM	EDO	US	Bronstein	Mexico	2
					Garcia	Brazil	2
					Knox	Egypt	2
					Knox	Mexico	4
					Knox	Taiwan	8
					Knox	Thailand	2
					Knox	Turkey	4
AN/SQS-35	MF	VDS	EDO	US	Baleares	Spain	5
			EDO/Nec	US/Japan	Shirane	Japan	2
				Japan	Yamagumo	Japan	2
AN/SQS-36	LF/MF	HM	Nec	Japan	Ishikari	Japan	1
				Japan	Yubari	Japan	2
AN/SQS-39V	MF/HF	HM	EDO	US	Claud Jones	Indonesia	1
AN/SQS-42V	MF/HF	HM	EDO	US	Claud Jones	Indonesia	1
AN/SQS-45V	MF/HF	HM	EDO	US	Claud Jones	Indonesia	1
AN/SQS-53	MF	HM	Various	US	Spruance	USA	10
					Ticonderoga	USA	27
					Arleigh Burke I/II/IIIa	USA	38
AN/SQS-56	MF	HM	Raytheon	US	Badr	Saudi Arabia	4
(DE 1160)					Baleares	Spain	5
(DE 1164)					Barbaros	Turkey	4
					Cheng Kung	Taiwan	7
					Descubierta	Egypt	2
					Descubierta	Morocco	1
					Descubierta	Spain	6
					FFG 7	Australia	4
					FFG 7	Bahrain	1
					FFG 7	Egypt	4
					FFG 7	Spain	6
					FFG 7	Poland	2
					FFG 7	Turkey	8
					FFG 7	USA	33
					Hydra	Greece	4
					Garibaldi	Italy	1
					Yavuz	Turkey	4
AN/SQS-505	MF	HM	Westinghouse	US/Canada	Nilgiri	India	5
					Kortenaer	Greece	9
					Kortenaer	UAE	2
AN/SQS-509	MF	HM	Westinghouse	US	Jacob Heemskerck	Holland	2
					Kortenaer	Holland	1
AN/SQS-510	MF	HM	Computing Devices	Canada	Halifax	Canada	12
		VDS/HM			Iroquois	Canada	4
		HM			Cdt Joao Belo	Portugal	3
					Vasco da Gama	Portugal	3
					Wielingen	Belgium	3
ASO 4	MF	HM	ATLAS Elektronik	Germany	Almirante Padilla	Colombia	4
					Espora	Argentina	5
ASO 84-41	MF	HM	ATLAS Elektronik	Germany	Assad	Malaysia	4
ASO 90	MF	HM	ATLAS Elektronik	Germany	Banyabandhu	Bangladesh	1
ATAS	LF	TAS	BAE Systems	UK	Cheng Kung	Taiwan	5
					La Fayette	Taiwan	6
					Type 21	Pakistan	6
					Delhi	India	1
CTS-36/39	HF	HM	C-Tech	Canada	Thetis	Denmark	4
					Flyvefisken	Denmark	3
					Leeuwin	Australia	2
					Sagar	Bangladesh	1

System	Frequency	Type	Manufacturer	Country	Installed on	Navy	Units
COMTASS					Fearless	Singapore	1
DE 1164	LF/MF	HM/VDS	Raytheon	US	De La Penne	Italy	2
(SQS-56)	MF/HF				Maestrale	Italy	8
					Ulsan	South Korea	9
DE 1167	MF	VDS	Raytheon	US	Descubierta	Egypt	2
		HM	Raytheon/Alenia	US/Italy	Minerva	Italy	8
DE 1191	MF	HM	Raytheon		Charles F Adams	Greece	1
DSBV 61B	VLF	TAS	Thales Underwater Systems	France	Georges Leygues	France	3
DSBV 62C	VLF	TAS	Thales Underwater Systems	France	Tourville	France	2
DSBX 1A (ATBF)	LF	VDS	Thales Underwater Systems	France	Tourville	France	2
DSQS 21	MF	HM	ATLAS Elektronik	Germany	Almirante Brown	Argentina	4
					Bremen	Germany	8
					Kwanggaeto the Great	South Korea	3
					Inhauma	Brazil	4
					Khamronsin	Thailand	3
					Makut Rajakumarn	Thailand	1
					Tapi	Thailand	2
					Kasturi	Malaysia	2
					Lutjens	Germany	1
					Rattanakosin	Thailand	2
DUBA 3A	HF	HM	Thales Underwater Systems	France	Cdt Joao Belo	Portugal	3
					Cdt Riviere	Uruguay	3
DUBA 25	MF	HM	Thales Underwater Systems	France	Type A69	France	9
					Type A69	Turkey	6
					Cassard	France	1
DUBV 23	MF	HM	Thales Underwater Systems	France	Suffren	France	1
					Tourville	France	2
					Georges Leygues	France	4
					Luhu	China	2
					Luda	China	1
					Luhai	China	1
DUBV 24	MF	HM	Thales Underwater Systems	France	Cassard	France	1
					Georges Leygues	France	3
					Jeanne d'Arc	France	1
DUBV 25	MF	HM	Thales Underwater Systems	France	Cassard	France	1
DUBV 43B/C	MF	VDS	Thales Underwater System	France	Suffren	France	1
					Georges Leygues	France	7
					Luhu	China	2
					Luda III	China	1
Echo Type 5	HF	HM		China	Daxin	China	1
	MF				Jiangwei I/II	China	12
					Jianghu I/II/III/IV	China	31
					Jianghu I	Egypt	2
					Osman	Bangladesh	1
G 750	MF	HM	Graseby	UK	Nilgiri	India	4
					Leander	New Zealand	1
HUMVAD			Bharat	India	Delhi	India	3
Model 610	MF	HM	EDO	US	Audace	Italy	2
(CWE 610)					Lupo	Peru	4
(AN/SQS-29)					Lupo	Venezuela	6**
					Van Speijk	Indonesia	6
					Moawin	Pakistan	1
Model 700E					Niteroi	Brazil	2
Model 780	MF	HM	EDO	US	Reshef	Israel	2
Model 796	MF	HM	EDO	US	Eilat	Israel	3
Model 997	MF	HM	EDO	US	Niteroi	Brazil	6
Mulloka	MF	HM	Thorn	Australia	FFG 7	Australia	2
OQR-1	VLF	TAS			Asagiri	Japan	8
					Hatsuyuki	Japan	
					Murasame	Japan	9
OQR-2	TAS	VLF	Oki	Japan	Kongo	Japan	4
(SQR-19)					Takanami	Japan	2
OQS-3	MF	HM	Sangamo/Mitsubishi	US/Japan	Haruna	Japan	2
OQS-3A	LF		Nec		Tachikaze	Japan	3
	MF	HM	Nec		Yamagumo	Japan	2
OQS-4/A	LF	HM	Mitsubishi	Japan	Asagiri	Japan	8
(SQS-23)	MF		Nec		Hatakaze	Japan	2
	LF		Nec		Hatsuyuki	Japan	11
					Shimayuki	Japan	1
OQS-5	LF	HM	Mitsubishi	Japan	Murasame	Japan	9
					Takanami	Japan	2
OQS-8	MF	HM	Hitachi	Japan	Abukuma	Japan	6
OQS-101	LF	HM	Nec	Japan	Shirane	Japan	2
OQS-102	MF	HM	Nec	Japan	Kongo	Japan	4
(SQS-53)							
PHS-32	MF	HM	Signaal	Holland	Dewantara	Indonesia	1
					Dong Hae	South Korea	4
					Fatahillah	Indonesia	3
					Po Hang	South Korea	24
PHS-36	MF	HM	Signaal	Holland	Karel Doorman	Holland	8
Platina (Bull Horn)	MF/LF	HM		RFAS	Kuznetsov	RFAS	1
					Parchim II	RFAS	11
					Slava	RFAS	3
					Sovremenny	China	2
					Sovremenny	RFAS	5

System	Frequency	Type	Manufacturer	Country	Installed on	Navy	Units
PMS 26	MF	HM	Thomson Marconi Sonar	UK	Almirante Clemente	Venezuela	2
					Erinomi	Nigeria	2
					Niels Juel	Denmark	3
					Turk	Turkey	7
PPIOM	HF	HM	ATLAS Elektronik	Germany	Kralj	Croatia	2
SA 950	HF	HM	Simrad AS	Norway	Alta	Norway	5
					Goteborg	Sweden	4
					Kaparen	Sweden	8
					Stockholm	Sweden	2
Shelon' (Elk Tail)	HF	VDS		RFAS	Grisha	RFAS	22
					Grisha	Ukraine	3
					Parchim I	Indonesia	16
SJD 5A	MF	HM		China	Chao Phraya	Thailand	4
SJD 7	MF	HM		China	Naresuan	Thailand	2
Sonac PTA			Patria New Technologies	Finland	Helsinki	Finland	4
					Rauma	Finland	4
					Telkka	Finland	1
					Hamina	Finland	1
SQS-3D	HF	HM	Simrad AS	Norway	Mirna	Croatia	4
					Mirna	Serbia & Montenegro	4
SS 105	MF	HM	Simrad AS	Norway	Nordkapp	Norway	3
					Silma	Estonia	1
					Valpas	Latvia	1
					Tursas	Finland	2
					Valpas	Finland	1
SS 242	HF	HM	Simrad AS	Norway	Lokki	Finland	2
SS 304	HF	HM/VDS	Simrad AS	Norway	Helsinki	Finland	4
					Kiisla	Finland	2
ST 570	HF	VDS	Simrad AS	Norway	Kaparen	Sweden	8
ST 240 (Toadfish)		VDS	Simrad AS		Rauma	Finland	4
					Kaparen	Sweden	8
					Hamina	Finland	1
TSM 2064		VDS	Thales Underwater Systems	France	Victory	Singapore	6
TSM 2362 (Gudgeon)	MF	HM	Thales Underwater Systems	France	Fearless	Singapore	6
TSM 2633 (Spherion)	MF	HM	Thales Underwater Systems	France	ANZAC	Australia	5
					ANZAC	New Zealand	2
					La Fayette	Taiwan	6
					Lekiu	Malaysia	2
					Oslo	Norway	3
TSM 2635 (Diodon)	MF	HM	Thales Underwater Systems	France	Drummond	Argentina	3
					Esmeraldas	Ecuador	6
					Nilgiri	India	2
(TSM 2630)		HM/VDS			Madina	Saudi Arabia	4
TSM 2643 (Salmon)	MF	VDS	Thales Underwater Systems	France	Flyvefisken	Denmark	4
					Goteborg	Sweden	3
					Stockholm	Sweden	2
(TSM 2640)		HM/VDS			Thetis	Denmark	4
TSM 2980 (Anaconda)	LF	TAS	Thales Underwater Systems	France	Karel Doorman	Holland	8
Type 170	HF	HM	Graseby	UK	Alvand	Iran	3
					Leander	Chile	3
					Nilgiri	India	5
					Leander	Pakistan	2
					Salisbury	Bangladesh	1
Type 174	MF	HM	Graseby	UK	Alvand	Iran	3
					Salisbury	Bangladesh	1
Type 184	MF	HM	Graseby	UK	County	Chile	3
					Leander	Chile	3
					Leander	Ecuador	2
					Leander	Pakistan	2
					Type 21	Pakistan	6
					Hercules	Argentina	2
					Viraat	India	1
Type 2016	MF	HM	Thales Underwater Systems	UK	Invincible	UK	3
					Type 42	UK	7*
Type 2031	LF	TAS	Thales Underwater Systems	UK	Type 22	UK	4
					Type 23	UK	10
Type 2050		HM	Thales Underwater Systems	UK	Type 22	UK	5***
					Type 22	Brazil	4
					Type 22	Chile	1
					Type 23	UK	16
					Type 42	UK	11***
UQQ-2 (SURTASS)	LF	TAS	Hughes Aircraft	US	Hibiki	Japan	2
					Stalwart	USA	5
					Victorious	USA	4
					Impeccable	USA	1

Note: HM - Hull-Mounted Sonar, TAS - Towed Array Sonar, VDS - Variable Depth Sonar, VLF - Very Low Frequency (around and below 1 kHz), LF - Low Frequency (below 3 kHz), MF - Medium Frequency (3-14 kHz), HF - High Frequency (above 14 kHz)

** Being replaced by 21 HS 7 * Being replaced by Type 2050 *** Replacing Type 2016

UPDATED

Australia

Mulloka sonar

Type
Hull-mounted scanning sonar system.

Description
Mulloka is a lightweight, relatively high-frequency (6 to 11 kHz) active hull-mounted scanning sonar developed in the 1960s for installation in Royal Australian Navy (RAN) anti-submarine escorts and designed for operation in coastal waters around Australia. The solid-state forced air-cooled equipment is of high reliability and has been designed using a standardised packaging approach to aid maintainability and keep production simple.

The equipment includes a dedicated online computer which is used to control transmission parameters, perform automatic signal processing functions and conduct checkout procedures. All signal interfaces have been grouped at a single location, so that modifications necessary to interface Mulloka with other ship equipment configurations are simplified.

The sonar beam-forming process involves the development of a large cylindrical transducer array consisting of 96 staves with 25 transducers per stave. Each driven in differing combinations and phases under computer control to form the required sonar beams electronically with a 20° beamwidth. The hydrophone elements of the array are driven by 480 power amplifiers during the transmit period, the length of which is a function of the pulse length of the transmitted signal. The transmit period is selectable over the range of approximately 1 to 4 seconds. The transmitter beams are formed sequentially during this period and cover the ocean for 360° in azimuth. The formation of the beam transmit pattern is random, moving between transmissions to the next in order to prevent the submarine commander having any indication of detection. Immediately following the transmission, the sonar reverts to the listening mode for a period determined by the range scale selected by the operator. Range is about 9,000 m.

Operational status
In 1979, a prototype Mulloka sonar was formally handed over to the RAN after undergoing trials in HMAS *Yarra* since 1975. A production programme to build systems to equip six RAN River class destroyer escorts was then completed.

In April 1980, it was announced by the Australian Ministry of Defence that an initial contract had been awarded to Honeywell Inc in America to provide a transducer array for the Mulloka sonar. Two Australian companies, GEC-Marconi Systems Pty Ltd and Dunlop Industrial and Aviation, were also participating. A contract for the electronics of the system was awarded to THORN EMI (Australia) Ltd in 1979.

In 1985, contracts were awarded for two systems to be fitted to two FFG 7 class frigates being built in Australia (*Melbourne* and *Newcastle*). As a result of the transferred technology, Plessey Australia was contracted to establish a production facility and to manufacture two transducer arrays and spares which were delivered over the period 1987 to 1989. In mid-1987, THORN EMI (Australia) Ltd was awarded a A$6 million contract to upgrade the system electronics, including a new display system.

Mulloka is to be replaced by the Thales TMS 4131 sonar suite during 2003-06 modernisation.

Contractor
THORN EMI (Australia) Ltd.

VERIFIED

Narama and Kariwara towed thin-line arrays

Type
Thin-line towed arrays for submarine and surface ship operation.

Description
Following the joint venture of the former Thomson Sintra Pacific and GEC-Marconi Systems companies, Thomson Marconi Sonar now supply two thin-line winchable towed arrays for military application. These rugged and robust thin-line towed arrays offer substantial savings in space and weight when compared to the traditional liquid filled arrays. These technologies are particularly well suited for winching and offer submarines a unique capability of a towed array that can be remotely winched and fully stowed on board. Both technologies offer excellent performance over a wide range of frequencies and tow speeds and can be configured to meet specific customer requirements.

Narama is based on enhanced liquid-filled array technology and can be supplied in a range of diameters from 40 to 65 mm. A revolutionary design concept gives the array a very robust nature and provides for reliable winching and long life. The simple and uncomplicated structure of Narama provides excellent acoustic performance. The array can be fitted with digital telemetry for large hydrophone channel populations, or with hard-wired preamplifiers for a very simple low-cost streamer. The small diameter allows a much smaller and lighter handling system to be used and confers on the system a very low self-noise, due to the improved signal-to-noise ratio and high-operating speed. The array incorporates advanced vibration isolation modules. It can be operated at speeds up to 15 kt without degradation to acoustic signals. Available array designs include short lengths for tactical use and longer surveillance arrays which use digital telemetry. The arrays supplied for the Oberon class submarines are of a self-streaming configuration, but the system is also compatible with the new Collins class submarines.

Kariwara uses a solid filled array technology and has been tailored for 40 mm diameter. The hybrid solid/liquid filled construction of the array provides an extremely robust construction while maintaining excellent acoustic performance. The construction uses a combination of tough buoyancy-controlled polymers assembled in modular functional sections which are joined by titanium electromechanical connectors. Not only is this solid construction easily winched and highly resistant to damage, but it provides graceful degradation by containing and localising the effects of damage. Kariwara is supplied with a Digital Telemetry System.

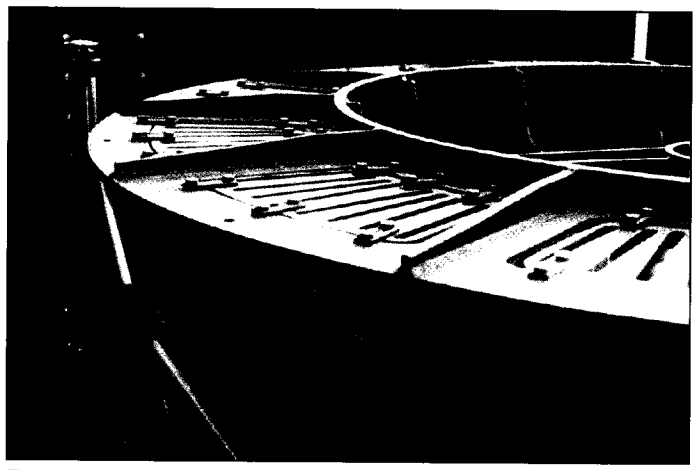
Operational status
Narama systems have been delivered to the RAN for the Anzac class frigates. Export sales have been made to a number of navies including Spain for R&D projects.

Kariwara is currently in service with the RAN on the first two units of the Collins class submarines.

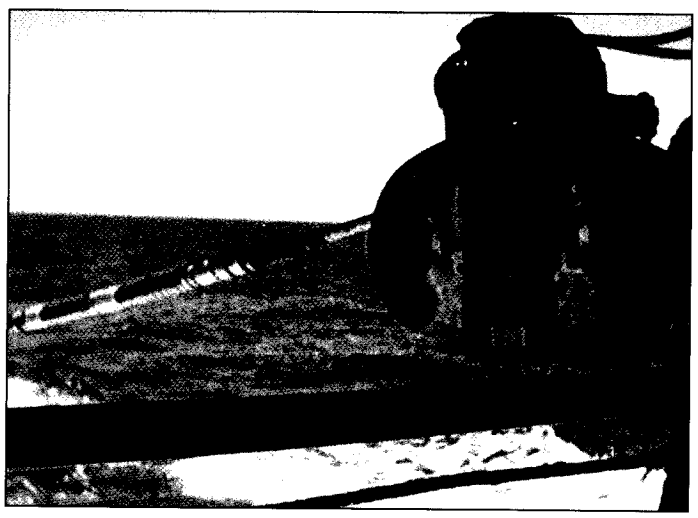
Specifications
Diameter: 25-50 mm
Length: up to 5 km
Channels: up to 1,000
Operating speed: up to 15 kt, max >20 kt
Survival speed: 30 kt
Axial stiffness: 1% strain at 15 kt
Min bend radius: 0.5 m (50 mm diameter array)
Tensile load: exceeds 100 kN (>10 t for 50 mm diameter)
Max crush load: >50 kN (5 t)/m

Contractor
Thales Underwater Systems, Rydalmere, New South Wales.

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The winch assembly used with the Kariwara thin-line array in Collins class submarines 0007221



Reeling a Narama towed array aboard a RAN vessel 0092505

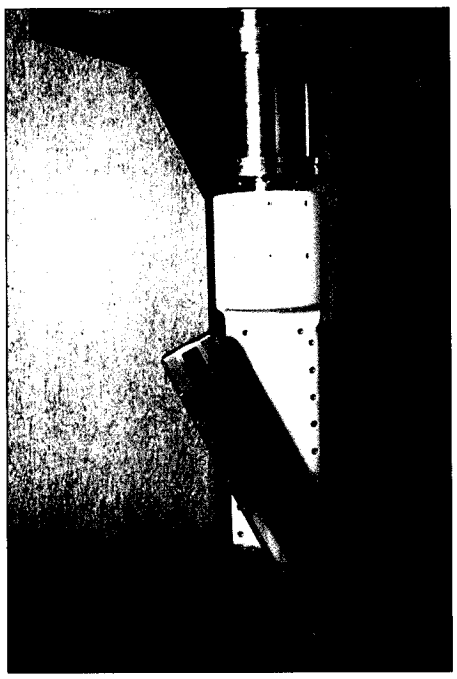
Petrel 5425

Type
Hull-mounted active volumetric acoustic processing sonar.

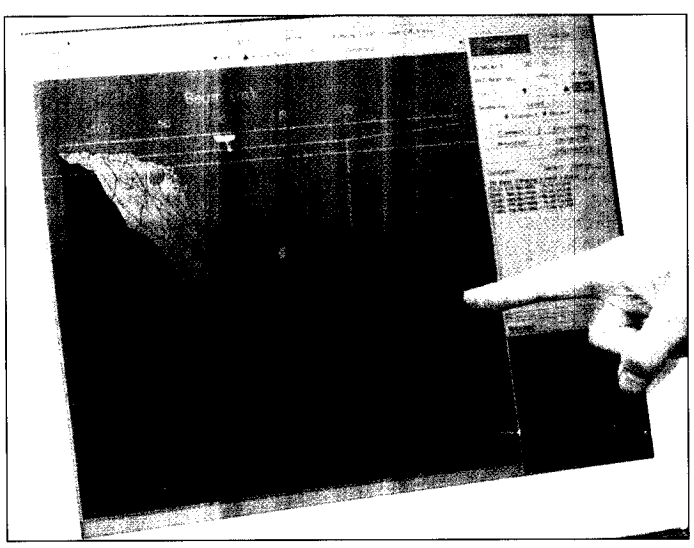
Development
The Petrel 5425 three-dimensional (3-D) sonar design is the result of a three-year development undertaken in Australia by Thales Underwater Systems in conjunction with the Royal Australian Navy (RAN) and the Australian Department of Defence Industrial Development programme. This development grew out of the RAN's operational requirement to optimise mine avoidance in coastal waters, by use of a high-frequency, high-resolution system. RAN analysis found traditional lower frequency systems were less effective in Australian coastal waters. The provision of a capability to provide real-time 3-D mapping of the seabed was also seen as important, given the large areas of shallow and unsurveyed waters within Australia's area of direct military interest.

Description
The Petrel 5425 (TSM 4424) has been designed to provide an instantaneous, high-fidelity resolution of range, bearing and elevation, within a 60° azimuth by 12° elevation sector ahead of the vessel. The sonar creates this volume by use of patented volumetric acoustic processing technology. This capability allows the separation of sea surface, seabed and water column returns, and allows for the reduction of reverberation and other artefacts by isolation of these into separate matrix areas. The latter capability is important as it means that Petrel is insensitive to changing water conditions and hence achieves good performance in warm coastal waters. Detection probability is rated as 95 per cent (2 sigma) while extremely low false alarm rates are germane at 1 in 50 hours. The data is processed to display an intuitive real-time three-dimensional data set of seabed and water column data ahead of the vessel and also icon prompted representation of point contacts such as mines.

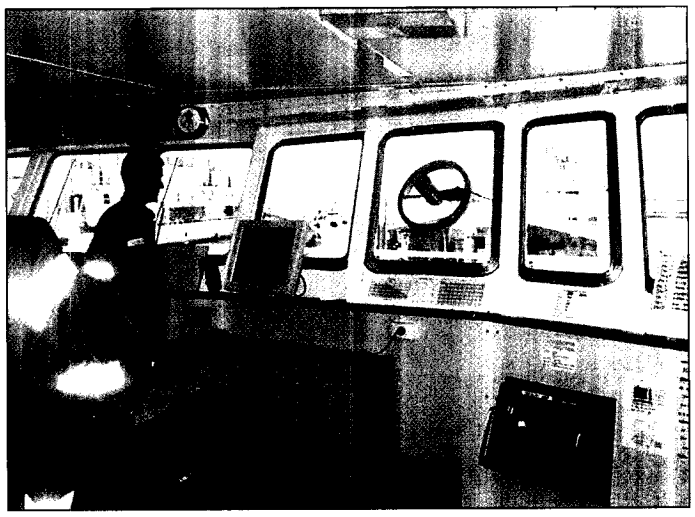
Petrel features a vertical linear, mechanically stabilised active array and a horizontal linear receive array and can be operated at speeds up to 12 kt, in up to Sea State 4.



The wet end of the Petrel TSM 5424
0007222



A display picture on the Petrel system (Royal Australian Navy) 0092502



Petrel in SML configuration using flat screen display surfaces
(Royal Australian Navy) 0092503

The system currently operates using X-Windows® but will be fitted with Windows® NT.

The sonar is designed for navigational safety and mine avoidance in both surface and submarine military applications. The primary display and operator interface is on the bridge and it is designed to minimise time demand on the mariner by providing automatic monitoring of features of a depth less than an operator selected limit by providing continuous search for point contacts with icon prompting and alarm for rapid operator recognition. Minimum detection range is 650 m and maximum is 1,000 m. Petrel is designed for the following roles:

- **Mine and natural obstacle avoidance:** Petrel detects surface, moored and seabed mines and will provide high resolution real-time spatial mapping for safe navigation in poorly charted or coral waters.
- **Shallow water hydrographic feature detection:** Petrel detects seabed features as small as 1 m^3 for subsequent examination by multibeam echo-sounding systems. This detection is undertaken ahead of the vessel for optimised survey vessel safety and mission efficiency.
- **Amphibious warfare:** Petrel provides real-time intuitive data on landing beach gradient and amphibious entry/egress routes. Petrel is fully retractable and can be operated by beaching craft.
- **Warship defence from swimmer attack at anchor:** Petrel will scan 180° in 6 seconds and will detect the diver's lung cavity and diving apparatus. Attacking divers can be tracked in 3-D and the availability of depth data permits optimised anti-diver charge fuse timing.
- **Shallow water anti-submarine warfare:** Petrel will detect bottomed small submarines including bottom crawling clandestine craft in shallow water.

Petrel is available as a surface ship variant and a submarine variant is under development. The distinction in variants is mechanical only, reflecting the need for mechanical roll stabilisation in small to medium surface warships, which operate in a highly dynamic environment. The submarine variant does not have mechanical stabilisation, with the transducer array fixed behind an acoustic aperture.

Operational status
2003 – Eight systems ordered for the Australian Navy Anzac class frigates.

Petrel has been fitted for survey operations aboard the RAN survey vessel HMAS *Mermaid* and is entering service with the RAN aboard the Adelaide class FFG 7.

Contractor
Thales Underwater Systems, Rydalmere, New South Wales.

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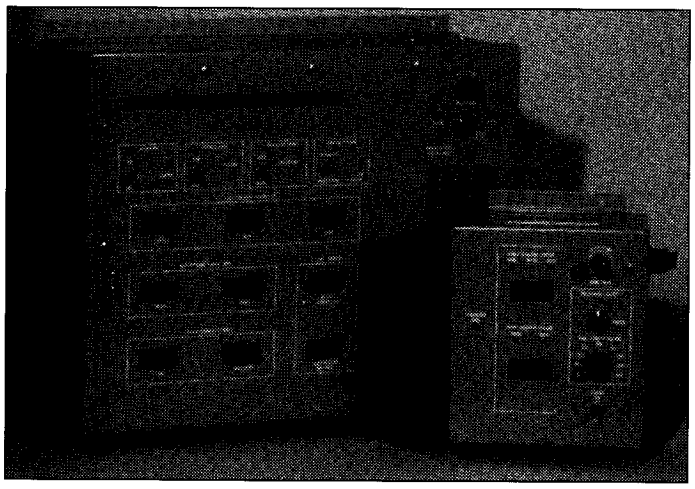
Canada

AN/SQQ-504 towing condition monitor

Type
Monitoring system for VDS sonar systems.

Description
The AN/SQQ-504 towing condition monitor aids ship's personnel in the successful launch, tow and recovery of the Variable Depth Sonar (VDS) body. With the introduction of this type of equipment, the command and sonar operations are provided with means to optimise operations and minimise risk to VDS equipment, due to the variability of sea conditions, ship's speed and motion and so on.

The monitor provides VDS towcable strain information (actual strain when the body is under tow, or predicted strain when the body has not been launched or is to be towed at a different cable length) to the operator and ship's command. The system also provides information by which the VDS operator can judge the performance of the VDS hoist system and enables personnel to monitor the degrading effect of ship's motion on the VDS sonar detection capability.



AN/SQQ-504 towing condition monitor, showing primary indicator (left) and remote indicator (right)

The system consists of a group of sensors, a processor unit, two recording units, three identical remote display units and a VDS operator's control and display unit. These items perform the functions of data acquisition, signal conditioning, data processing, display and recording. Sensors include boom and deck accelerometers, a cable strain gauge, a boom switch, a cable length synchro and ship's speed data.

Operational status
The AN/SQQ-504 is fitted to Canadian Navy destroyers.

Contractor
Northrop Grumman – Canada Ltd, Burlington, Ontario.

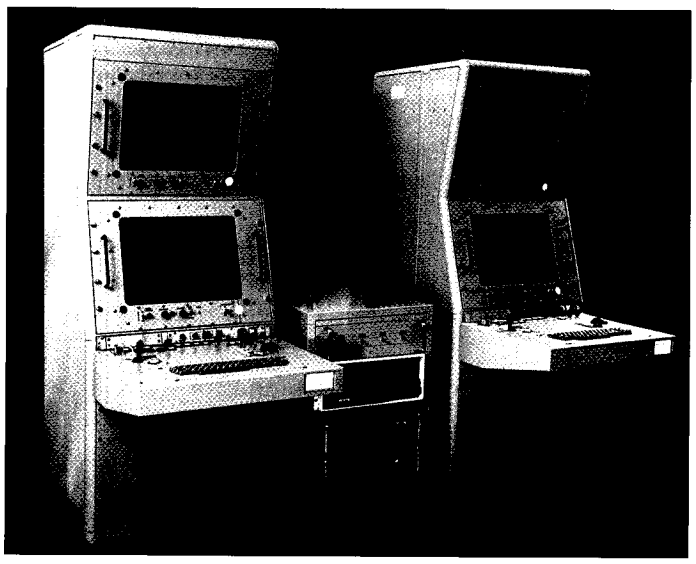
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AN/SQR-501 CANTASS

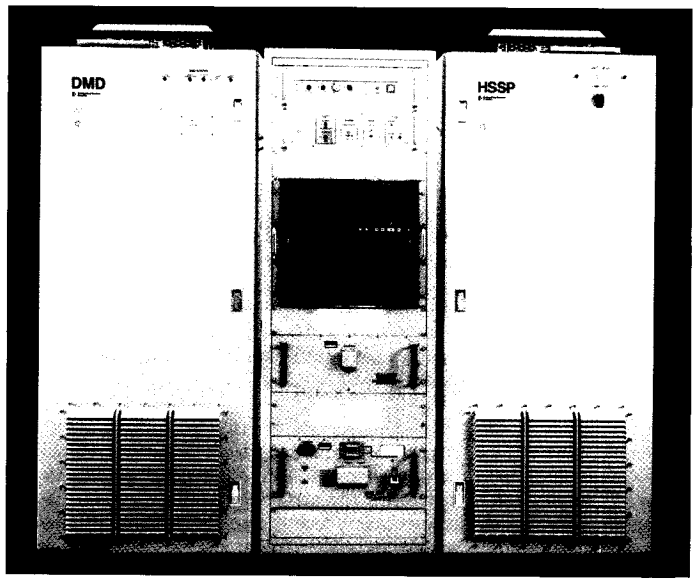
Type
Surface ship towed array sonar system.

Development
The CANTASS system was developed following extensive experience with an Experimental Towed Array Sonar System (ETASS) developed at DRDC, in Canada following experiments with hydrographic towed array systems.

Description
The AN/SQR-501 is a passive, critical angle low frequency towed array which uses a General Dynamics Canada display and processing subsystem, the 'wet end' of the Lockheed Martin AN/SQR-19A towed array and Indal Technologies handling



AN/UYQ-501 display consoles of the AN/SQR-501 CANTASS



Electronic cabinets of the AN/SQR-501 CANTASS

gear. The acoustic data processing system uses the General Dynamics Canada AN/UYS-501 signal processor, modular interfacing and data management electronics. The acoustic data processing subsystem also provides for the storage and playback of raw acoustic data by means of a Sony DR 1000L digital recorder.

The system provides frequency and bearing analysis of acoustic emissions from long ranges and is consistent in both shallow water and beyond the second convergence zone. Data is presented on high resolution 19 in CRT displays in a variety of formats. The formats were defined following extensive human factor analysis by DRDC - Toronto (DCIEM). Audio data is presented as a further aid to detection and classification. Processing algorithms were developed by the Canadian Defence Research Establishment Atlantic and implemented by General Dynamics Canada Ltd.

The system can carry out simultaneous processing on up to 43 beams in narrowband, DEMON and each of four verniers. Processing is also carried out coherently in broadband around 360° in 5° steps together with two audio channels. Up to 120 operator initiated tracks can be sourced in bearing and frequency.

Processing and data manipulation is carried out entirely in software using the Ada programming language. The modular design offers a growth capability and adaptability to meet changing requirements. Developed for a surface ship application, the design of the interfaces, display and processing subsystems allows for adaptability to a variety of sensors and platforms including submarines.

Operational status
All systems are in full operational use on the 12 Canadian Halifax class frigates.

Contractor
General Dynamics Canada, Maritime Systems,Ottawa, Ontario.

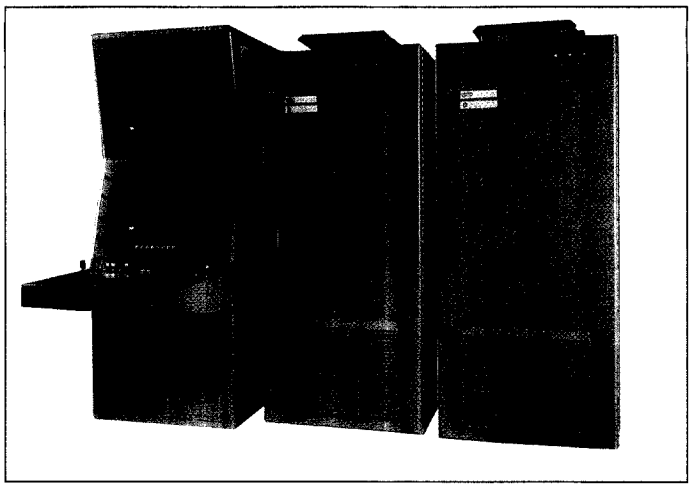
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AN/SQS-510 (V)

Type
Medium-frequency active sonar system.

Description
Developed in 1982, the AN/SQS-510(V) is an adaptable, medium-frequency (4.3 to 8 kHz), hull-mounted or variable depth, active sonar system, which was created as a major redesign of the AN/SQS-505. It integrates the existing transmitter group, transducer and hull outfit or towed body equipment with the AN/UYS-501 programmable digital receiver, processing and display groups and modern digital signal and display processing algorithms. It provides simultaneous active and passive digital signal processing, display processing and Computer-Aided Detection (CAD) for rapid detection and localisation of active and passive contacts both narrowband and broadband. In addition to normal blue water operations, this sonar is optimised for performance in three specific scenarios; shallow water submarine detection, mine avoidance and torpedo detection. The sonar system is controlled from a dual-screen operator's console. The high-resolution digital colour monitors provide synthesised displays of processed active and passive acoustic data. The operator is alerted to active and passive contacts by sophisticated CAD and tracking algorithms. Passive alerting is provided in both active and listen

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Display console and electronics cabinets of the AN/SQS-510 sonar

states. A major upgrade to the AN/SQS-510 occurred in 2003 providing improved active processing and the introduction of narrowband displays. A further upgrade providing enhanced torpedo detection capability is proposed for the Autumn of 2004.

Operational status
The AN/SQS-510(V) is installed on the Portuguese Vasco da Gama (6.4 to 8 kHz operating frequency) and Joao Belo class frigates and on the Canadian Halifax class frigates (Canadian Patrol Frigate) in a hull-mounted mode and the Iroquois class DDH-280 destroyers in both hull-mounted and VDS. General Dynamics has also supplied the Belgian Navy with the AN/SQS-510 for the Wielingen class frigates.

Greece is proposing to upgrade the AN/SQS-505 sonar on its Kortenaer class frigates to AN/SQS-510 standard, work commencing in 2004.

Specifications
Modes: CW, Linear Period Modulation (LPM), active
Range scales: 1,835 to 55,045 m in 6 selectable bands
Frequency: 2.2-8.6 kHz
Pulse length:
CW – 400 ms, 200 ms
LPM – 320 ms, 200 ms, 10 ms
Bearing resolution: >10°

Contractor
General Dynamics Canada, Maritime Systems,Ottawa, Ontario.

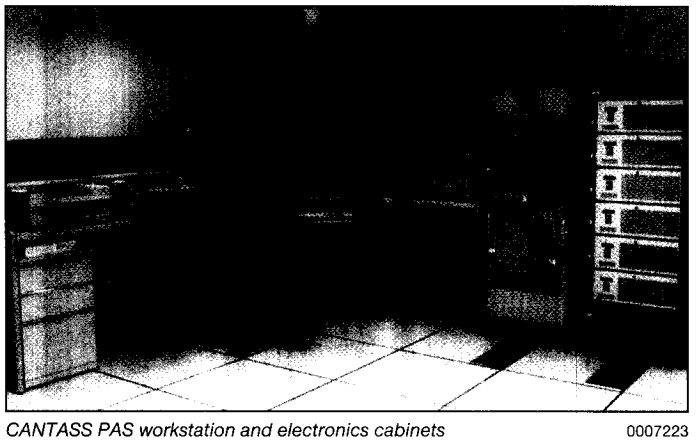
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CANTASS PAS

Type
Post-mission analysis system.

Description
CANTASS PAS (Canadian Towed Array Sonar System Post-Analysis System) is an advanced post-mission COTS-based analysis system that processes, stores, analyses and classifies sonar data collected by CANTASS fitted ships. Data is assimilated and processed from tape in over three times real time. The system randomly accesses up to 80 h of processed sonar data. The operator workstations display data on a high-resolution monitor, where analysts tag interesting time ranges of data for future access. Processed data is displayed on up to six operator workstations at up to eight times real time. To highlight patterns in acoustic data the system provides four types of acoustic cursors: cross-hair, extended cross-hair, harmonic and comb. The displays are X-Windows based and graphically oriented. These features help analysts distinguish events from background noise. Display formats available to the operators include search summary; single-beam/bearing; one hour narrowband; one hour compressed; one hour broadband; and amplitude line integration. Several of the formats have subformats which allow the operator to view many displays of the same format type simultaneously. All display formats are generated in less than two seconds. The signal processing system takes raw acoustic data beam-formed in 43 beams (parameter reconfigurable) at three times real time and applies advanced special analysis to produce narrowband, broadband, amplitude line integration and demodulated noise (Demon).

The system is divided into four software components: system controller software; mass memory software; operator workstation software; and signal processing software.



CANTASS PAS workstation and electronics cabinets 0007223

Operational status
Delivered in 1995 and in service with the Canadian Navy at ADAC Halifax and Esquimalt.

Contractors
Array Systems Computing Inc, Toronto, Ontario.

VERIFIED

CTS-24 ASW OMNI sonar

Type
Active hull-mounted sonar.

Description
The CTS-24 is a medium-frequency sonar designed for navies operating in shallow as well as deep water. The narrow vertical beam, 6°, (horizontal beam width is 9°) maintains excellent performance in shallow water, while the 24 kHz operating frequency provides extended detection ranges in blue water.

Applications for the CTS-24 are for shallow and deep water ASW, mine detection/avoidance (surface, moored and bottom mines), MCM support roles (ROV/AUV tracking) and general surveillance.

The main features of the sonar are:
- automatic detection
- automatic tracking of up to three targets, target range, bearing, depth, speed and heading are automatically updated
- electronic stabilisation of receive beams for ship's roll and pitch
- electronic tilt (+8 to –24°) for target interrogation in the water column, as well as ocean bottom
- high-resolution (0.25 m) zoom window (250 m wide) can be set through the full operator selectable range scale
- source level: 223 dB/μPa/m
- 13.5 kW omni transmit power.

Various modes of operation are available providing:
Omni-active: simultaneous audio and video presentation of CW or FM modes. Three target tracker channels provide automatic tracking of targets. Own ship track is also displayed.
Omni passive: omni video presentation with steerable audio sector for classification.
Surveillance: provides a 12° sector azimuth steerable operation for minimising effects of reverberation in shallow water. Video and audio presentation.
Maintaining close contact: provides a broad 30° depressed beam for maintaining contact on close in targets without the need for operator interaction.
High resolution: provides a 250 m window with a 0.25 m range resolution, adjustable to any position of the selected operating range.

Operational status
Awaiting production order contract.

Contractor
C-Tech Ltd, Cornwall, Ontario.

VERIFIED

CTS-36/39 OMNI sonar

Type
Hull-mounted sonar.

Description
The CTS-36/39 Omni sonar is a multipurpose hull-mounted ship system for use in surveillance, ASW and MCM support roles in coastal waters and has been optimised for shallow water operation.

The scanning and multibeam sonar uses narrow horizontal and vertical receiving beams (6°), high-speed scanning and digital processing techniques to provide instantaneous detection, classification and target data through a full 360° field of view. Sector transmission is operator selectable in 24° sector increments for operation in areas such as harbours or narrow channels. Transmit power and pulse

length are also operator selectable to provide optimum setting for any area of operation. Simultaneous video and audio information is available in both active and passive modes, with the audio sector being steerable in passive. Automatic detection and target tracking are provided in active mode using selectable CW or FM transmission. Three independent receive channels (each 60° × 6° at –3 dB points) can each track automatically one, two or three targets. Target range, depth, course, speed and heading are instantaneously displayed and updated for each target. Own ship's track is also displayed.

The CTS-36/39 also provides:

- Detection of various types of targets such as divers, mines, submarines and others
- Detection of targets in the water column as well as bottom targets such as wrecks and rocks on the seabed using electronic tilt
- Detection and location of large targets at long ranges
- Electronic roll and pitch stabilisation of receive beams
- Interface to ship's own command/communications and control (C^2 or C^3) systems.

In surveillance mode the operator can select the transmit sector width and position, using a 12° receive beam stepped through the operator selected sector. Maintaining contact on close targets is aided by the use of a broad receive beam at a fixed, depressed angle of 30°. The electronic tilt feature enables extended detection range to counter the effects of ray refraction in thermocline conditions, as well as providing enhanced capability in detecting and identifying seabed targets in shallow areas exhibiting high reverberation. Automatic detection and target tracking are provided with a resolution of 1 m in range and 0.75° in bearing. Target range, depth, bearing, speed and heading are constantly updated and displayed. Target cursor and markers provide a history track on the display.

The MMI comprises touch screen panel and trackball with a 20 in high-resolution display monitor. This provides PPI, B-scan, passive and surveillance sector displays for operator selection.

The transducer is accommodated in a self-contained retractable dome that is stored in the retracted position inside a well tube that forms the interface with the ship's hull. The hoist unit is located inside the ship compartment where the well tube is welded to the hull.

The system can function as a stand-alone unit or be integrated into a full combat system.

Operational status

The CTS-36/39 is no longer in production, but remains in service. It is operational with the Danish Navy Thetis class and Flyvefisken class ships. A total of 19 ship sets has been delivered.

Specifications

Total weight: 650 kg
Operating frequency: dual-frequency 36 kHz/39 kHz operator selectable; CW mode; FM chirp.
Ranges: 250 m, 500 m, 1,000 m, 2,000 m, 4,000 m operator selectable
Electronic tilt: from +8 to –24°
Electronic stabilisation: ± 25° roll, ± 10° pitch
Beamwidth: receive – 6° in horizontal and vertical
transmit – horizontal omni or selectable sector, vertical 6°
Transmitter: 270 channels; power output/channel 50 W max, 13.5 kW omni total
Source level: 223 dB/μ Pa/m
Source power: 10 kW

Contractor

C-Tech Ltd, Cornwall, Ontario.

UPDATED

Hydra MSS

Type

Integrated ASW/MCM sonar suite.

Description

The Hydra MSS (MultiSonar System) integrated sonar suite is on order for the Swedish Navy to carry out both ASW and MCM surveillance for surface vessels.

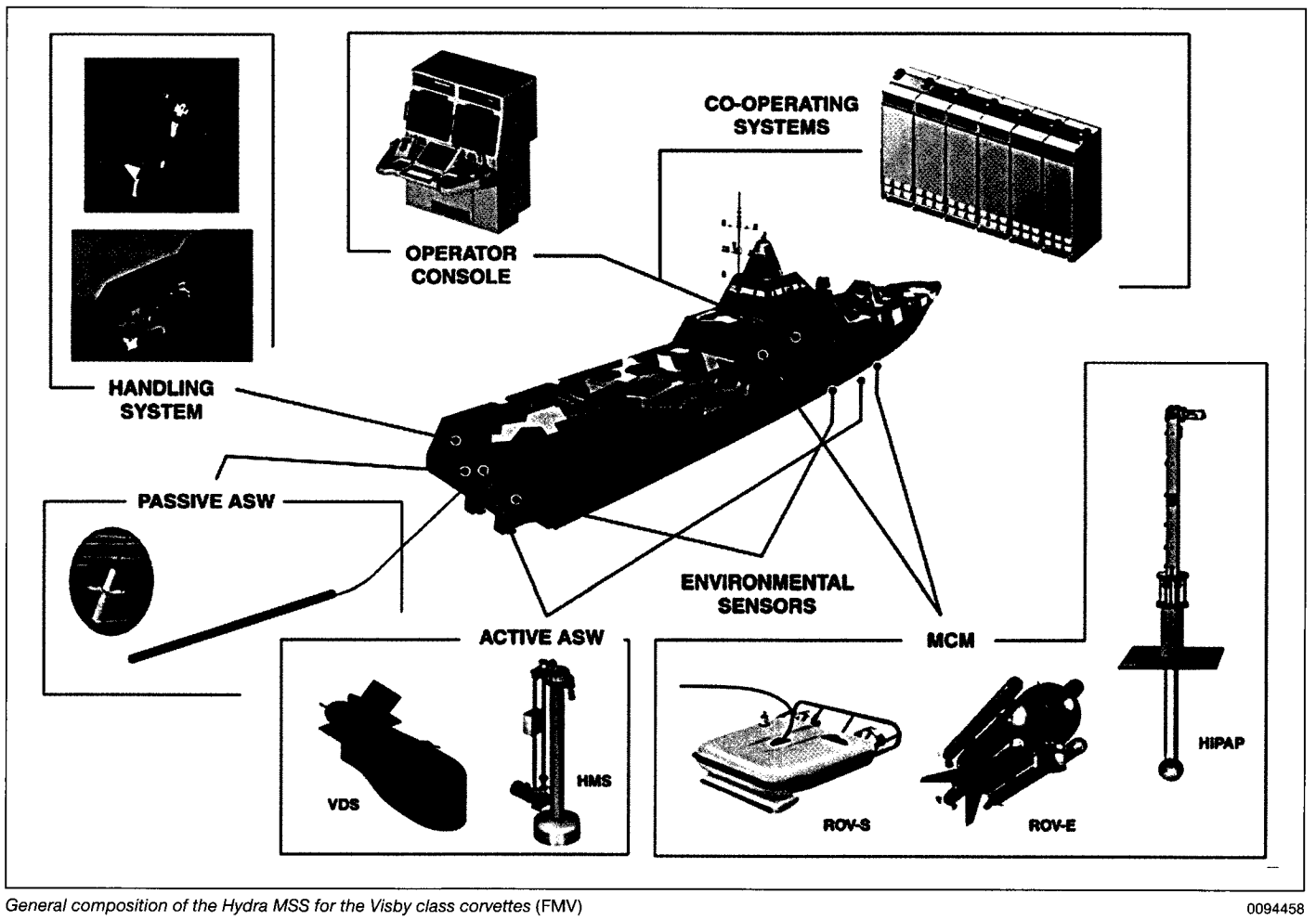
The fully integrated multisensor Hydra MSS comprises a passive towed array sonar, a dual-frequency passive/active VDS, a hull-mounted sonar (active HF primarily for mine avoidance) and sonars to control two ROVs and eight sonobuoys. The ROVs are a Double Eagle Mk III with detection and classification sonars, camera and conductivity, salinity and depth sensor and a Seafox ROV with identification camera and classification sonar for target identification and mine disposal.

Hydra MSS is integrated with the underwater element of the CETRIS C4II system allowing ASW or MCM personnel to manage, control and administer all underwater sensor operations either directly or indirectly through the Hydra suite.

The active/passive VDS is considered to be the primary sensor for long-range detection and localisation of both moving and stationary targets. The hull-mounted sonar provides a complementary capability, which while not as flexible as the VDS owing to its fixed depth, does provide classification against bottom targets in shallow waters where deployment of the VDS is impractical.

The passive towed array sonar is the primary sensor for operation in open waters where it is supported by up to eight sonobuoys. Together these sensors also provide a torpedo threat warning.

Hydra incorporates a self-noise monitoring element that provides information for the constant monitoring and control of self-generated noise. An advanced variant of the NECTA environmental tactical aid is also embedded in the Hydra MSS using



General composition of the Hydra MSS for the Visby class corvettes (FMV)

0094458

3-D colour displays. This provides facilities to calculate the optimal sensor configuration to maximise the detection capability of both ASW and MCM sensors within the prevailing underwater environment.

For MCM the hull-mounted sonar provides detection and classification, with the Double Eagle enabling a detailed search of the full water column. In search mode the Double Eagle is positioned well ahead of the ship ensuring that minimum detection range is maintained well outside the danger area of a mine. Once detection and classification have been achieved, the Seafox is then deployed for final identification and disposal of the target.

The system uses the latest technology including digital CD-ROM.

Operational status
On order to equip the first four Visby class corvettes with a follow on order for a further three sets for the fifth and sixth Visby and a shore based training set. With the cancellation of the sixth Visby the Swedish Navy is evaluating the options for the use of the sixth system. The towed array portion of the Hydra system is also on order for the Goteborg class corvettes.

Contractor
General Dynamics Canada, Maritime Systems, Ottawa, Ontario.

VERIFIED

Indal Technologies sonar handling equipment

Type
Sonar towed bodies, handling equipment and sonar domes.

Description
Indal Technologies Inc specialises in the provision of sonar towed bodies, handling equipment and sonar domes, primarily for underwater ASW and MCM applications.

For VDS, there is a range of systems that includes the hydrodynamic towed body housing the sonar transducer, an electromechanical towcable equipped with a low drag, rigid Flexnose fairing, a launch/recovery system for the towed body, and a tow winch which includes a no 'fleet-angle' level wind system and passive and active motion compensation systems. In addition, there is a mechanical device known as Sidewinder, which provides electrical and optical (multifibre) continuity for power and signal without the need for slip rings. A large inventory of VDS handling systems is available ranging from LFA (Low Frequency Active) sonar transmitters to mine identification high-frequency sonar.

The company has supplied the Second Acoustic System (SAS) handling system; a very large handling system used for deploying, towing and recovering acoustic systems from a US Navy T-AGOS 23 SURTASS ship.

The OK-410 (V) Handling and Stowage Group (H&SG) deploys, streams and recovers a tactical towed line array on the Canadian Navy's CANTASS programme.

The SUBTOW handling and storage group has been designed and produced for the ESISS (Experimental Submarine Integrated Sonar System) towed array handling system installed in a flooded compartment on a Canadian Navy Oberon class submarine.

Indal Technologies Inc designs and manufactures hull-mounted sonar domes, both for the Canadian SQS-505 and the Raytheon SQS-56/DE1160 sonar systems. The domes typically include the C-5 hull outfit which raises and lowers the sonar transducer out of the dome and into the ship's hull for repair or protection.

Operational status
VDS handling and towing systems: More than 35 systems in operational service with Brazil, Canada, Finland, India, Italy, Norway, Singapore and Sweden.

OK-410 (V) H&SG: Halifax class and Annapolis class.

SAS handling system — T-AGOS 23.

Sonar domes: various models in operational service with Canada, Greece, Morocco, Portugal, Saudi Arabia, Spain, Turkey and the US.

SUBTOW — In operation.

Nixie torpedo decoy handling system — In operational service with the Canadian Navy.

The latest contract is from BAE Systems for the supply of towed array handling systems for the Astute class submarines.

Contractor
Indal Technologies Inc, Mississauga, Ontario.

UPDATED

LFHUSS

Type
Acoustic sound source.

Description
The LFHUSS (Low Frequency High power Underwater Sound Source) system has been designed for the Agency for Defense Development (ADD), Republic of Korea. This is a calibrated high power, wide frequency sound source housed in a stable tow platform. The array of active sonar transducers provides acoustic output capabilities over a frequency range from 1 to 6 kHz at an SPL of 205 dB. The tow body also includes a suite of wet-end sensors comprising a monitor, hydrophone, location beacon, and depth, temperature, pitch and roll sensors. The system is controlled through an electro-mechanical cable by a PC-based MMI. The MMI controls all sonar functions including signal generation, display and recording of all sensor data.

Operational status
Acceptance testing was being conducted in the Republic of Korea in July 2003.

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.

VERIFIED

Model 15-750

Type
Variable depth sonar handling and towing system.

Description
The model 15-750 provides a launch, variable depth towing and recovery capability for an Indal Technologies towed body, weighing approximately 4,000 kg, fitted with a sonar transducer and environmental and heading sensor package.

The system comprises an electromechanical cable fitted with low drag Flexnose fairings, a hydraulically driven single-layer winch, a cable tension stabiliser/spooler assembly, an overboard handling assembly and a towed body. During launch and recovery of the towed body, the winch and overboard handling unit operations are automatically integrated.

The system is controlled by a single operator from a control station, and is suitable for either 'open deck' or 'between deck' installation.

The winch consists of a single, large, chain-driven drum mounted on a static shaft. The chain is driven from a sprocket mounted on the output shaft of a planetary gearbox. Input to the gearbox is from a fixed displacement motor powered through a multidisc, fail-safe brake. The starboard side of the drum is recessed to allow ready access to the Sidewinder mechanism mounted on the shaft inside the drum. This provides a continuous electrical connection between the towcable and the deck-mounted cabling to the sonar processing equipment.

The cable tension stabiliser consists of a sheave mounted at the end of a swinging arm which is supported by a hydropneumatic spring system. This spring system comprises a quantity of nitrogen gas at a precharged pressure, contained in an extendable bladder within an accumulator. By injecting hydraulic oil into the accumulator, the volume of the bladder is adjusted, thus changing the effective pressure and spring rate of the gas. Pressure exerted by the gas spring is coupled through a hydraulic circuit into two cylinders which position and restrain the swinging arm sheave, thus resisting tension in the cable.

The control console is designed for location adjacent to the winch from where the operator has a clear view of the ocean, enabling him to visually monitor as well as control deployment and recovery of the towed body.

Operational status
The Model 15-750 system is in service with the Indian and Italian navies.

Specifications
Tow speeds: Launch and recovery 8-14 kt
Operation 6-20 kt
Survival 30 kt
Cable length: 229 m
Sea state operation: Launch/recovery - 4

Contractor
Indal Technologies Inc, Mississauga, Ontario.

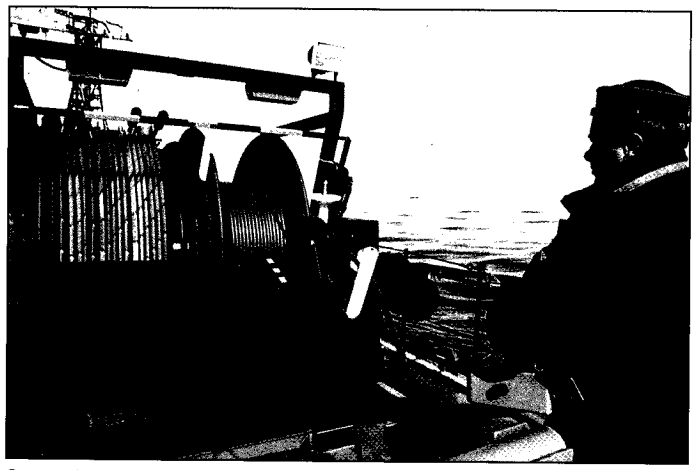
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Finland

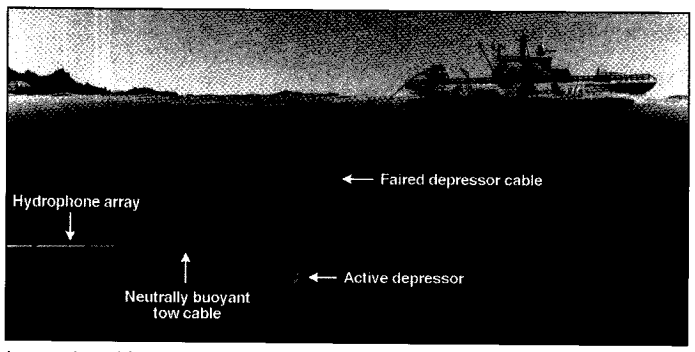
Sonac PTA

Type
Passive towed array system.

Description
The Sonac PTA passive towed array sonar has been optimised for use in archipelagos and other areas of shallow water where environmental conditions make submarine detection difficult. The simple, lightweight hardware is suitable for installation in small inshore patrol vessels.



Sonar winch of the Sonac PTA



Impression of Sonac PTA deployed from small coastal vessel

The sonar features 24 hydrophone channels feeding digital information to an onboard processor for display and threat analysis. Data transmission is through fibre optic cables mounted in the towcable. Automatic electronic cancellation of propeller and machinery noise allows a short towing cable (600 m) without loss of detection sensitivity. In addition, the array itself is only 78 m long and vibration isolation modules in the array and fairing of the towcable prevent interference due to turbulence. The configuration allows the maximum manoeuvrability during search operations in restricted waters. Nominal towing speed is 3 to 12 kt.

Array depth is regulated by an active depressor, which is controlled by the operator. As well as providing precise depth control in shallow waters, the depressor also allows the array to penetrate thermal layers.

The omnidirectional hydrophones each incorporate an integral electronic unit that filters, amplifies and digitises the sound signals before transmission to the onboard processor.

Onboard processing equipment is housed in a single cabinet that also incorporates the operator's control panel and two VDUs. Dedicated processors perform signal analysis on the sonar returns while separate general purpose computers handle the operator interface and navigation calculations, also providing BITE functions.

System features include:

- broadband surveillance
- narrowband surveillance
- combined broadband and narrowband
- target spectral analysis
- classification aid
- navigation with tracking information
- ray trace
- depressor history
- BITE
- transient alarm with audio replay
- beam audio output

In broadband mode, surveillance signals from all directions are presented together with direction and signal power indicated for each source covering the preceding 30 minutes. In narrowband mode the spectral estimates of each signal are displayed. The compact processor unit makes installation in a small patrol vessel simple. Optional peripheral equipment includes a no-break power supply, and also a data recorder to store incoming information from the array in unprocessed form for post-operation analysis.

Sonac PTA provides the operator with easy access to all essential information. The six main displays offer:

- broadband surveillance: sound intensity versus bearing with waterfall history
- narrowband surveillance: sound spectra versus bearing with waterfall history
- more detailed information of targets being tracked are analysed and displayed
- audio information from a selected direction is generated for headphones and/or for classification purposes
- alarm and replay of unexpected events, transients, and so on is performed
- navigation information with tracked target information is presented.

The system features a menu-based interface that guides the operator in all phases of the operation. Access to the system is via a trackerball and a few special keys. Operation of the peripherals, such as active depressor, raw data recorder, and so on are included in the user interface.



The operator console of the Sonac PTA

Signals are digitised in the towed array. In order to optimise the operation in different environments, the parameters of the array (amplification, 'own ship' noise cancellation) are remotely controlled from the processing unit within a large dynamic range. The data cannot be affected by ship-generated EMI disturbances because they are digitally transmitted to the processing unit via a fibre optic link. The signals are interpolated, filtered, beam-formed and analysed in the compact processing unit located in the presentation cabinet. The results are presented on two-colour video monitors by means of clear waterfall history displays. Open architecture is used both in software and hardware, which guarantees easy interfacing with other systems as well as with upgrading.

Operational status

In service with the Finnish Navy on the Hamina, Helsinki and Rauma classes since 1993. Being deployed by the Telkka class of the Finnish Frontier Guard as they enter service.

Specifications

Array length: 78 m
Towcable length: 600 m
Depressor cable length: 120 m
Operational speed: 3-12 kt
Operating depth: 100 m (max)

Contractor

Patria Finavitec Oy, Tampere.

VERIFIED

France

Albatros/TMS 4530

Type

Stand-alone torpedo alert system.

Description

The Albatros torpedo alert system is an advanced modular sonar system specially designed for long-range torpedo detection and classification.

It includes a permanent, panoramic and completely automatic torpedo surveillance function, which delivers pre-alert information. This warns the operator of a threat, allowing him to start and control the final classification phase performed in the direction given by the pre-alert.

The prealert function is achieved using a low-level panoramic beam selector, Sycat, and a medium-level classification stage, which sifts actual torpedo signals from false alarms.

The Sycat neural algorithm has been designed to provide a quick assessment of torpedo/non-torpedo classification, with special attention being paid to ships that radiate high-frequency spectral lines.

The basic system comprises:

- a short special towed array
- a small-size Angler-type towing and handling system
- a processing cabinet
- a display.

The main characteristics of the system are:

- large azimuth coverage
- permanent surveillance
- automatic pre-alert
- bearing warning without port/starboard ambiguity
- final classification and decision under operator control.

Albatros forms part of the new Sea Defender integrated anti-torpedo countermeasures system. Albatros is available in two configurations: a tri-element

sensor towed array design providing automatic resolution of left/right ambiguity without the need for ship manoeuvres; and a lower performance standard single element line array.

The stand-alone system includes a compact processing cabinet and operator's console ready for installation in the combat information centre.

Operational status
Development has been completed. The system is due to begin equipping the Australian Adelaide class frigates in 2003.

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED

Anaconda/TSM 2980 TACTAS

Type
Towed array tactical sonar.

Description
Anaconda is an export version of a tactical towed array sonar derived from the DSBV 61B, currently in service with the French Navy. It uses an advanced technology sonar receiver built around the Mustang processor. This latter equipment was developed by the former Thomson Sintra Activités Sous-Marines to increase the performance of all sonars, particularly in automatic detection, narrowband analysis, automatic tracking, adaptive beam-forming and self-noise cancellation.

Operational status
Eight systems are operational on the Royal Netherlands Navy Karel Doorman class frigates.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Angler

Type
Towing and handling systems.

Description
Angler towing systems constitute a family of equipments designed to be adapted to various types of linear towed arrays.

Main characteristics are:

- compact and lightweight design
- system operated by a single operator most of the time
- easy and fast onboard installation
- a slip ring allows permanent sonar operation during handling.

The Angler family comprises different models adapted to the various towed sonars (cables, arrays), one of them being the TSM Lamproie (TSM 2933) passive towed array sonar.

Operational status
Operational at sea. The system is believed to have been installed in the Pakistan Navy's Agosta 90B class submarines.

Contractor
Thales Underwater Systems, Sophia Antipolis.

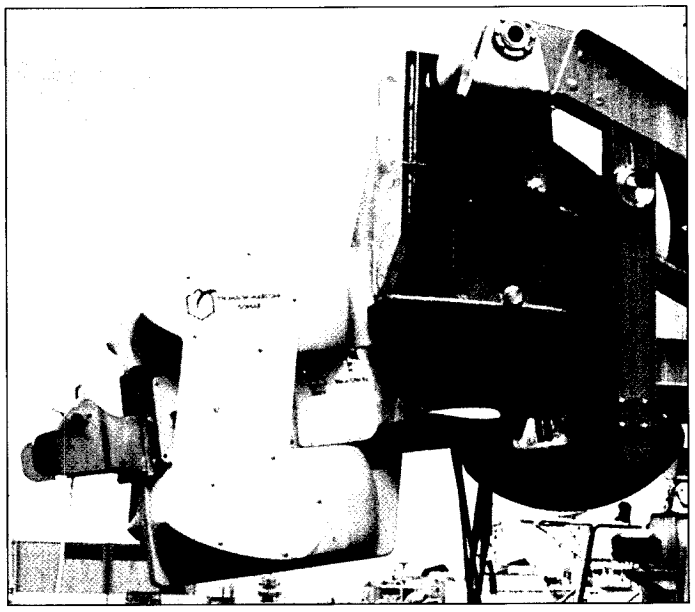
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Captas 20/TSM 2651/TSM 2652

Type
Combined Active/Passive Towed Array Sonar (CAPTAS).

Description
CAPTAS 20 is a low-frequency active/passive sonar for surface ships. Two configurations are available which feature different functions:

- Version V1: TSM 2651, ASW active sonar (frequency range 1.4 to 2.2 kHz) concurrently operating with a passive sonar for self-defence against torpedoes.
- Version V2: TSM 2652, same functions as version V1, plus a tactical very low-frequency passive towed array sonar (frequency range 10 to 2,000 Hz).



CAPTAS 20 towbody in frame ready for deployment (Thales Underwater Systems)
0067259

The CAPTAS 20 has been specially designed to cover deep water as well as shallow water applications. The handling system and cable length make it possible to deploy the arrays at depths well below most of the surface layers (30 to 200 m operating depths). The towed body shows a remarkable stability at any selected depth which enables its use in very shallow coastal waters (around 50 m).

The CAPTAS 20 V1 uses a special linear passive array for receiving echoes from active array transmissions and for detecting radiated noise of torpedoes. The use of tri-element hydrophone units permits target bearings to be measured in real time with no left-right ambiguity, from 30 to 150°, to port and starboard. This major capability has been sea-proven on the ATAS V1. This feature is critical under torpedo attack when detection and response time is of the utmost importance or when detecting at long range in the convergence zone, when the number of perceived echoes is often low and not compatible with a ship's manoeuvres.

CAPTAS V2 has a similar functionality to V1, but with the capability of detecting submarines passively with the lower frequency receive towed array which has greater gain at the lower frequencies.

The transmitting body houses wideband ceramic transducers in a free flooding ring configuration which provides a high source level for detection under low noise conditions, and a wide FM bandwidth for operation in conditions of strong reverberation. The unit operates in either radial or cavity mode, or both modes can operate simultaneously.

The winch is of new design and moves back on rails to lower the body into the water which leaves only the cable to be paid out.

The towing cable set comprises a hardened, faired-profile cable whose very low drag makes it possible for the transmit array to prove highly stable when towed at a great depth and a neutrally buoyant horizontal cable to position the receive linear array far behind the ship, which strongly reduces the influence of ship radiated noise. Precise towed body depth control is maintained with the tow cable, and enhanced with the wings on the towed body.

The twin ceramic ring version weighs 900 kg. In trials conducted near Spain in 1999, successful detection and tracking of a submarine with excellent left/right discrimination was achieved at ranges up to 18.75 n miles in moderate to difficult environmental conditions. A detection was also observed at 32 n miles under convergence zone conditions.

Operational status
Under development and a prototype has undergone sea trials. The V1 system has been sold to Saudi Arabia for the new, modified La Fayette class frigates. In mid-1999 the first production CAPTAS 20 carried out successful multistatic sonar sea trials under the Franco-Dutch co-operation agreement related to LF sonars. The V2 version has been ordered by Norway for the new Fridtjof Nansen class frigates of the Norwegian Navy (see entry Captas Mk 2).

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Captas Mk 2/UMS 4229/UMS 4249

Type
Combined active/passive towed array sonar (Captas).

Description
The Captas Mk 2 is the latest evolution of the Captas 20 LF active/passive sonar for surface ships.

As with the Captas 20, it can be proposed in either V1 or V2 versions.

Two configurations are proposed, depending on the towed body characteristics;

- UMS 4229 with a 'standard body' with two free flooded ring elements for transmissions (using the same body as the Captas 20)
- UMS 4249 with a 'high body' with four elements giving a higher sound level.

The receive array for active ASW and passive anti-torpedo function uses the 'triplets' technology with 128 triplets (versus 32 for the Captas 20).

The handling system has been upgraded to accept a fully faired cable giving better depth characteristics.

The signal processing provides HFM + WCW matched filters on all beams, with a special code to discriminate very slow moving targets.

Operational status
Under development, the Captas Mk 2 V1, UMS 4229 BV1 was sold in 2000 to the Royal Norwegian Navy to be fitted on board the five new Norwegian frigates being built by Bazan.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Diodon/TSM 2630

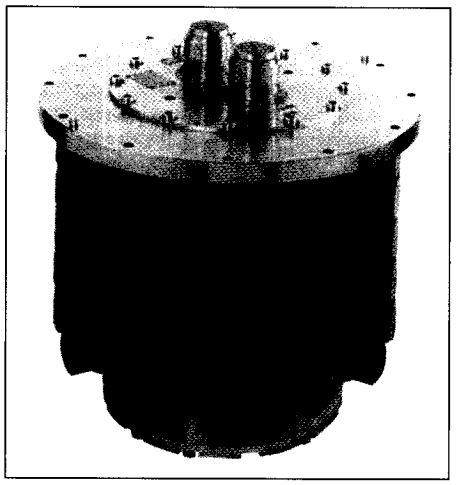
Type
Hull-mounted and variable depth sonar systems.

Description
Diodon is a panoramic high-frequency active sonar for small- and medium-sized surface ships. It performs signal and data processing, target classification, automatic detection and tracking, and man/machine interface.

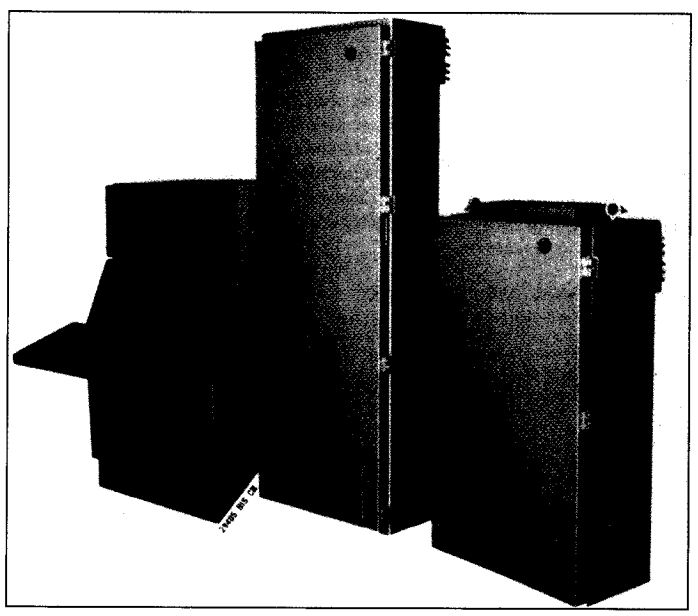
The sonar operates equally effectively in shallow and deep water. Control is exercised through a single operator console using a dual-screen high-resolution colour display. The array can be fitted within a fixed dome or supplied as a Variable Depth Sonar (VDS); in case of a combined system, the same electronics suite can operate both the hull-mounted and VDS arrays. Embedded facilities include passive listening, sound ray tracer, an acoustic propagation prediction for the day and a recording system that can be used for debriefing and training. The array comprises 24 staves producing 48 preformed beams. Transmissions are panoramic, sectorial in 15° increments or panoramic in stepped sectors.

Presentations are in large panoramic scope for search; magnified scope and Doppler scope for attack; digital readout of target bearing, range and speed; audio channel and test unit indicator.

In the VDS version, the Diodon is fitted with a Swan 2000 towing system. Diodon can be combined with other active or passive TSM sonars.



Diodon sonar transducer array
0007224



Diodon sonar system, showing (left to right) display console, receiver and power supply

Operational status
In service with a number of navies including: Argentina (Type A 69 frigates, 3 units), Ecuador (Esmeraldas class frigates, 6 units) India (Nilgiri class, two units), and Saudi Arabia (Madina class frigates, four units).

Specifications
Acoustic array: 24 identical staves; weight 450 kg
Frequency: 11, 12, or 13 kHz (selectable)
Transmitter: omnidirectional transmission in CW and FM modes
Receiver: 48 preformed beams; advanced processing with replica correlator in FM and spectrum analysis (FFT) in CW
Video processing: data processing in FM and CW modes: automatic detection and tracking; simultaneous multitrack extraction (up to 64); target analysis (apparent length, Doppler measurement). The sonar is easy to link to the 'own ship' combat system
Display: high-resolution flicker-free colour TV monitors
Total weight: 1,500 kg (additional 8 t for the winch and handling system in the VDS version)

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

DSBV 61B

Type
Surface ship towed array sonar.

Description
The DSBV 61B is a five-octave digital, very low frequency, passive towed array, sonar system consisting of a linear array, a towing cable which is also used for data transmission, a winch for handling and storage of array and cable, and the necessary signal processing and data extraction electronics. The latter is made up of five cabinets plus two display consoles associated with two totes. The design allows two selectable towing modes: critical angle towing or towing behind the DUBV 43C VDS body.

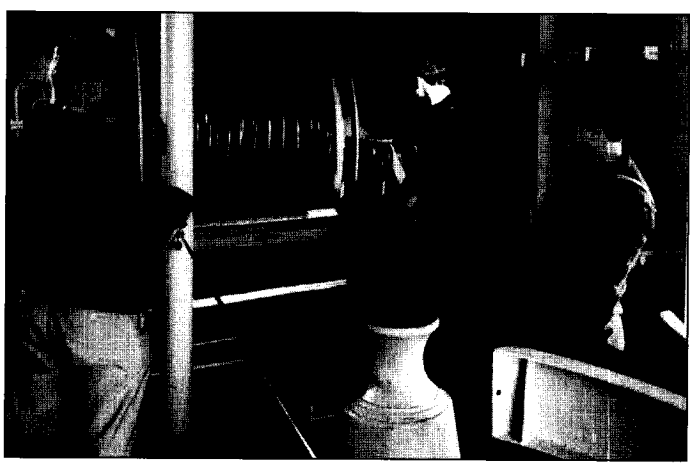
The display consoles feature three-colour display of target information and can display, on request, the various sonar memory pages. A built-in fault display allows a quick reconfiguration and/or rapid maintenance of the system.

Range is said to be in excess of 80 n miles.

Operational status
Operational on the F70 type ASW corvettes D644-646. An export derivative known as Anaconda is described briefly under a separate entry.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED



DSBV 61B linear towed array sonar (serial equipment) on board the Primauguet *F-70 type ASW destroyer*

DSBV 62C/TSM 2932 sonar

Type
Surface ship very low frequency passive towed array.

Description
This stand-alone sonar, which can be installed on board surface ships or submarines, is a VLF passive towed array sonar in operation in the French Navy.

The DSBV 62C uses the same analogue array as in the submarine version, plus an additional section for digitisation of signals and transmission via the heavy cable, which is used in a critical angle towing configuration.

The sonar incorporates both broadband and narrowband processing, with ADT, panoramic threat verniers and narrowband track fusion. Lofar and Demon are also available to the operator. The basic system has the capacity to process signals from various array architectures.

The array is towed on the end of a 3,000 m towcable behind the ship and operates at depths between 40 and 200 m at 27 kt.

Operational status
Delivered and at sea on Tourville class frigates and Indian frigate *Ganga.*

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

DUBA 25/TSM 2400

Type
Hull-mounted active panoramic sonar system.

Description
The DUBA 25 medium-frequency attack sonar fitted in the French Aviso class ships is an active sonar with a panoramic transducer array and assembly with sonar dome supplied by the French Navy. A hull-mounted sonar, the DUBA 25 provides all-round surveillance, acquisition and attack facilities for ASW operations. The power employed is sufficient for operating ranges of several kilometres. The transducer array consists of 36 staves arranged to form a cylinder 115 cm in diameter and provided with roll stabilisation. Frequency range is 8-10 kHz and the sonar is associated with the ASW rocket launcher on the Type A 69 frigates.

Each of the 36 beams is 10° wide and CW or FM pulses are 30 or 90 ms.

Operational status
No longer in production. Operational since 1975. Currently on board six Type A 69 frigates in the Turkish Navy and nine in the French Navy and the destroyer *Cassard* (DUBA 25A).

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

DUBV 23D/UMS 4110CL

Type
Surface ship medium-frequency active search sonar.

Description
The DUBV 23D is a bow-mounted, medium-frequency, panoramic sonar for anti-submarine operations. The 48-column transducer array is housed in a bulb at the fore part of the ship, the bulb being of streamlined design to reduce parasitic noises to permit listening at high speeds. The panoramic sonar is intended for both search and attack roles.

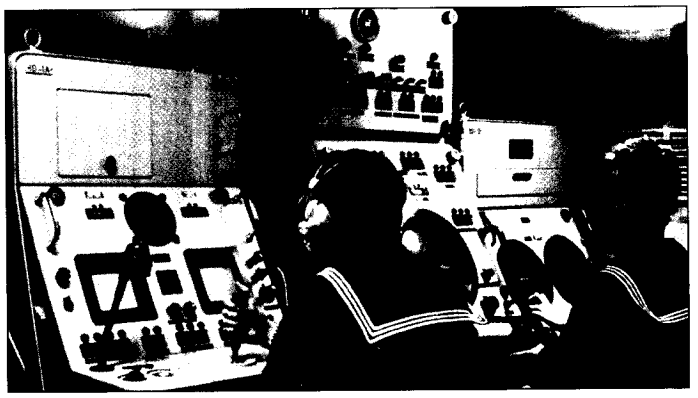
In addition to the transducer array, the equipment includes the transmitter/receiver unit, a computer section for the processing of data being fed to weapons, and control and display consoles at the anti-submarine attack station.

The DUBV 23D is of identical design to the towed sonar DUBV 43B/C and in French vessels the two sonars are used together for ASW.

Operating modes provide for: panoramic surveillance, sector surveillance, step surveillance, passive surveillance at sonar frequency, panoramic attack transmission, or searchlight' attack transmission. In addition to the system's own display devices, the DUBV 23D provides for target data outputs to other ships' systems and repeater PPIs.

The sonar makes use of Reliable Acoustic Path (RAP) propagation with detection ranges of 5.4 to 8 n miles.

Operational status
The DUBV 23D is in service in four 'Georges Leygues' (DD 640-643) and two 'Tourville class frigates, and in the *'Duquesne'* of the French Navy. The system is no longer in production, but systems in service are being upgraded through the SLASM programme (see SLASM entry) and the joint French-Italian Horizon Programme under the designation UMS 4110CL.



DUBV 23D sonar control console

Specifications
Transmitter
Transmission frequency: 4-5.5 kHz (medium frequencies)
Pulse duration: 4, 30, 150, 700 ms (>1,000 ms in the UMS 4110CL)
Power: 96 kW (2 × 48 kW)
Type: CW, FM (linear frequency modulation with non-coherent data processing at reception)
Scatter echo: with or without rejection
Doppler effect correction: on all 48 channels
Cadence: adjustable step by step from approximately 1,370-43,875 m
Receiver: panoramic, directional, passive listening in sonar band

Contractor
Thales Underwater Systems, Sophia Antipolis. ***UPDATED***

DUBV 43B/C

Type
Variable depth sonar system.

Description
The DUBV 43B/C medium-frequency (5 kHz) Variable Depth Sonar (VDS) comprises a streamlined towed body containing the sonar transducer array. The sonar is usually used in conjunction with the DUBV 23 sonar. It is equipped with stabilisers providing for control in roll, pitch and depth. The submerged weight of the fish is around 8 tonnes. The range of towing speeds is 4 to 30 kt, and detection ranges of up to 20 km are quoted. The VDS can be towed at depths between 10 and 200 m at speeds up to 24 kt (depths of 600 m in the C variant).

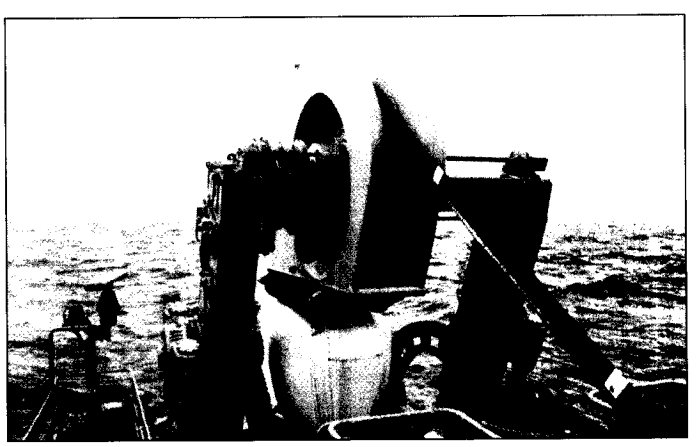
The transmitter has a peak power of 96 kW and transmits a beam 15° wide at a frequency of around 5 kHz, achieving ranges in the region of 20,000 m depending on environmental conditions. In exceptional conditions ranges of 30,000 m have been achieved.

Operational status
The DUBV 43B is in service in the *Duquesne* and 'Georges Leygues' (DD 640-642) class frigates. The DUBV 43C is in service with the remaining Georges Leygues class frigates of the French Navy. A copy of the sonar equips the Chinese Luda class destroyer.

Two updates have been added to the system:
(a) UTCS 1B which includes improvement of the signal processor
(b) a URDT torpedo alarm receiver.

Contractors
Thales Underwater Systems, Sophia Antipolis.
DCN, Paris.

UPDATED



DUBV 43C VDS towed transducer and towing gear aboard the French corvette Georges Leygues

Gudgeon/TSM 2362

Type
Lightweight panoramic active surveillance sonar.

Description
The Gudgeon TSM 2362 is a lightweight HF active panoramic sonar designed for use in shallow water conditions on small surface ships of 150 tonnes and above. The single-operator system performs surveillance, tracking, classification aid and ASW operations.

Sound ray tracing and maintenance test functions are integrated. The small acoustic unit can be mounted in a fixed or retractable dome, or can be carried in a towed fish.

The basic configuration comprises a dome, cylindrical acoustic array, power supply/transmitter cabinet, receiver cabinet, display console and, in the VDS version, a Swan 1000 type towing system.

The acoustic array, an adaptation of the HS12 dipping sonar array, comprises a cylinder consisting of 12 staves each of six transducers. The transmitter operates in CW or FM in omnidirectional modes around the 13 kHz frequency band.

The receiver produces 18 preformed beams with bearing stabilisation. It carries out coherent FM processing with pulse compression and CW spectral analysis. Post-processing includes normalisation, echo sorting, correlation in time and space, and automatic target location and tracking. It also features directive audio for echo classification. The sonar uses processing algorithms developed for ATAS and Spherion.

The console features a dual, multicolour, non-flicker high-definition TV monitor, data being presented on a PPI display with multiping or extraction video and a tactile touch-sensitive keyboard. The console also features a double zoom target analysis function measuring apparent length plus Doppler measurement. Automatic tracking on up to 64 targets is achieved with range scales of 1, 2, 4, 8, 12 and 16 km.

The sonar also features integrated sound ray tracing and prediction of detection range.

Onboard recording and training functions are also incorporated.

Hull-mounted and VDS versions of Gudgeon are easily connected and, depending on the associated circuitry, the two sonars can operate simultaneously or alternately.

Operational status
Six hull-mounted sonars have been sold to Singapore to equip the first six units of the Fearless class and one shore-based unit for training.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

INCA

Type
Interactive classification aid.

Description
The INCA (INteractive Classification Aid) is designed to enhance classification, which is the mandatory function of passive detection and the main task of intelligence gathering. INCA therefore can form a major element in the ASW scenario, as indeed does any classification aid, aboard any type of ASW platform (airborne, surface vessel, or submarines).

It gathers classification parameters after spectral and/or audio analysis. Spectral analysis is performed on current or stored signals and is immediately displayed. Spectrum analysis capabilities include Lofar, vernier, Demon, Ali, and spectrogram and features an ×8 speed-up in analysis. INCA performs audio analysis in signals using a pass-band filter, variable speed (×4, 2, 1, ½, ¼, ⅛) and normal/reverse, as well as transient analysis.

INCA selects possible sources for any contact by comparison with classification statistical data stored in the database. INCA then helps in building a confidence level for every classification hypothesis. These confidence levels are then sorted to give the likeliest classification hypothesis.

Operational status
System fully developed.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Salmon/TSM 2640

Type
Hull-mounted and variable depth sonar systems.

Description
Designed in the early 1990s. The Salmon sonar is a compact, medium-range, high-frequency active sonar designed for light patrol vessels conducting ASW operations mainly in shallow waters. It offers high-detection probability in severe noise environment and includes sophisticated signal and data processing, automatic detection and tracking functions and operator aids.

The basic version consists of an acoustic array of 24 staves housed in a streamlined towfish body, and producing 36 preformed beams, a towing winch, a transmitter and a receiver unit and an operator console equipped with a multicolour display. Embedded facilities include passive listening, sound ray tracer, integrated onboard simulator, and an acoustic propagation prediction for the day and a recording system.

FM and CW modes matched filter processing provides automatic detection and tracking and simultaneous multitrack extraction on up to 64 targets; target analysis is carried out using apparent length and Doppler measurement. The sonar is easy to link to the own ship combat system.

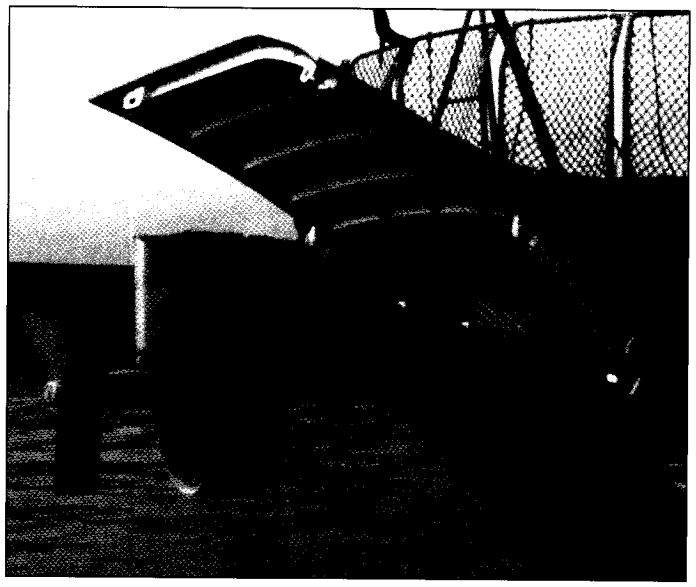
A hull-mounted version is also available.

Operational status
In production. Systems have been installed on the Stockholm class (two units), and three of the improved variant on the Goteborg class corvettes of the Royal Swedish Navy. Salmon systems have also been supplied to the Royal Danish Navy for fitting on board the Stanflex 2000 Thetis class fishery patrol vessels (four units), and the Stanflex 300 Flyvefisken class patrol vessels (four units).

Specifications
Acoustic array: 24 identical staves of 7 transducers; weight 260 kg
Frequency: 19 kHz (approx) (two frequencies)
Transmitter: omnidirectional transmission in CW or FM modes
Receiver: 36 preformed beams; advanced processing coherent in FM with pulse compression and spectrum analysis (FFT) in CW
Display: two high-resolution flicker-free colour TV monitors
Total weight: 7,630 kg

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED



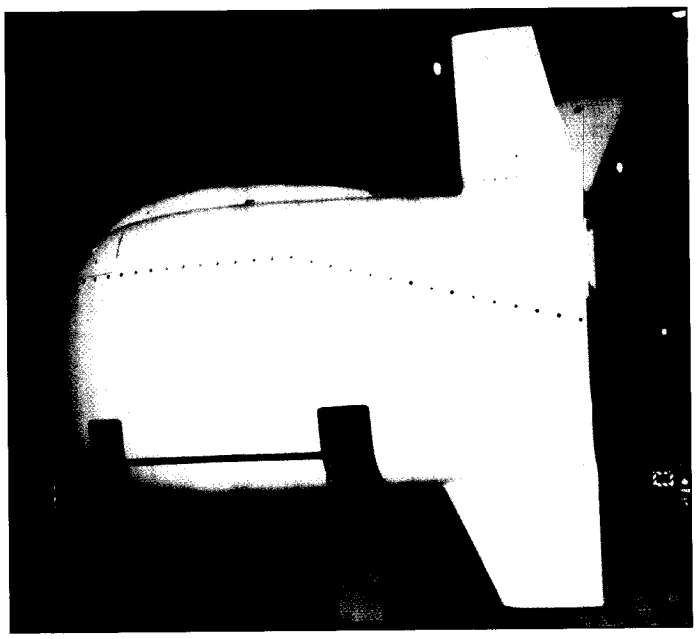
A Salmon VDS sonar fitted on the Danish frigate Thetis. *The illustration shows the vessel before having her stern modified to a transom configuration*

SLASM/TSM 2670

Type
High-performance integrated sonar system.

Description
SLASM (also referred to by the French Navy as ATBF) (Système de Lutte Anti-Sous Marine) is a high-performance integrated sonar system for large ASW surface ships (frigates or destroyers), comprising the following main subsystems or functions:

- a low-frequency, deep diving, active towed array sonar
- an active medium-frequency hull-mounted sonar
- an active medium-frequency variable depth sonar
- a passive very low-frequency towed array sonar
- a torpedo alert system, using the VDS or towed array



Towed body for the SLASM system (Courtesy DCN Lorient) 0024702

- sonobuoy processing.

The system consists of:

- a large, deep diving, towed fish housing two 1 kHz low-frequency transmitter arrays, and the medium-frequency transmitter/receiver array
- a long linear array, to be towed clipped on to the towfish, or towed independently
- a hull-mounted medium-frequency transmitter/receiver array
- a large towing and handling system, a by-product of the existing DUBV 43 system.

Behind the towfish is towed the LF receiver and a torpedo warning receiver. The transducers of the DUBV 23 have been retained in the towfish and are mounted on two vertical panels covering 120 to 150° on either side. The towfish weighs approximately 12 tonnes.

Signal and data processing are performed through three identical cabinets, each being able to process any function of the system; two more cabinets house the recording and simulator system, the post-processing and the system controller. Detection is performed out to the first and second convergence zones (70 n miles).

The man/machine interface consists of nine multifunction consoles and two dedicated monitors.

The array is towed out to 600 m astern of the vessel down to depths of 200 m. A very low-frequency tactical passive array (Aq 1) can be towed 200 m astern of the fish, both arrays forming part of the new SLASM which can operate in bistatic mode.

Claimed performances are a towing speed slightly in excess of 15 kt and a range in excess of 30 km.

Operational status

The prototype was trialled on the frigate *Cdt Rivière* in 1998.

The SLASM has been ordered by the French Navy to upgrade the F 67 ASW frigates. The first operational unit entered service aboard the French frigate *Tourville* in mid-1995 and *De Grasse* in 1996. The sonar has undergone trials in the Mediterranean and Atlantic.

A second version is foreseen, probably through a collaborative venture with some other European navies; this second batch is to be installed in the French Navy aboard the F 70 ASW frigates, by the end of the century.

Contractor

Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Spherion B/TSM 2633

Type

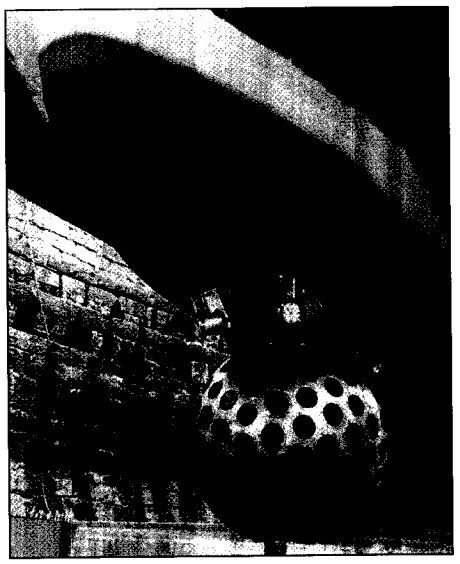
Bow-mounted sonar systems.

Description

Developed in 1982, Spherion is a long-range, medium-frequency active sonar for ASW surface combatants. It comprises a spherical bow-mounted array with an electronic processing system that allows for real-time computation in transmission and reception modes; three-dimensional stabilisation to compensate for pitch, roll and yaw in the parent vessel; and a beam-tilting capability to counter adverse sound velocity profiles and strong reverberation. Spherion also includes a torpedo alert function.

The sonar can be combined with the medium-frequency Diodon VDS, sharing the same electronic cabinets and console.

Data processing in FM and CW modes provides automatic detection and tracking and simultaneous multitrack extraction on up to 64 targets; target analysis is carried out using apparent length and Doppler measurement. The sonar is easy to link to the 'own ship' combat system.



Bow-mounted array of Spherion sonar

Operational status

In production and operational at sea. Spherion has been chosen by the Royal Norwegian Navy to update the Oslo class frigates. It also equips the Australian and New Zealand navies Anzac class frigates. Two other navies (Malaysia for the Lekiu class and Taiwan for the 'La Fayette' type frigates) have also selected the Spherion system. A total of 25 systems has been ordered. In June 1999 it was announced that a new version of Spherion, referred to as TMS 4131S or MRS 2000, had been ordered as part of the upgrade programme for the Australian Adelaide class frigates. The TMS 4131S, which is developed from the technology of Spherion B, will replace existing hull sonars on the frigates. In July 2000, the TMS 4131S was selected to equip the five new Norwegian frigates ordered from Bazan.

Specifications

Acoustic array: Spherical with 160 individual transducers
Frequency: 6-8 kHz (four frequencies)
Transmitter: omnidirectional and sectoral transmissions in CW and FM modes, various modes including TRDT
Beamwidth: 10°
Receiver: 36 preformed beams stabilised in azimuth and elevation; advanced processing with replica correlator in FM and spectrum analysis (FFT) in CW
Display: high-resolution, flicker-free colour TV monitors
Total weight: 4,000 kg

Contractor

Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Swan

Type

Towing and handling systems.

Description

Swan towing and handling systems constitute a family of equipments adapted to various sizes of VDS. Swan systems include:

(a) towed bodies, adapted to sonar array sizes;btowed faired cables;cwinch assemblies (winches, poles, hydraulic power units);dwinch operator consoles.

Main characteristics of the Swan family are:

(a) active stabilisation of the towing system, which compensates for the ship's stern movements. In conjunction with a highly stable towed body, it enables the VDS to operate in rough seas;
(b) high survival towing speed;
(c) safe and easy operations, with secured launching and recovery sequences (only one man is required for operations);dcompact size.

To date, the Swan family consists of three models: Swan 200, Swan 1000 and Swan 2000, respectively adapted to Gudgeon, Salmon and Diodon sonars. Derivatives are possible for other sonar types.

Three versions have been ordered or delivered to date, in order to meet 'own ship' characteristics:

(a) a turntable version, to be installed upon the deck;
(b) a sliding or railed version, to be installed below the helicopter deck;
(c) a containerised version.

Operational status

Operational at sea.

Contractor

Thales Underwater Systems, Sophia Antipolis. ***VERIFIED***

Germany

ASA 92 series

Type
Active towed array sonar system.

Description
The ASA 92 LFASS (Low Frequency Active Sonar System) is a compact, lightweight, low-frequency system intended to support anti-submarine operations and surface ship surveillance in shallow water and convergence zone operations.

Among the main features of the system are:

- a long-range detection capability using low-frequency transmission (the pilot system is understood to have achieved detection ranges at around 45 km)
- an ability to operate in thermal layers at various depths by employing submersible antennas for transmitting and receiving
- the detection of quiet submarines using active transmission
- the ability to use the passive mode simultaneously with the active mode for the detection of noisy targets such as torpedoes, surface ships and noisy submarines
- shallow and deep water operation using an optimised array and handling system configuration.

The ASA 92 LFASS can be operated fully in parallel, in both active and passive mode.

In active mode the sonar operates in a low-frequency range with omnidirectional transmission including instantaneous right/left discrimination achieved through the twin line receiving array arrangement. The active array transmits at around 2 kHz with an output power in excess of 200 dB. The passive receive array covers the 50 Hz to 2.5 kHz frequencies. Both CW and FM pulses are available for the detection and classification of fast-moving targets with high Doppler, as well as slow-moving and stationary targets with low or zero Doppler.

Targets are displayed in true motion, multi-ping history, ship centre PPI display and simultaneously in an echogram, that is a rectangular bearing/range display with right, left or right and left side presentation. Also available are envelope curve, bearing/time and frequency/time (passive) displays. Additional display modes are provided for classification. The system features a detection range prediction function.

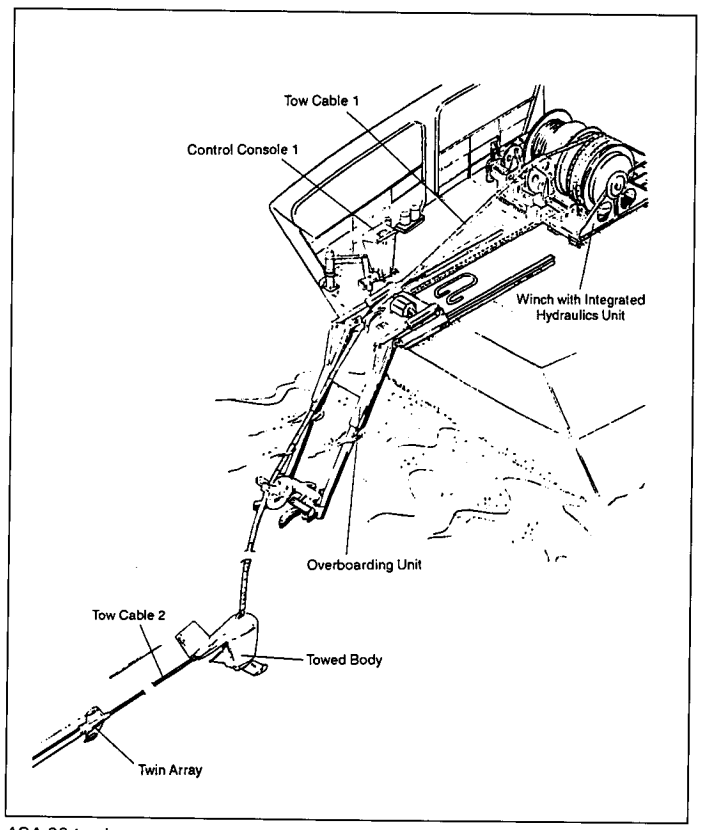
The passive mode allows full panoramic surveillance to be carried out. Broadband and narrowband processing can be performed in a frequency range typical for towed array sonars. Displays include bearing/time records and — for target related noise analysis (Demon, Lofar) — frequency/time records.

A torpedo warning function is included.

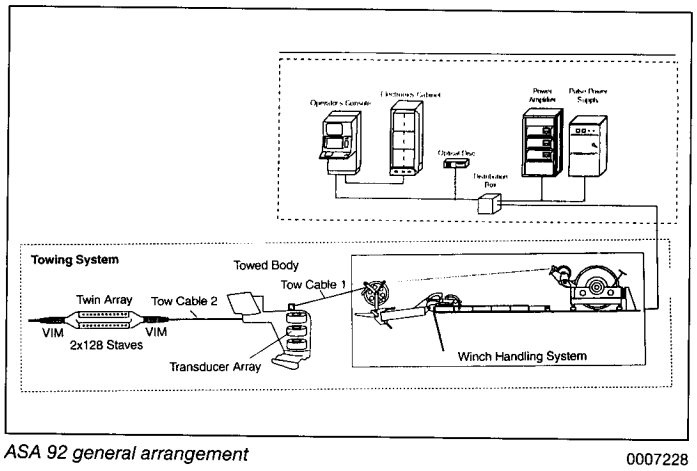
Targets detected in active or passive mode can be assigned to automatic target trackers.

Other system features include an audio channel, recording/replay of sonar data and sonar performance prediction.

The open architecture system uses powerful signal processors and a LAN-interfaced multifunction operator's console. This is based on workstation technology and proven industrial standard software for display in a Windows-type environment. The COTS-based technology results in a minimum number of assemblies and reduces the number of PC boards, decreasing the number of electronics cabinets, spares and so on.



ASA 92 towing arrangement 0007229



ASA 92 general arrangement 0007228

The body can be towed at depths between 20 and 350 m.

The ASA 92 LFASS towing system is a compact design of approximately 10 tonnes total weight and is designed to be mounted below a helicopter flight deck, as well as on the deck aft. To facilitate paying out the receive array and cable, the tail of the towed body separates. Once the receive array is deployed the tail is bolted back on to the main body. The ASA 92 LFASS system can be integrated with any ASO 90 type of sonar.

Operational status
The LFASS system underwent sea trials off Norway between September 1996 and February 1997 and in Chile in July 1998 and again off Norway in November 1998. The system has successfully demonstrated its capability to carry out convergence zone detection in Pacific waters where the first convergence zone is approximately 31 n miles. The German Navy intends to introduce the towed array sonar into the four Brandenburg class frigates around 2005.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

ASO 90 series

Type
Hull-mounted and variable depth sonar systems.

Development
The ASO 90 series (comprising DSQS-23 and DSQS-24) has been developed from experience with the DSQS-21 systems which were built in various versions.

Description
The ASO 90 systems feature electronically stabilised cylindrical transmit and receive arrays with a large number of transducers. Arrays are either hull-mounted or variable depth types. Variable depth type sonars, either in a combination with hull-mounted or as stand-alone systems, may be used in the event of adverse sound propagation conditions.

Advanced detection techniques for parallel, active and passive mode operation over 360° azimuth combined with spatial and temporal signal processing using the latest technology, enable the detection of submarine echoes even in difficult waters. The usual techniques of Doppler filter bank (continuous wave) and pulse compression (frequency modulation) are supplemented by special pre- and post-processing of the signal data for full-colour presentation on a multifunction operator's console which incorporates a window display surface and open system architecture, typical for all ASO 90 systems. Incorporating automatic fault detection and location functions, complete stand-alone or integrated assemblies can be configured for interface to other ships' systems including onboard or ship-based simulators, as well as recording/replay units.

The ASO 90 is designed for computer-aided detection, localisation and classification over an entire 360° azimuth. The modular design of the systems enables them to provide, as required, underwater telephone; automatic target tracking; classification; ray trace; intercept; torpedo warning; mine avoidance; vertical stabilisation; simulation; interface to own ship's fire-control system; interface to ACTAS, TAS or VDS systems. ASO 90 can be extended to a fully integrated ASW system.

Operational status
Current range of sonars in service with the German Navy as DSQS-23BZ on four Brandenburg class frigates and on order for three South Korean KDX-2 destroyers. Four DSQS 24C systems have been ordered for the Netherlands De Zeven Provinciën frigates. Three of these frigates are in service and one is building. A system is also installed on the Bangladesh frigate Bangabandhu, a modified Ulsan class frigate.

Specifications

Sonar system	HMS array	VDS array	Frequency	Recommended ship size
ASO 95	2.5 m	1.2 m	Low	Destroyers, frigates
ASO 94	1.0/1.2 m	1.0/0.6 m	Medium	Frigates, corvettes
ASO 93	0.6 m	0.6 m	Medium	Corvettes, off-shore patrol vessels
ASO 94 C	1.0 m	-	Medium	Off-shore
ASO 93 C	0.6 m	-	Medium	Patrol vessels

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

DSQS-21 (AS0 83-86) series

Type
Hull-mounted and variable depth sonar systems.

Description
The DSQS-21 series sonars (also known as the AS0 83 to 86 series) are designed for operation in surface ships as part of an anti-submarine weapon system. For operations against submarines below the thermal layer, the sonar can be supplemented with a towing system providing a Variable Depth Sonar (VDS) capability.

Computer-aided detection techniques are used for classification and tracking and the information is presented on colour CRT displays to permit Doppler coding and the discrimination of data on the integrated displays. A 'Z' in the designation indicates variants equipped with electronic stabilisation to minimise the effects of ship's motion.

The VDS is designed to alternate with the hull-mounted sonar, and the displays of the two sonars are integrated. Fitted with automatic depth control and heave compensation for stability of the 'towfish', the VDS can be handled automatically or manually.

Operational status
In service but no longer in production. Installed on Argentine Almirante Brown class destroyers (four ships - DSQS-21BZ) and Espora class frigates (five ships - ASO 4/AQS-1), Brazilian Inhauma class corvettes (four ships - DSQS-21C), German Bremen class frigates (eight ships - DSQS-21BZ), Colombian Almirante Padilla class frigates (four ships - ASO 4-2), Malaysian Kasturi class (two ships - DSQS-21C) and Laksamana class corvettes (four ships - ASO 84-41), South Korean Okpo class (KDX-1) destroyers (three ships - DSQS-21BZ), Thai Tapi class frigates (two ships - DSQS-21C) and Rattanakosin (two ships - DSQS-21C) and Khamronsin class corvettes (three ships - DSQS-21C). Three systems designated DSQS-21B will be installed on the Sachsen class destroyers of the German Navy.

Specifications

Sonar		Diameter of transducer arrays		No of preformed beams	
		HMS	VDS	HMS	VDS
DSQS-21	**B/BZ**	1.8 m		64	
	BZ/VDS	1.8 m	1 m	64	32
DSQS-21	**C/CZ**	1 m		32	
	CZ/VDS	1 m	0.6 m	32	32

Contractor
ATLAS Elektronik GmbH, Bremen.

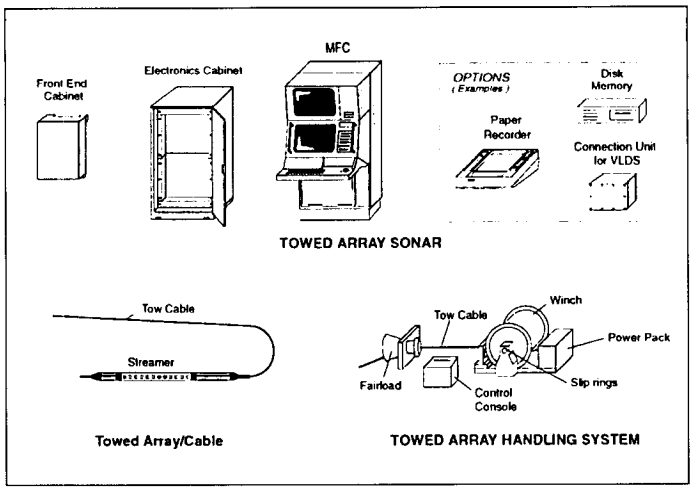
UPDATED

TAS 90 series

Type
Passive towed array system.

Description
The TAS 90 series is designed for installation on surface ships and operates down to very low frequencies.

The sonar uses the latest spatial and temporal signal processing techniques and can detect weak signals from submarines, torpedoes and surface ships even in difficult acoustic conditions. Data extraction and presentation is on full-colour, raster display and provides a permanent overview of the tactical situation. Detailed analysis of detected targets is carried out using Lofar, Demon and SPECTRUM techniques. Detection, tracking and analysis operations by the operator are facilitated by special features such as surveillance channels, independent broadband/narrowband facilities, frequency/time records with long time history, and magnifier and transient detection. The TAS 90 series is fully compatible with the ASO 90 active sonars either as a stand-alone system or an integrated version.



Passive TAS system arrangement 0007230

Various combinations in lengths of cable and streamer stored on an easy to operate winch are provided. The streamer has a long acoustic aperture, with a large number of preformed beams.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

Vanguard

Type
Multipurpose sonar.

Description
More than 70 years of experience in sonar system development has led to an innovation that will increase the safety of surface vessel forces in war and peacetime, even under bad conditions.

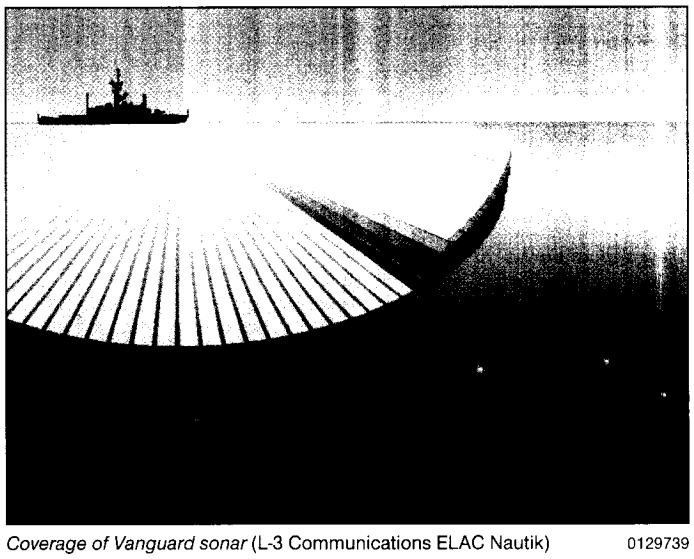
The multipurpose sonar system Vanguard (NDS 3070) is a versatile dual frequency active and broadband sonar system conceived for use on surface vessels to assist navigation (integrating with log, compass, sound velocity, roll and pitch and a printer) and to provide detection of dangerous objects supplying collision avoidance, obstacle avoidance, mine avoidance and torpedo alarm.

It is designed primarily to detect mines, but can also be used to detect other moving or stationary underwater objects.

The system can be used as a navigation sonar in narrow or dangerous waters. In addition it can complement the sensors on board anchoring surface vessels with regard to surveillance and protection against divers.

Furthermore, a passive mode is also available to detect and receive sonar signals and underwater noise over a wide frequency range, providing surveillance for self-protection and pinger location. The long range LF mode is combined with a high-resolution HF mode with 2-D LF active sonar in sector and omni mode and 3-D HF forward looking sonar with 90° sector.

Specifications
Frequencies:
active - 30 kHz (LF) and 70 kHz (HF)
passive - 8 to 40 kHz
Measurement ranges: 100, 500, 1,000, 2,000 and 4,000 m



Coverage of Vanguard sonar (L-3 Communications ELAC Nautik) 0129739

Detection ranges (typical):
mines – 2,000 m at 30 kHz; 880 m at 70 kHz;
obstacles – 3,300 m at 30 kHz, 1,200 m at 70 kHz;
small submarines – 4,000 m at 30 kHz, 1,450 m at 70 kHz
Bearing accuracy: LF <2°, HF <1°

Contractor
L-3 Communications ELAC Nautik GmbH, Kiel.

UPDATED

International

DMSS2000 LF

Type
Hull-mounted active and passive sonar system.

Description
The DMSS2000 LF is a kit designed for the upgrading of the DE1160 LF sonar as specified by the Italian Navy.

The system uses the same active transducers and transmitters of the DE1160 LF sonar and incorporates new open architecture processing and display system using colour display processing.

The system includes automatic computer-aided detection and tracking, multiple simultaneous receivers for enhanced shallow water performance, a small object-avoidance detection function, and colour displays. The system also integrates a torpedo detection function.

Geographic stabilised PPI displays and B-scan displays are used for detection and enhanced A-scan and range-crossrange windows are used as classification aids.

A rapid replay feature is provided to allow the operator to evaluate target motion and discriminate against false alarms. The system has the ability to replay up to 20 pings from memory for classification analysis.

The design of the system is implemented using COTS technology.

The digital processor unit is composed of a number of separate dedicated processors connected with the redundant system-wide pair of Ethernet buses.

Each processor within the digital processor unit contains a multipurpose module set in a VME baseplate.

Modules are designed in the 6U Eurocard format and are based on industry standards – many are available as third party off-the-shelf modules. All software is developed to DoD-STD-2167A requirements as standardised development methodology.

Operational status
Developed to Italian Navy requirement for installation in Italian Navy ships.

Contractors
Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy.
Raytheon, Portsmouth, Rhode Island, USA.

VERIFIED

MFS-7000

Type
Multi function self-defence sonar.

Development
The MFS-7000 is being developed to equip the new Type 45 'Daring' class destroyers of the Royal Navy. It is intended that the bow-mounted medium-frequency sonar system will provide a self-defence capability against submarine, torpedo and mine (in-volume) threats.

The sonar will be a development of the EDO Model 997 series hull-mounted sonar that has been sold to the Brazilian Navy. The bow dome will be designed and manufactured by W & J Tod of Dorset.

Operational status
Following submission of tenders for the project on 21 September 2001, Ultra Electronics teamed with EDO sonar and combat systems division was awarded a contract in January 2002 for the development of the system to equip the Royal Navy's new Type 45 Daring class destroyers. The contract provides for the supply of six ship sets of equipment, with delivery of the first system planned for 2004 and the final delivery in 2007.

Contractors
Ultra Electronics, Ocean Systems, Weymouth, Dorset.
EDO Combat Systems Division, Chesapeake, Virginia.

UPDATED

Israel

CORIS-TAS

Type
Passive towed array sonar for surface vessels.

Description
The CORIS-TAS LF, critical angle towed array sonar is based on a towed array fitted with wide-aperture hydrophones receiving LF acoustic signals radiated from surface vessels and submarines. Three main functions are performed: detection, tracking and classification.

It provides full azimuth coverage and performance capability over the 10 to 1,600 Hz frequency band, divided into four sub-bands for maximum array efficiency, with no degradation in the lower sub-bands. Broadband detection is carried out with automatic normalisation and jammer rejection, and narrowband detection with 0.3 kHz frequency resolution in the lower sub-band. Over-the-horizon detection is achieved by combining LF detection with advanced signal processing. Broadband, narrowband and Demon tracking are provided and accurate classification is achieved through the relevant spectral displays.

The system is managed from an operating console equipped with two 19 in monitors – a search monitor and a tracking and classification monitor.

Operational status
Available for fitting to the Israeli Navy Eilat class corvettes.

Contractor
Rafael, Armament Development Authority, Haifa.

VERIFIED

Italy

SNA-2000

Type
Mine avoidance and navigation sonar system.

Description
The SNA-2000 is a bow-mounted lightweight active sonar designed to provide safe navigation capability by detecting natural obstacles and small objects such as mines, even in shallow water with high reverberation. The sonar provides a maximum sector coverage of 90° (horizontal) by 40° (vertical), but the operator can select a reduced vertical coverage sector. The elevation coverage is obtained by electronically stabilised beams that allow the system to estimate the obstacle's depth. Furthermore the system includes a torpedo detection capability forward of the ship to complete the azimuth sector provided by a passive towed array. The SNA-2000 operates in FM mode for mine detection and CW mode for torpedo detection. The system consists of three main units:

- Transducer array
- Transmitting/receiving unit
- Console

The transducer is a planar array installed in the bow of large and medium ships or in the hull of small ships. The transmitting/receiving unit and the console are largely based on COTS technology. The console is a very compact unit with a 20 in LCD colour display suitable for the bridge.

Advanced signal processing is used to improve detection capability.

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

VERIFIED

Japan

Introduction

Most early Japanese ASW ships were fitted with various types of US sonar systems. Based on these US sonars, the Japanese have developed a series of indigenous hull-mounted sonars. The latest sonars use state-of-the-art digital processing and display technology developed in Japan. Current developments in surface ship sonars are related to passive, low frequency, towed array sonars.

VERIFIED

OQR-1

Type
Passive towed array sonar.

Description
The OQR-1 passive towed array sonar (TACTASS) operates at a very low frequency. This sonar is thought to be a Japanese version of the US SQR-18A.

Operational status
The OQR-1 equips the nine 'Murasame', and eight 'Asagiri' class destroyers, and has been retrofitted to some of the 11 'Hatsuyuki' class.

Contractor
NEC Corporation, Tokyo.

UPDATED

OQR-2

Type
Passive towed array sonar.

Description
The OQR-2 passive towed array sonar (TACTASS) operates at a very low frequency and is considered to be equivalent in capability to the US SQR-19A. When combined with the OQS-102 hull-mounted sonar, the combined suite has the capability of the US SQQ-89 system.

Operational status
The OQR-2 equips the Kongou, Takanami and Murasame class destroyers and will equip the new 7,000 ton guided missile destroyers that are planned.

Contractor
Oki Corporation, Tokyo.

VERIFIED

OQS-3

Type
Hull-mounted sonar.

Description
The OQS-3 is a Japanese licence-built version of the US SQS-23 sonar. The bow or hull mounted, low frequency, active search and attack sonar uses bottom bounce detection.

Operational status
The OQS-3/3A equips the 'Haruna' (2 units), 'Yamagumo' (OQS-3A) (1 unit), 'Takatsuki' (2 units) and 'Tachikaze' (OQS-3A) (1 unit) class destroyers.

Contractors
NEC Corporation, Tokyo (OQS-3).
Hitachi, Tokyo (OQS-3A).

UPDATED

OQS-4

Type
Hull-mounted sonar.

Description
The OQS-4 Mod 1 is a low frequency, bow-mounted, active search and attack sonar. The indigenously designed OQS-4 solid-state system is an improved OQS-3 with enhanced signal processing and electronics. The OQS-4A Mod 2 is a medium frequency sonar.

Operational status
The OQS-4 Mod 1 equips the Hatakaze (2 units) and Tachikaze (2 units) class destroyers and the Ishikari class (2 units) frigates and the 4A Mod 2 the Asagiri (8 units) and Hatsuyuki class (11 units) destroyers and the Shimayuki training ship.

Contractors
NEC Corporation, Tokyo. (OQS-4)
Mitsubishi, Tokyo. (OQS-4A)

UPDATED

OQS-5

Type
Hull-mounted sonar.

Description
The hull-mounted active search and attack OQS-5 is a low frequency sonar.

Operation status
The OQS-5 equips the new 'Takanami' (4 units) and 'Murasame' class (9 units) destroyers.

Contractor
NEC Corporation, Tokyo.

UPDATED

OQS-8

Type
Hull-mounted sonar.

Description
The active search and attack OQS-8 sonar is a hull-mounted medium frequency search and attack sonar system that is derived from the US Raytheon SQS-56 and manufactured under licence in Japan.

Operational status
The OQS-8 equips the six Abukuma class frigates.

Contractor
Hitachi Corporation, Tokyo.

UPDATED

OQS-101

Type
Hull-mounted sonar.

Description
The indigenously designed OQS-101 is a low-frequency sonar equivalent to the US SQS-53 system. The sonar is mounted in a bow dome.

Operational status
The OQS-101 equips the 'Shirane' class (2 units) destroyers.

Contractor
NEC Corporation, Tokyo.

UPDATED

OQS-102

Type
Hull-mounted sonar.

Description
The indigenously designed OQS-102 bow-mounted active search and attack sonar is a low frequency system equivalent to the US SQS-53C sonar.

Operational status
The OQS-102 equips the four Kongo class AEGIS destroyers, and is on order for the improved Kongo class.

Contractor
NEC Corporation, Tokyo.

UPDATED

Netherlands

PHS-32 sonar

Type
Hull-mounted search and attack sonar system.

Description
The PHS-32 is a medium-range high-performance search and attack sonar in which the newest technological developments for signal processing and operation are employed and aided by the use of a general purpose computer. The computer yields a compact, lightweight sonar for corvettes from 200 tonnes up to frigate size ships.

The signal processing facilities provided include fast Fourier transformation processing of all preformed beam receiving channels. All data are presented on a single TV-type display, while operation has been much simplified by the use of light pen control. Automatic tracking of up to four targets is provided. These features, combined with a high accuracy, make this sonar very useful in an attack.

A circular transducer permits all-round coverage in various modes of transmission such as: Omni, TRDT, MCC (wide vertical beam), LISTEN (passive with time/bearing recorder presentation). An audio beam is also available. The system can be delivered in a fixed, retractable or VDS-dome outfit.

The features of the PHS-32 include: single-operator control; display data processing for continuous presentation and memory mode (ping history); four-target automatic tracking; built-in energy storage for lower peak power demands on ships' mains; integrated online and offline test systems.

Automatic co-ordination of transmitting pulse and vertical beamwidth in rough weather reduces the effect of roll and pitch.

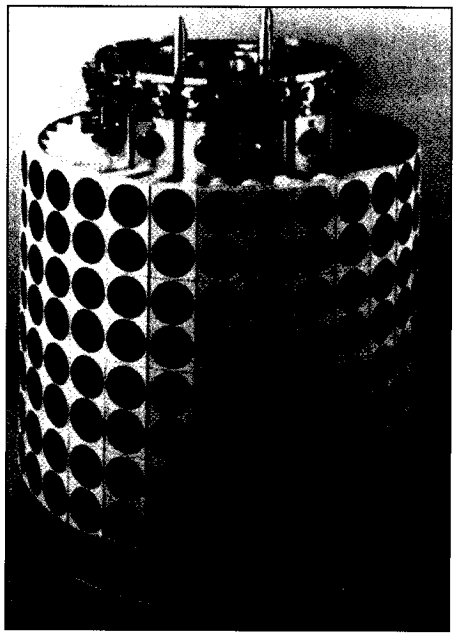
Operational status
No longer in production.

In operational service on board *Fatahillah* (3 units) and *Ki Hajar Dewantara* (1 unit) frigates and two Singa class ASW patrol boats of Indonesia and the 'Po Hang' (24 units) and 'Dong Hae' (4 units) classes of South Korea.

Specifications
Frequencies: 9.3, 10.5 or 11.7 kHz
Pulse lengths: 12.5, 25, 50, 100 ms and 400 ms long pulse (CW or FM)
Detection range: > 10,000 yd
Vertical beamwidth: 12 or 20°
Bearing accuracy: 1° RMS
Range accuracy: ± 0.5-2%
Notch filtering: selectable rejection bandwidth
Own Doppler correction: on all 60 channels
Weights
Electronic cabinets: (sonar console, duplexer and amplifier cabinet, transmitter cabinet) 1,041 kg
Retractable hull-outfit including transducers: 7,900 kg
Fixed hull-outfit including transducer: 2,500 kg
Variable depth system: 5,000-8,000 kg

Contractor
Thales Nederland, Hengelo.

UPDATED



Lightweight modular transducer of PHS-32 sonar

PHS-36

Type
Hull-mounted search and attack sonar systems.

Description
The PHS-36 is a licence-built active search and attack MF sonar based on the Canadian AN/SQS-509 system. The PHS-36 series of sonar systems is modular in design and intended for worldwide operation on any type of surface ship. The PHS-36, which is fitted in the Karel Doorman and Jacob van Heemskerck class frigates of the Royal Netherlands Navy is fully integrated into the SEWACO (Sensor Weapon Control and Command) system.

The PHS-36 provides information for the data handling functions of active sonar, passive sonar, acoustic support and track management and other functions such as equipment monitoring. The sound velocity processing and recording system also provides data for acoustic support.

A colour-coded presentation on a high-resolution display gives a graphic picture of sonar information.

The dual-processing system performs FM and CW processing simultaneously to cope with both noise-limited and reverberation-limited conditions, as well as with a variety of submarine running conditions as provided for ASW scenarios. The main functions performed by the sonar processor are auto-detection, auto-track initiation and auto-track processing.

The flexibility of the modular PHS-36 sonar processor allows easy add on of a towed line array with or without active adjunct or other types of ASW sensor.

Operational status
No longer in production.

In operational service with the Royal Netherlands Navy Karel Doorman and Jacob van Heemskerck class frigates.

Specifications
Transmission
Frequencies: 5.5, 6.5 and 7.5 kHz
Pulse type: CW, FM, FM + CW (a sequential transmission per interval)
Pulse length: 75-1,200 ms depending on range-scale/pulse type selections
Reception
Preformed beams: 32
Beam width: 15°
Bandwidth passive mode: Band I low; Band II high

Contractor
Thales Nederland, Hengelo.

UPDATED

Norway

SS 2450

Type
Anti Submarine Warfare Sonar.

Description
The lightweight SS 2450 active multibeam ASW sonar features a hull unit housing a fixed, cylindrical array protected by a GRP dome. The sonar can also be delivered with a retractable hull unit. The sonar transmits at an operating frequency of 24 kHz either with omni-directional coverage or in a single beam. The beams are electronically controlled to support tilt and continuous stabilisation of the beam pattern against roll, pitch and yaw. The sonar also features processing of passive data.

The WINSON®/WINCON® operator unit uses object-oriented software and is based on commercially available components (COTS), which improves maintenance and allows easy integration into the vessel's weapon system. Multiple screen worksheets are available for control and presentation of data and presentation views include omni-directional, B-scan with Doppler and echogram, as well as passive DEMON data. Relative and true motion view features are available. Post-processing features ping-to-ping filter, normalisation and automatic tracking. Both automatic target and position tracking can be used. Audio output is used in addition to the visual presentation. External connections include Ethernet and/or serial lines.

Specifications
Operating frequency: 24 kHz
Source level (omni): 213 dB (re. 1 µPa at 1 m)
Transmission: Omni or single beam
Horizontal beamwidth: 12°
Vertical beamwidth: 15°
Vertical tilt: –20° to +10°
Pulses: CW, stepped FM

Contractor
Kongsberg Maritime, Horten.

UPDATED

ST 240 Toadfish

Type
Dipping and variable depth sonar.

Description
The ST 240 Toadfish is a lightweight, active, single frequency, high-resolution sonar system designed for ASW and for detection of other submerged targets. The transducer array is located in a submersible body, which may either be towed or dipped.

The system comprises a Control and Display Unit (CDU), Power and Beamformer Unit (PBU), towed body (Toadfish) and a hydraulic crane system and winch system. The ST 240 is an omni and sector transmitting system with multibeam reception covering 360°. Operating modes include omni, sector B-seam echogram and Doppler, and passive with Demon. Tracking is implemented in active modes. The Toadfish is equipped with a CID sensor transferring temperature and salinity to present a real-time ray trace on the screen during launching. Transmission modes are CW and FM, with the possibility for Doppler analysis In CW. The power and beamformer unit receives preprocessed digital data from the towed body and performs signal processing (detection, normalisation and ping-to-ping correlation) with a fast digital processing system using the full dynamic range of the signals. Tracking is achieved in the omni and sector modes and presented on a special display window. The omni, sector and passive modes display windows for bearing, time and temperature. The unit interfaces with the single-operator control and display unit in which presentation is performed on a raster scan, high-resolution 20 in colour monitor. Interfaces to log and gyrocompass are provided, as well as temperature input from an external probe for display of the present ray pattern without changing the towed body depth. The Toadfish also has its own compass to give the true fish bearing during towing or dipping. The ST 240 can be integrated with other sonars in the Simrad range using a common dual display, single-operator control and display unit.

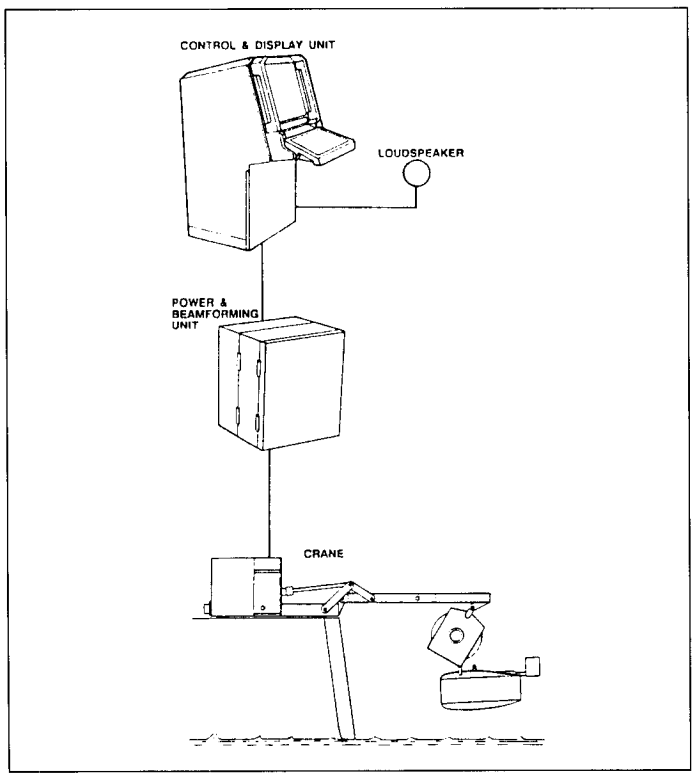
A similar system called ST 570 with an operational frequency of 57 kHz is also available.

Operational status
In operation on several vessels including the Finnish Navy Rauma class and the FAC *Hamina* and Swedish Navy Kaparen class FAC.

Specifications
Frequency: 24 kHz
Beam-forming: 64 digitally formed beams
Beamwidth transmission:
Single beam: 8° (horizontal); 12° (vertical)
Sector: 30°, 60°, 120° (horizontal omni); 12° (vertical)
Pulse length: CW - 1.3-200 ms (range dependent) FM (subpulse) - 1.3-83.2 (range dependent)
Number of subpulses: 2-8 (selectable)
Range scale: 500-12,000 m
Operating depth: 100 m

Contractor
Kongsberg Maritime, Horten.

UPDATED



General layout of ST 240 Toadfish

ST 2400

Type
Anti Submarine Warfare Sonar.

Description
The ST 2400 is a towed active sonar designed for ASW surveillance and search missions on coastal protection vessels. The lightweight, compact sonar can be installed without docking.

The towed unit contains a fixed cylindrical array operating at 24 kHz, encapsulated in a robust, hydrodynamic body. The array provides omni and sectorial transmission and multibeam reception covering 360°. The design of the towed unit provides stability at all operational velocities, including dipping mode. Automatic depth control is obtained by adjustment of the towing cable. If the towed unit is lost, an acoustic pinger is activated, thus easing recovery.

The WINSON®/WINCON® operator unit is based on commercially available components (COTS), using object-oriented software, and offers easy integration into the vessel's weapon system. Multiple screen worksheets are available for control and presentation of the sonar data. Presentation views include omni-directional, sector and B-scan with Doppler and echogram, and also DEMON processing of passive data. Sonar data can be presented in a geographical or vessel reference system. Features include automatic target and position tracking as well as an audio channel. The active/passive sonar post processing features: ping-to-ping filter, normalisation and automatic tracking. External connections include Ethernet and/or serial lines.

The system also includes a built-in test functionality.

Specifications
Operating frequency: 24 kHz
Source level (omni): 213 dB (re. 1 µPa at 1 m)
Sectors: 30°, 60°, 120° and omni
Horizontal beamwidth: 8°
Vertical beamwidth: 12°
Pulses: CW, stepped FM

Contractor
Kongsberg Maritime, Horten.

UPDATED

WINSON®

Type
Sonar Operator Unit for ASW and MCM.

Description
The WINSON®/WINCON® operator unit is designed for operation of various sonar equipments, including ASW and MCM sonars. WINSON® - the Windows Sonar Display Software, runs on WINCON® - the WINSON® Console. The operator unit is based on commercially available components (COTS) that simplifies maintenance and allows easy integration into the vessel's command and control system.

WINSON® is a component-based software, with a flexible and modular design, that allows tailoring to specific sonars, with the possibility of additional functionality. Operation is carried out using a control panel and/or menus. Data is presented in single or multiple views in sector, tactical, true motion, B-scan, echogram and ray-trace displays. Screen images can be stored for later retrieval. The operator can chose from a number of selectable palettes, including grayscale. Automatic target tracking and position tracking is available with geographical or vessel reference system applied to the data. External connections use Ethernet and/or serial lines.

WINCON® consists of a robust aluminium console, which can be freestanding, wall or rack mounted, and which contains one or two computers, one or two flat-screen LCD colour displays, as well as the splash-proof foil type control panel. The foldable control panel features a PC keyboard, dedicated buttons, a joystick for tilt/train, and a roller ball.

Contractor
Kongsberg Maritime, Horten.

UPDATED

Russian Federation

Introduction

Due to security constraints and the generally inaccessible location of sonar equipment, it is not possible to treat RFAS underwater equipment in the same manner as has been adopted for that of other nations. Instead, the following notes summarise what little has been gathered. While this inevitably falls well short of the ideal treatment, it is hoped that readers will find the ensuing paragraphs of some help.

Underwater acoustic experiments by what was formerly the Soviet Union, initially in relation to communications applications, are widely agreed to date back to the years immediately before the First World War, but the earliest references to anything resembling what is now known as sonar occur in the 1930s when research into hydrophones for submarines is mentioned. At this time, the possibilities of thermal detection devices for both aircraft and surface shipping were pursued. In the same period, the then Soviet Union is credited with the production of passive seabed acoustic detector equipment. Early Soviet records claim that at the start of the Second World War, the naval forces had a variety of sonar equipments available for shore and ship installations.

Most, if not all, of those reported were apparently passive devices, those for submarine fitting consisting of an elliptical array made of 8, 12 or 16 hydrophone elements. There were also passive sonar sets for surface ships, one of these being named *Tamir* which began sea trials in 1940. This equipment is stated by the former Soviet Union to have become the standard sonar employed in the anti-submarine campaign of that time. According to historians, official and unofficial, neither the then Soviet Union's former allies, nor her enemies, appear to have been very impressed by the results achieved. By the post-Second World War period, the nation had gained access to sonar technology originating in Germany, UK and the US, either by gift or as reparations.

Since then, there has been steady and impressive growth of interest in all aspects of submarine warfare, and sonar equipment has been accorded a priority within these activities at least as great as that given to it by the Western navies. The advent of ASW helicopter and aircraft carriers, such as the *Moskva*, *Leningrad* and *Kiev*, in advance of comparable ships being commissioned in Western navies, might imply a higher priority.

The appearance of these ships was preceded by smaller vessels designed for ASW operations and special purpose aircraft and helicopters for naval duties, the latter being deployed in both land-based and embarked formations. These developments occurred in the mid-1950s to mid-1960s period.

Among classes of vessel which the Russians rate as having a primary ASW function, all are fitted with hull-mounted sonar suites and variable depth sonars. These classes include the Kara class cruisers, Kashin and Udaloy class destroyers, Neustrashimy, Gepard and Krivak class frigates and among smaller classes of vessels the Grisha and Parchim class frigates. In addition, many smaller patrol vessels carry sonar and ASW armaments and most larger warships are fitted with some form of sonar purely for self-defence purposes, or as back up to support vessels with a primary ASW function. Most of the vessels with a primary ASW role also carry Ka 25 (Hormone) or Ka 27 (Helix) helicopters with an ASW capability including dipping sonar, sonobuoys and MAD.

One sonar on which some information is available is the Bull Horn (NATO codename) system carried by the Sovremenny class destroyers. This system probably operates in the 20-30 kHz frequency band and comprises a unit of four pull-out chassis, with a small (77 mm) CRT behind an orange filter screen. The lower three racks feature simple on/off toggle switches and push-buttons, only two multiple selector switches being visible. The only outputs seem to be to the small CRT and a meter which implies a simplistic sonar technology from the 1960s.

Much more recently, a certain amount of information has become available on acoustic and non-acoustic ASW systems. The RFAS appears to be making a considerable effort to develop non-acoustic sensors, including surface signature detection systems which sense the disturbance on the ocean surface caused by a passing submarine.

Wake detection systems that sense the turbulent wakes, internal wave wake, or contaminant (radioactive or chemical) wake of submerged submarines are also believed to be under development, as are magnetic or electric field detection systems that pick up the submarine or the subsurface disturbances caused by its passage. These wake and disturbance detection systems must operate at high altitude to offer effective surveillance and must therefore be either airborne or spaceborne.

The accompanying list is considered to be the most up-to-date covering the earlier First and Second Generation Soviet sonars. Later generations of Soviet sonar listed will be updated as further details become available.

Operational status

Herkules, Herkules-2 (GS-572)
Type: HF active/passive sonar
Development: Herkules was designed in 1948-52 for the 'Kynda' (Project 58) class cruisers. It underwent trials in 1953. Trials of Herkules-2 were conducted in 1955. The system entered service in 1956.
Description: Herkules (NATO Codename Wolf Paw) employed a 1.0 m diameter, 1.0 m high cylindrical array using 32 groups of magnetostrictive nickel plates. The HF sonar operated at 20 kHz. This was the first Soviet 360° scanning sonar to use beam forming and rotation by compensator.
Operational status: No longer in production or service.
Contractor: Vodtranspribor design bureau, Morfizpribor, St Petersburg (design)
Vodtranspribor, St Petersburg (serial production)

Titan (MG-311)
Type: Active search sonar
Development: Titan was developed in 1955-59 for the 'Petya' (Project 159) class patrol boats. Sonar trials were conducted aboard a Petya class vessel in the Black Sea in 1959. The sonar entered service in 1960.
Description: The cylindrical scanning Titan submarine search sonar had a diameter of 1.8 m and a height of 1.0 m. The receive array used a single scanning beam.
Operational status: No longer in production or service.
Contractors: Morfizpribor, St Petersburg (design)
Vodtranspribor, St Petersburg (serial production)



This is probably the most detailed unclassified view of a modern four-unit group of a low-frequency hull search and probable medium-frequency VDS sonar. The ASW fire-control computer and switchboard are at the far end of the control space. This arrangement could be typical of the sonar layout found on Krivak class destroyers (Jane's Intelligence Review)

Vychegda (MG-312)
Type: Active target tracking sonar
Development: The Vychegda was designed in 1955-59 for the 'Petya' (Project 159) class patrol boats. Sea trials were carried out in the Black Sea in 1959 and the sonar entered service in 1960.
Description: The sonar used a hydraulically rotated flat active/passive array 1.8 m wide by 1.2 m high. Bearings were measured using phase discrimination, and the set operated at 13 kHz in the active mode.
Operational status: No longer in production or service.
Contractors: Morfizpribor, St Petersburg (design)
Vodtranspribor, St Petersburg (serial production)

Orion
Type: LF/MF search and attack active/passive sonar
Development: Designed for the 'Moskva' (Project 1123) class helicopter cruisers in 1960-65, trials were carried out on the *Moskva* in 1967. The sonar entered service in 1968.
Description: This powerful scanning sonar was developed for detection and automatic tracking of submarines and surface ships using either convergence zone or bottom bounce techniques. The square plain hydraulically driven array measured 4 × 4 m and rotated horizontally in sectors of 30° for transmission using preformed beams for reception. It tilted between +15° and −55°. It radiated on a frequency of 3.5 kHz at 40 kW. The system used about 50 cabinets with tube electronic equipment.
Operational status: No longer in production or service.
Contractor: Morfizpribor, St Petersburg (design, prototype manufacture and serial production)

Zvezda (M-1)
Code-named Ox Yoke/Ox Tail by NATO this MF bow/flank/TAS is one of the latest sonars to be developed by Russia.

In service aboard Russian Neustrashimy and Gepard class frigates.

MG-7
This is a swimmer detection and small obstacle avoidance sonar and is fitted on most major warships and small mine warfare vessels.

Vega/Pike (MG-325)
Codenamed Mare Tail by NATO this MF VDS sonar of the mid-1960s is thought to have an operating range of around 4 n miles in active mode and 2 n miles in passive.

In service aboard Russian Kara class cruiser and Kashin class destroyers and Krivak class frigates of a number of navies.

Piranha (MGK-332)
Codenamed Bull Horn by NATO this active/passive sonar is associated with the RBU 6000 ASW rocket launcher on surface warships. It is reported that MGK-332 operates in both FM and CW modes in three frequencies (4.5, 5 and 5.5 kHz) with a 380 Hz bandwidth. The sonar is understood to combine both bow mounted and VDS elements.

In service with Russian carrier *Kuznetsov*, Moskva class cruisers, Sovremenny class destroyers and Parchim class.

Bronza (MG-345)

This is a MF sonar operating on three frequencies - 6.5, 7 and 7.5 kHz. It is either used as a hull mounted, VDS or dipping sonar used from a surface ship. Typical detection ranges for the sonar is 3.5 n miles dipping, 3 n miles for VDS and 2.5 n miles for hull.

In service with the navies of Bulgaria (Pauk class), Cuba (Pauk class dipping), India (Pauk class dipping), Russia (Pauk class).

Polinom

A sonar suite codenamed Horse Jaw (hull)/Horse Tail (VDS) by NATO this omnidirectional MF active search/attack scanning sonar integrates bow and VDS array elements. The VDS element is said to be capable of operating down to depths of 200 m. The system is stated to operate on multiple convergence zones in the Mediterranean achieving ranges in the order of 60 n miles.

In service aboard the Russian carrier *Kuznetsov*, Kirov class cruisers and Udaloy class frigates.

VERIFIED

Platina (MG-335)

Type

MF active/passive sonar.

Development

Platina was designed in 1967-75 for the 'Grisha III' (Project 1124M) class frigates. It was later mounted on the Sovremenny (Project 956) class destroyers and on other classes of modernised ships. Sea trials were carried out on Grisha class ships built in Kiev and Zelenograd between 1975-76. The sonar entered service in 1976.

Description

The Platina system (NATO codename Bull Horn) comprises two sonars - a hull mounted cylindrical array 2.3 m in diameter, and a towed array. Both sonars carry out search and localisation functions over 360° using pre-formed beams in 30° scanned sectors. The beams are rotated horizontally and can tilt vertically. Three active frequencies are used - 6.0, 6.5 and 7.0 kHz. The sonar operates either in the direct path mode (range about 3.25 n miles) or to the first convergence zone mode (range about 16 n miles).

Operational status

No longer in production, but remains in service aboard Sovremenny class destroyers of China and the RFAS, and Slava (Project 1164) class cruisers and Parchim II (Project 1331) class frigates of the RFAS. The system is also mounted on the carrier *Kuznetsov* (Project 1143).

Contractors

Morfizpribor, St Petersburg (design and prototype manufacture).
Priboi, Taganrog (serial production).

VERIFIED

Shelon'

Type

Active/passive dipping sonar.

Development

Shelon' was designed in 1960-67 and entered service in 1968 aboard 'Grisha' (Project 1124) class frigates.

Description

Shelon' (NATO codename Elk Tail) was designed for search, detection and tracking of submarines from stationary vessels. It used a 1.7 m diameter, 1.0 m high cylindrical array at the end of a 200 m cable. Operating on frequencies between 7.0 to 9.0 kHz in active mode the sonar used three 120° beams which rotated simultaneously in passive and active receive.

The communication sonar was the Hosta (MG-26) which was mounted in the same housing with the main array. The sonar is mounted either on the starboard side near the quarterdeck, or at the stern.

Operational status

No longer in production. Remains in service in some Grisha class frigates of Indonesia, RFAS and Ukraine.

Contractors

Morfizpribor, St Petersburg (design).
Vodtranspribor, St Petersburg (serial production).

VERIFIED

United Kingdom

ATAS V1/V2/V3

Type

Active/passive towed array sonar.

Description

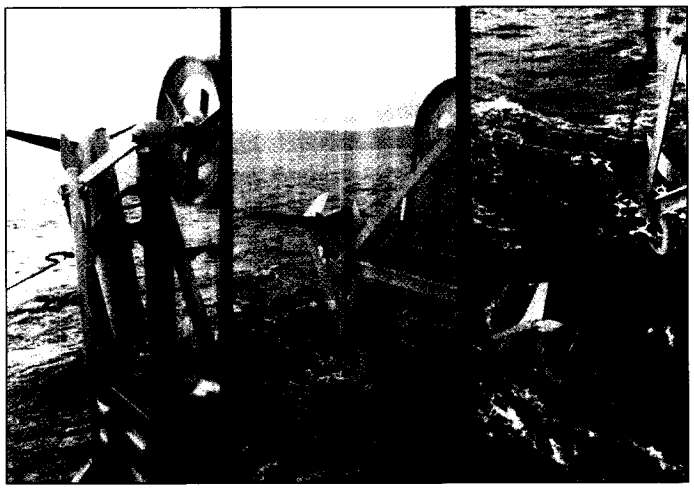
ATAS is an active (FM) towed array sonar incorporating the best features of active variable depth sonars and passive towed arrays. The system provides both active detection of targets and simultaneous torpedo warning capability (ATAS V1). Provision is also made to permit the addition of a conventional, low-frequency passive towed array (ATAS V2) and integration with other hull-mounted sonars and command systems. It is possible to operate simultaneously in the active and the VLF passive modes (V3) by adding one cabinet, one display and some additional electronics (one rack) to the V2 version.

The ATAS system comprises a high-power, low-frequency transmitter, operating in three frequencies around the 3 kHz band, which can be deployed at up to 900 m behind the towing platform, together with an in-line receiver array towed a further 300 m behind the transmitter; all of which may be towed at depths suited to prevailing oceanographic conditions. The port/starboard ambiguity normally associated with a towed array is automatically and instantaneously resolved within the system without the need for ship manoeuvre. ATAS can be operated at depths of 235 m and speeds up to 16 kt.

The transmitter has a high-power acoustic sound source consisting of a vertical stave of 10 low-frequency flextensional transducers contained in a 250 kg glass fibre body measuring 1.3 m high by 0.9 m wide and 1.0 m deep. The flextensional transducer consists of a piezo-ceramic stack operating in piston mode, enclosed in a elliptical shell. Transmissions in CW or FM are omnidirectional in the horizontal plane with a vertical beamwidth of 25°. The LF receiver array is a 25 m long, 89 mm diameter flexible tube housing 32 sets of hydrophones and associated electronics to condition and digitise hydrophone signals. The VLF receiver array is 100 m long and 50 mm in diameter of the same construction as the LF receiver. The receiver gives full azimuth cover and in the broadside direction, a bearing resolution of up to 0.5°. The receiver uses 96 preformed beams with bearing stabilisation. ATAS can hold information on as many as 200 potential targets and can highlight the 24 most likely ones.

The processing equipment uses current technology to provide high-processing capability within a single compact unit.

The compact nature of ATAS permits it to be deployed from non-specialised ships of 200 tonnes and above, including ships of opportunity or ships taken up from trade, with a minimum of modification to the platform. Hull penetration is eliminated and a space of only 1.8 m by 5.6 m is required on the stern of the ship for



ATAS sonar showing the deployment mechanism and the transmitter

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

the self-contained winch and handling equipment which weighs 4.7 tonnes (excluding in-water equipment). Other shipborne equipment comprises two electronics cabinets and a display unit incorporating dual high-resolution colour monitors. The display console can be installed remotely from all other equipment; it displays active and passive search, localisation and classification information in addition to performance of the day and performance monitoring data. All system equipment can be supplied in containerised form.

Operational status
Development has been completed and ATAS and systems have been delivered to two major customers. Taiwan is acquiring ATAS for the later units of the Cheng Kung class frigates and the new French-built La Fayette class (Kang Ding class). Pakistan has acquired two ATAS systems for its ex-Royal Navy Type 21 frigates. Oman will not now purchase ATAS as it has cancelled its ASW requirement for the two Qahir type Vigilance corvettes and three Al Bushra Vigilante type patrol craft.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

Bearing Ambiguity Resolution Sonar (BARS)

Type
Torpedo detection towed array sonar.

Description
The Bearing Ambiguity Resolution Sonar's (BARS) technology provides a unique proven solution to the ambiguity problem inherent in conventional towed array sonar systems. The passive, high-frequency BARS sonar is optimised for torpedo detection and provides the instantaneous bearing resolution which is essential for rapid response, without the need to resort to platform manoeuvres. Its shipborne signal processor is compact and VME compliant. BARS technology has been proven in many sea trials around the world and is currently in production as part of the ATAS system. Bearing ambiguity is overcome by using a tri-element hydrophone configuration which allows processing in two dimensions. The horizontal aperture allows for the resolution of the ambiguous array response.

BARS is suitable for installation on both ships and submarines and may be configured as a stand-alone system or as an adjunct to existing sensors. As a stand-alone system, BARS will provide threat detection without the need for extensive modifications, while as an adjunct sensor BARS may be retrofitted to enhance existing capabilities.

The system is designed to be compatible with the AN/SLQ-25A Nixie towed acoustic countermeasure.

Operational status
BARS has successfully completed a Foreign Comparative Test programme for the US Navy. This programme was run in conjunction with the Joint UK/US SSTD Project and demonstrated the benefits that BARS can provide.

Contractor
BAE Systems Underwater Systems, Waterlooville, Hampshire.

UPDATED

CHIP

Type
Fast time acoustic analyser.

Description
The CHIP (Concurrent High-speed Integrated Processor) analysis equipment has been developed using the Thales Underwater Systems Series 5 technology, for the detailed spectral (Demon and broadband) analysis of surface, subsurface or airborne tape recorded acoustic data. It incorporates automatic scaling of all processing parameters so that non-real-time processing can be undertaken without the need for manual correction. This enables tapes to be played at 0.5, 1, 2, 4 and 8 times the recording speed, while maintaining the correct frequency/time relationships and presentation on the display. It has 16 input channels and eight processing channels, each of which is independently configurable to a comprehensive set of processing parameters. A large input storage facility is provided to capture data from tape for immediate replay and reprocessing.

Control is exercised with an easy-to-use menu system and a high-definition colour VDU to control processing which is carried out by an array of digital signal processors.

An operator can set the equipment to undertake an initial exploratory analysis unattended, returning to assess the resultant data by viewing time histories stored in the display memory or inspection of the continuous hard-copy printouts.

Operational status
In service with a NATO navy.

Contractor
Thales Underwater Systems,, Templecombe, Somerset.

UPDATED

COMTASS

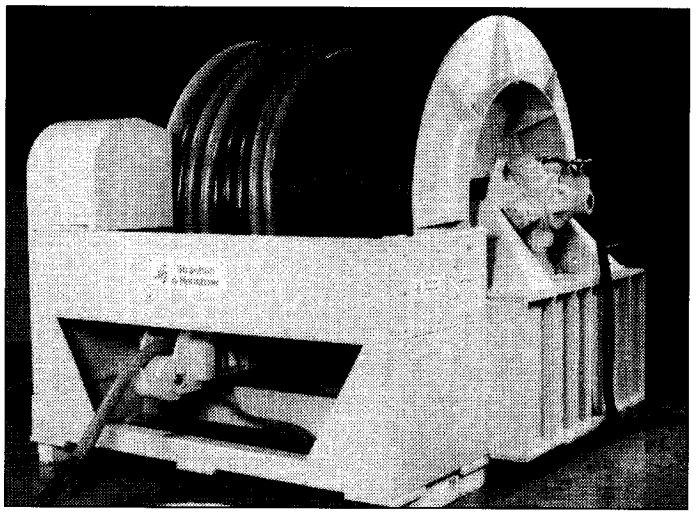
Type
Compact towed array sonar system.

Description
COMTASS is a compact towed array system belonging to the Thales Underwater Systems Series 5 family of modular sonar systems. It requires the minimum of structural changes for installation and can be fitted to a vessel in less than half a day. The high-performance array has been designed to withstand high-speed towing. The processing and electronics are contained in two 19 in units, each with power supplies and cooling fans, and flexibility to interface to any command system. The total modularity of the display and processor gives scope for additional processing if required.

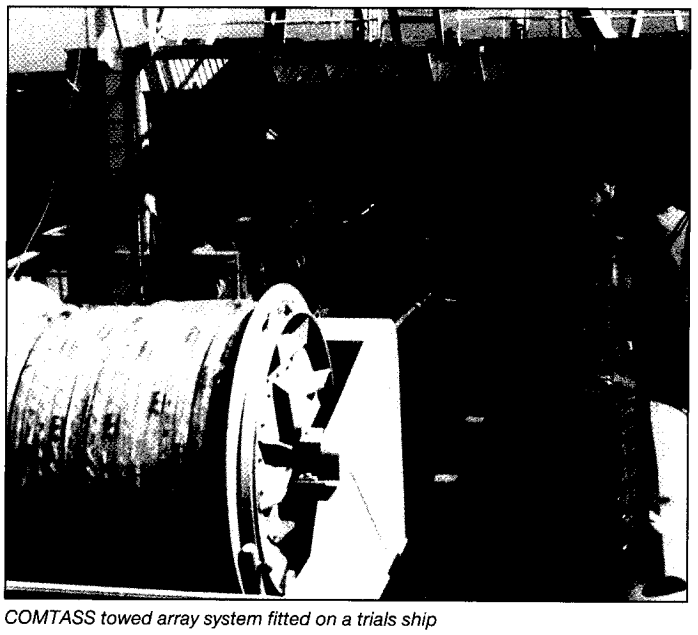
The standard console, which requires only one operator, allows for the simultaneous display of broadband and narrowband passive data for the long-range surveillance of surface and submarine targets. It is also possible to integrate active sonars into the COMTASS console, with flexible control of the displayed data.

The system provides passive detection and tracking of targets on a multifunction operator's console with detection ranges given as 30+ n miles, with an extensive over-the-horizon ships' surveillance capability. The console consists of two high-resolution, colour, refreshed raster-type displays in a variety of formats, according to the customer's specification.

The handling system, consisting of winch and control panel, is provided by Strachan & Henshaw. The system is designed for minimum maintenance and semi-automatic deployment. To provide further flexibility it can be palletised or



COMTASS lightweight array and handling system



COMTASS towed array system fitted on a trials ship

containerised for easy removal or transfer between vessels, and for quick fitment to reserve or auxiliary vessels. The critical angle tow lends itself to ease of handling, deployment and retrieval.

The sonar can integrate with hull-mounted sonars. The diameter of the array is 63 mm.

Operational status
COMTASS has been evaluated by a number of navies and has been fully validated by the UK defence authorities. Now in service with the Singapore Navy aboard the Fearless class vessel *Brave*.

Contractors
Thales Underwater Systems, Templecombe, Somerset
Strachan & Henshaw, Bristol (handling system).

UPDATED

G 750

Type
Active and passive hull-mounted search sonar.

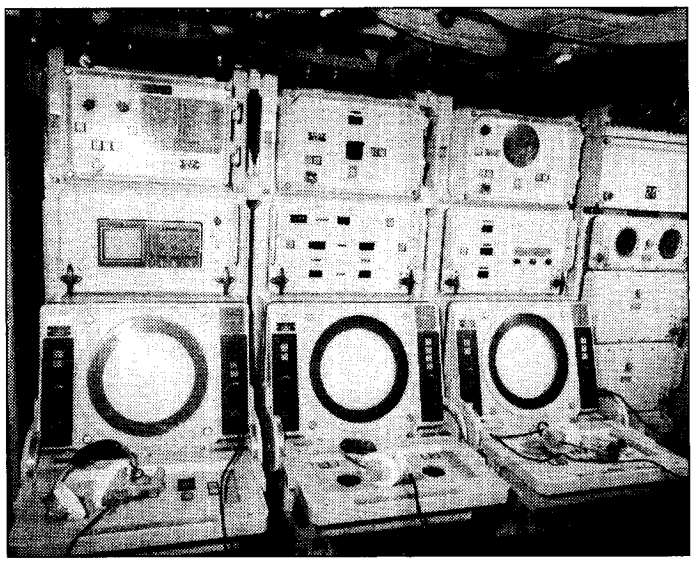
Description
The G 750 is a search and attack all-round sonar for ships of frigate size and above. It is a modernised and improved version of the Type 184M, providing accurate fire-control data from two independent automatic tracking systems, while simultaneously maintaining all-round surveillance, independent Doppler search and classification and continuous torpedo warning.

Three separate processing and display systems are incorporated for:
- all-round search and tracking (PPI)
- Doppler
- passive search.

Digital readout displays are used extensively and visual displays are supplemented by audio in all three systems. Nine cabinets are required for the complete electronics. Three are display consoles; three contain transmitter and control equipment, two house receivers and one is used for monitoring purposes. For installation in smaller ships or submarines, single passive or PPI display systems with smaller transducers are produced. In the standard G 750 system, an improved version of the Type 184M cylindrical 32 stave transducer is used to form a large number of beams. Range and bearing measurement is by in-beam scanning, obviating the need for separate expanded displays.

Target range and bearing are measured by either of two methods:
- by means of a manually positioned marker technique, in which the circular markers are placed over the target echo, it being the marker position that is measured; or
- by echo gating, where the echo range and bearing are measured directly. This form of tracking is used normally on acquisition of a possible target and is available on either computer-assisted or non-computer-assisted basis. Marker boxes representing the gated area replace the circles. In both methods the targets are individually identified by dotted or full markers.

Provision is made for interfacing the G 750 sonar with computer-based ASW and tactical information systems to provide a source of range, bearing and target Doppler data. Operational capabilities of the equipment include active detection of submarines throughout 360° and the ability to track two targets simultaneously. Similar detection coverage and tracking capabilities are available in respect of torpedo targets, with suitable outputs to torpedo warning and avoidance systems. There is also an active search capability over a 45° arc with facilities for determining target Doppler. Four 11° beams forming a 45° 'searchlight' provide a 360° search facility capable of measuring target Doppler up to ± 40 kt. The system is designed for operation in adverse reverberation conditions, with ripple or omnidirection dual-frequency modulated and Doppler CW transmission modes. The system can be applied as an HF or LF variant. Targets can be tracked to a maximum range of 20 km.



Type G 750 sonar control console

Operational status
No longer in production. In service with the Indian Navy on the Nilgiri class (three units). Also carried by *Canterbury* ('Leander' class frigate) of New Zealand.

Contractor
MARCOM Defence, Chichester, W Sussex.

VERIFIED

PMS 26

Type
Hull-mounted active sonar system.

Description
Hull-mounted ship sonar designed for single-operator control in both the surveillance and attack roles.

The 9.5, 10 and 10.5 kHz (three operating frequencies) sector scanning sonar is a self-contained system for ships and patrol craft down to 150 tonnes. It provides full 360° coverage in four steps of 90° and may be manually controlled to cover a particular sector, or set to carry out automatic search procedure. It incorporates a 'maintenance of close contact' facility for tracking close or deep targets. The single-operator controls the sonar through a special console. He is provided with three sources of sonar information: audio, visual Doppler, and visual sector.

Standard transmission mode is FM and CW with pulse lengths of 250 ms or 1 second with an additional short CW pulse short range. Maximum effective range is about 2.5 n miles.

The Doppler facility provides increased initial detection range and improved classification capabilities compared with conventional small ship sonars. The PMS 26 transducer array is mounted within a hull outfit with a glass-reinforced plastic dome.

Operational status
In operational service but no longer in production. A total of 14 PMS 26 systems remain in service on board three Danish frigates (Niels Juel class), two Nigerian Mk 9 corvettes, seven Turkish patrol craft and two Venezuelan coastguard vessels.

Contractor
Thales Underwater Systems, Templecombe, Somerset.

UPDATED

Sonar domes

Type
Composite domes and housings for sonars.

Description
Sonar domes and housings are manufactured to suit a wide variety of hull and towed array sonars. The design of the housings is supported by extensive 3-D full solid modelling techniques, FEA and PAFEC, for acoustic, structural and dynamic analysis, and is constructed of innovative composite materials to meet a wide range of customer and project solutions.

Operational status
Sonar domes and housings have been or are being manufactured for the Norwegian Navy (5 domes for the Fridtjof Nansen class frigates); the UK Royal Navy (Type 45 Daring class destroyers); and the Spanish Navy (5 × 10 m domes for the Alvaro De Bazan class frigates), with a prototype body for Odim Spectrum in support of the Swedish Visby class corvettes.

Contractor
W & J Tod Ltd, Crewkerne, Somerset.

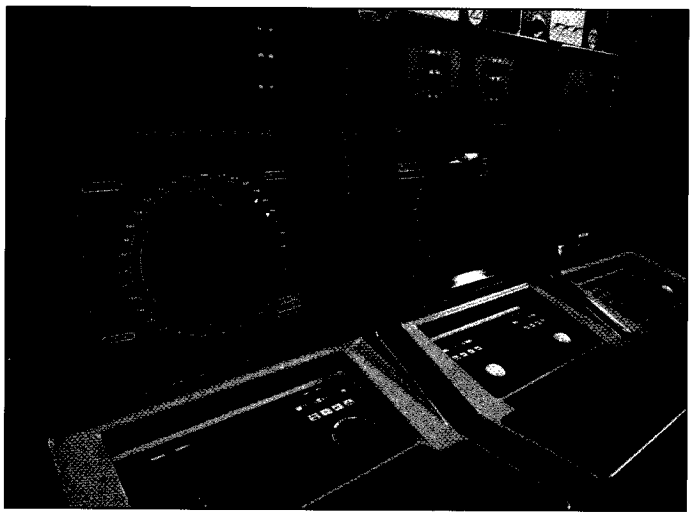
NEW ENTRY

Type 184M/P

Type
Active and passive hull-mounted search sonar.

Description
The Type 184M was one of the Royal Navy's primary surface ship anti-submarine search and attack sonars.

It is a 360° scanning sonar incorporating both active and passive modes of operation; it provides range, bearing and target Doppler data to the fire-control



Type 184 sonar control console

computer. The Type 184M was designed in association with the Admiralty Underwater Warfare Establishment (AUWE) and was fitted in many RN surface ships. The equipment has also been supplied to a number of other navies.

The equipment provides a dual-frequency transmission (between 7-9 kHz) and three receiver systems. The latter comprise:

- an all-round search and tracking PPI system with eight receiving channels
- a four-beam sector search Doppler system with B-scan display
- a continuous torpedo warning system with its own display.

A circular 32 stave transducer array is employed.

Solid-state modernisation kits (184P) to improve the performance and reliability of this sonar have been developed. This programme was implemented in three phases. The first phase introduced a 16 channel PPI system and replaced all electromechanical selectors and timers with solid-state electronics. The second phase offered improved detection capability against moving targets. The 31 digital filters in each of the four Doppler beams measure up to ± 40 kt of target speed with a resolution of better than 3 kt. The third phase provided separate Doppler, PPI and hydrophone effect geographically stabilised memory colour displays, with special attention paid to man/machine interfaces.

The PPI display offers improved detection through noise discrimination; four-beam sector search Doppler display provides moving target detection capability; and the hydrophone effect display in the passive mode presents the output of the hydrophone effect processor on the periphery of a circular plot with maximum noise signal directed towards the centre.

Operational status

No longer in production. No longer in service with the Royal Navy. Ships fitted with the system have been sold to Argentina (Type 42 (2), Chile (County (3) and Leander (3) classes, Ecuador (Leander class (2), India (carrier *Viraat*) and Pakistan ('Leander' (2) and Type 21 (6) classes. Upgrades including enhanced passive operation and an integrated torpedo detection capability are currently being considered.

Contractor

MARCOM Defence, Chichester.

VERIFIED

Type 2016 sonar

Type

Hull-mounted fleet escort active and passive search and attack sonar with bow- or keel-mounted variants.

Development

Design was initiated in the late 1960s and an experimental equipment underwent tests in HMS *Matapan*. A development contract was awarded in 1973 and the first prototype was completed in 1978 with fleet weapons acceptance in 1983. A bow-mounted variant, incorporating electronic beam stabilisation, was developed in 1983.

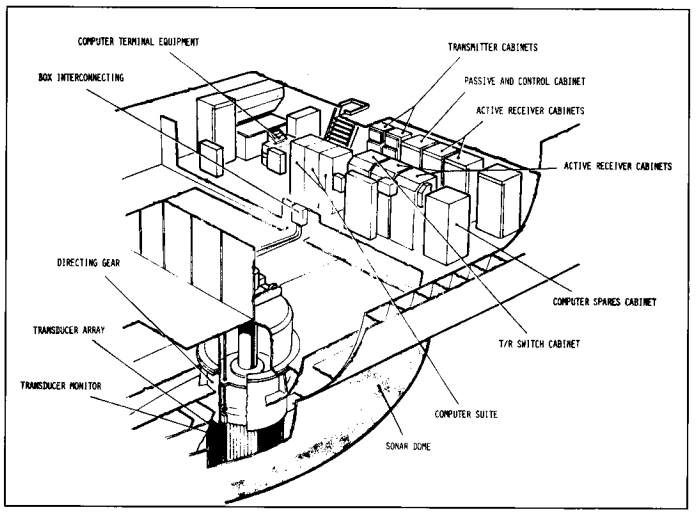
Description

The Royal Navy's Type 2016 fleet escort sonar is a replacement for the existing RN sonars Types 177 and 184. It employs computer-aided techniques which are operator interactive, have automatic detection and tracking, enhanced signal processing and displays complemented by an information storage facility.

The Type 2016 is a hull-mounted panoramic surveillance and attack equipment with facilities for classification and multiple target tracking. Interference between nearby vessels using the Type 2016 sonar is largely eliminated by the use of a broadband transducer. The sonar display console is designed for manning by a single operator under normal cruise conditions, this crew member being able to initiate the preparatory actions necessary for urgent action.



Console of Type 2016 sonar aboard an RN frigate. Three displays (left to right) are for classification, surveillance and passive presentation



Arrangement of Type 2016 fleet escort sonar equipment and hull outfit compartment

The Type 2016 system comprises the following main elements: four active receiver cabinets, one passive and control cabinet and one T/R switch and beam-former cabinet, all housed in Marconi MC70 type cabinets. The computer suite consists of three D.811A cabinets and a separate cabinet for computer spares. The two transmitters are housed in two standard RN/AUWE cabinets. The solid-state electronics are based on a modular system approach using medium-scale integrated devices, printed circuit back planes with wire wrap connections and standard line-drive receivers for all inter-cabinet signal connections. Extensive use is made of hybrid circuit techniques to reduce volume.

The Type 2016 array system, which is roll stabilised, is fitted in a ribless monocoque glass-reinforced plastic sonar dome within a fixed hull outfit. Depending on the ship fit, the array is mounted either in a keel or bow dome; array stabilisation is either hydraulic or by electronic beam-steering. Range is reported as being in the region of 5.35 n miles. Operating frequency is in the range of 4.5 to 7.5 kHz.

The sonar consists of a mechanically stabilised cylindrical array of 64 staves each comprising 12 elements. The array creates two beams, one nearly horizontal comprising 32 pairs of beams which is used for tracking, and one at 7° to the horizontal to penetrate the surface layer. A further 12-element auxiliary vertical array, which rotates around the main transducer array, is used to measure propagation characteristics. The total power output is 44 kW.

The display console contains three main displays and a top-mounted Versatile Console System (VCS). The right-hand display is dedicated to passive and auxiliary data, the passive data are displayed with two different integration times, enabling both torpedoes and more distant targets to be tracked. The auxiliary data is used for data logging and system information including the display of such items as course, speed, weather, sea bottom conditions and bathymetric information. System monitoring information is also provided here and on a maintainer's teleprinter or intelligent terminal, which enables faults to be pinpointed down to board level. The other two displays can be used to view surveillance, classification or target history information and are fully interchangeable. Special keyboards are provided at both positions for interaction with the automatic tracking process, display selection and data transmission to the command/combat information system.

Operational status

In service with the UK Royal Navy Invincible class aircraft carriers and Type 42 destroyers. Production was completed in 1987. Being replaced by sonar 2050 in Royal Navy.

Contractor

Thales Underwater Systems, Templecombe, Somerset.

UPDATED

Type 2031Z sonar

Type
Towed array sonar system.

Description
The Type 2031Z is a towed array sonar system fitted to ASW frigates of the Royal Navy. Using the innovative 'Curtis' architecture developed at the UK Admiralty Research Establishment in Portland, Dorset, the 2031Z electronic signal processing suite provides a five-octave broad and narrowband analysis facility capable of tracking the most elusive threats. It is reported that it can be towed at speeds up to 10 kt, with very long detection range capability (possible out to the third convergence zone in the Norwegian Sea).

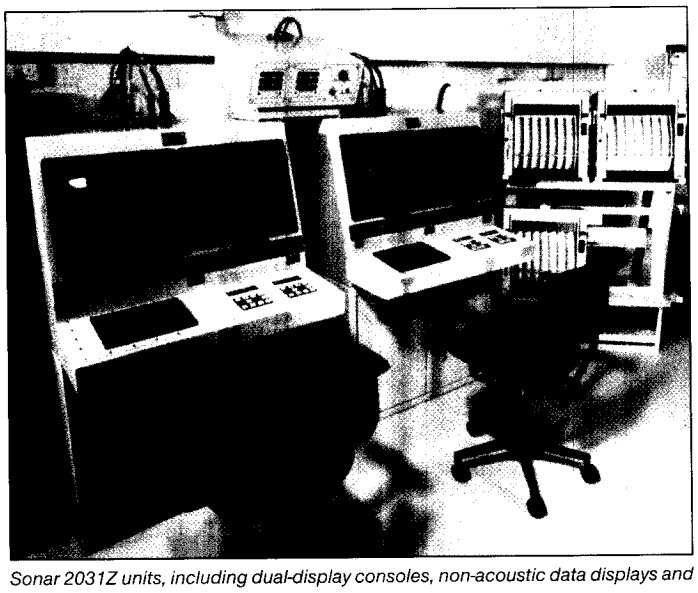
The array itself, said to be over 500 m long, is towed behind the ship and has a very low self-noise characteristic and is considerably longer than that used by any other self-contained sonar. It provides good bearing accuracy, even down to the very low frequency end of the acoustic spectrum. The combination of an advanced signal processing architecture and a high-performance towed array ensures that the system is a dual-capability sensor, able to fulfil both the tactical and surveillance role.

The modular nature of the 2031Z, with regard to the digital signal processing electronics and the towed array itself, makes it possible to configure other types of sonar systems from the same range of modules. As an example, a variant of the 2031Z signal processing, suitable for submarine applications, is also available and has been delivered to the Royal Navy as the Type 2046.

Operational status
The Type 2031Z is in service with Royal Navy Type 22 (Batch 3, four ships) and Type 23 frigates (first 10 ships). A total of 24 systems were delivered.

Contractors
Ultra Electronics, Ocean Systems, Weymouth, Dorset.
Thales Underwater Systems, Templecombe, Somerset.

UPDATED



Sonar 2031Z units, including dual-display consoles, non-acoustic data displays and hard-copy recorders

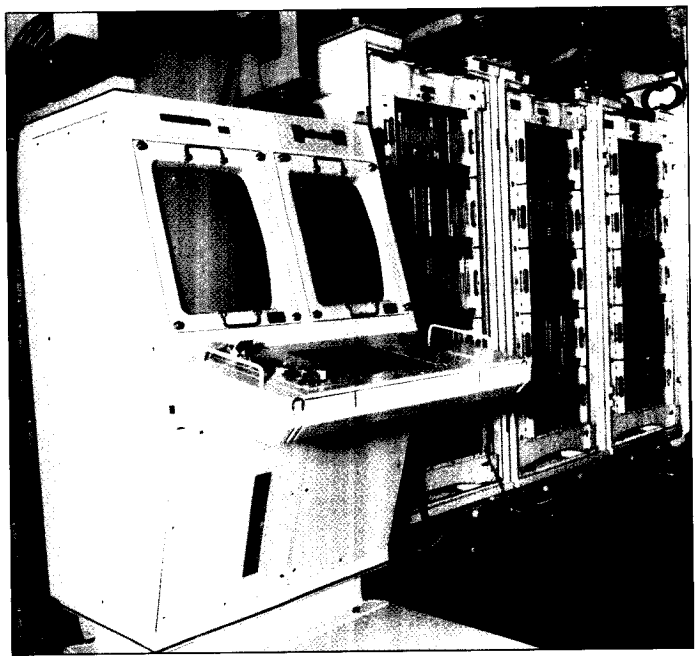
Type 2050

Type
Hull-mounted active search sonar system.

Description
The Type 2050 is the medium-range, medium-frequency hull-mounted attack sonar for the Royal Navy fitted to the Type 42 destroyers and Type 23 and Type 22 frigates. It is the successor to the Type 2016 and is compatible with both bow and keel variants of the Type 2016 array. The equipment includes digital signal processing and distributed data processing using Digital Signal Processing (DSP) cards and Argus M700 processors.

The data processing facilities and man/machine interface allows for single operator control. The equipment interfaces to the combat system data highway feeding data to the CACS action-information system. The sonar can track up to 40 targets simultaneously using linear FM or CW pulses. The geographically stabilised FM picture is presented on one display and CW Doppler on the other.

An update programme for Type 2050 incorporates an adjunct wideband array and new passive processing technology to provide improved torpedo alert capability.



Type 2050 hull-mounted sonar system

Operational status
The UK MoD has procured 34 Type 2050 sonar systems for the Royal Navy, fitted in Type 23 frigates, and retrofitted into Type 22 frigates and some Type 42 destroyers. Type 22 units transferred to Brazil (4 units) and Chile (1 unit) have retained the Type 2050 and two Type 22 units are being transferred to Romania.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Type 2087

Type
Low-frequency active and passive towed array sonar.

Development
Development of the Type 2080, an LF active towed array and Type 2057, a very long passive towed array for surface ships and submarines was begun in 1988. In 1993 these two programmes were combined into Type 2087 to rationalise sonar systems and a combined Staff Target was approved in April 1994 for the fully integrated, variable depth, towed active/passive Type 2087. The sonar is being developed to replace the Type 2031 passive towed array on Type 23 frigates and is needed to combat the advances in quieting techniques now applied to both nuclear and diesel-electric submarines and to improve detection capability in littoral waters.

Description
Type 2087 will be capable of operating in a wide range of environments, from deep ocean to littoral waters and from tropical through temperate and Arctic waters. The sonar will be fully integrated into the Type 23 frigate combat suite with minimum change to the command system.

Type 2087 will be a towed, VLF, active and passive sonar with high-power, long-range detection and variable depth capabilities. It will be a combined active, low-frequency VDS transmitter with a wide aperture passive towed array receiver. The active frequencies are lower than those currently used in Royal Navy surface ship active sonars. This will enable the sonar to take advantage of better sound propagation offering greater detection ranges. The sonar has many common features with the CAPTAS series, for example, the active towed body with omnidirectional, free-flooded ring projector technology. The 2087 uses four free-flooded ceramic ring projectors in a vertical array. To resolve port/starboard bearing ambiguity a triplet array configuration is employed in a directional MF (active receive) module of the receive array. Passive HF receiver elements will be contained in the transition module while the fully digital passive LF towed array will incorporate modules common to those already in use in the Type 2076 submarine sonar.

Data and images will be presented on dual-display OPUS 2 multifunction consoles and the suite will consist of five multifunction consoles, four of which will be operator consoles, the fifth being for the sonar director.

The Type 2087 is being designed to integrate with the existing hull-mounted Type 2050 sonar carried by the Type 23 frigates and the new Surface Ship Torpedo Defence system (SSTD) via the combat system highway of the Outfit DNA(1) command system.

An environmental impact assessment carried out by the MoD has indicated that the Type 2087 has the potential to be harmful to marine mammals. The effect is influenced not only by the intensity of the sound but also by its duration and

frequency. As a result a series of measures designed to minimise any harmful effects are being incorporated into the design.

Operational status
In March 2001, a team led by Thales Underwater Systems was selected as prime contractor for the Type 2087 project. It is intended that the Type 2087 will replace the Type 2031Z towed array in the Royal Navy's Type 23 frigates from around 2006. Fleet Weapon Acceptance is scheduled for June 2009. A derivative of the sonar is also projected for the Franco/Italian frigate programme.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester. ***UPDATED***

United States

21 HS series

Type
Commercial COTS sonar.

Description
The 21st Century Hull Sonar (21 HS) family is a multimode hull, bow or VDS active and passive sonar systems based on the US Navy AN/SQS-53C sonar. The sonar is designed for installation on surface ships of varying sizes and hull configurations. It provides long-range search, detection and tracking using direct path, surface duct and variable depression modes. The 21 HS provides simultaneous active and passive receive processing at four distinct centre frequencies: 3.5, 5, 7 and 13 kHz determined by the customer's sonar requirements and constrained by the specific ship's available power and weight capability.

The sonars feature computer aided detection and automatic tracking with multiple target capability.

Typical array configurations comprise 216 transducers in 36 staves providing 36 preformed beams with 300° coverage. Transmissions are in CW or FM with additionally a shallow water short wide-band pulse. Three pulse widths are used (20, 100, 500 in sec) with a source level between 220-235 dB.

The 21 HS active capability provides multiple search strategies using CW, FM and SW (shallow water) waveforms. Passive capability provides detection of broadband, DEMON and narrowband radiated noise for enhanced torpedo detection as well as ASW. The system also provides an integrated obstacle avoidance capability against mine-like objects. The system uses three colour master-scan display consoles with, X-Windows® displays that can be user customised. The 21 HS offers a very small footprint for a high-power sonar.

Operational status
Trained sonar operators were used to evaluate the 21 HS MMI under operational conditions during tests conducted aboard a US Navy DDG 51 destroyer in June 1996. All of the sea test objectives were met or exceeded.

Northrop Grumman was awarded a contract by Ingalls Shipbuilding, to refit two Venezuelan Mariscal Sucre class (Lupo type frigates) with the 21 HS-7. The systems were delivered during 1999.

Specifications
21 HS-3
Frequency: 3.5 kHz
Cabinets: 7
Footprint: 5.6 m²
Electrical weight: 6,000 kg
Array weight: 11,000 kg

21 HS-3ER
Frequency: 3.5 kHz
Cabinets: 12
Footprint: 7.8 m²
Electrical weight: 10,000 kg
Array weight: 64,000 kg

21 HS-7
Frequency: 7 kHz
Cabinets: 5
Footprint: 5 m²
Electrical weight: 4,000 kg
Array weight: 2,700 kg

21 HS-13
Frequency: 13 kHz
Cabinets: 2
Footprint: 1.2 m²
Electrical weight: 455 kg
Array weight: 227 kg

Contractor
Northrop Grumman Corporation Electronic Sensors & Systems Sector, Oceanic and Naval Systems, Annapolis, Maryland.

UPDATED

AN/SLX-1 MSTRAP

Type
Multisensor torpedo recognition and alertment processor.

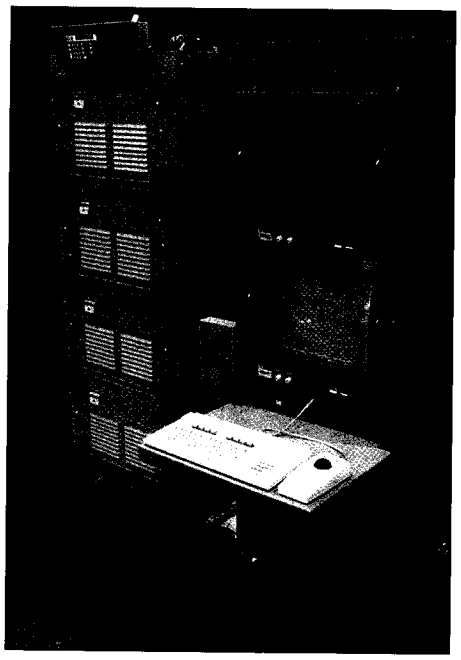
Description
Designed for installation aboard surface ships and submarines, the MultiSensor Torpedo Recognition and Alertment Processor (MSTRAP) COTS-based system provides warning of an incoming torpedo threat on an easy-to-read display. (See also AN/SLX-1 entry under Countermeasures - Acoustic Decoys section). This multifunction system provides information, digital signal processing and the controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions, TMA, threat evaluation and tactical advice. Displays with automatic visual and audio alarm of torpedo threats allow sufficient time to make tactical decisions and effective deployment of countermeasures and appropriate ship evasive manoeuvres. Results can be displayed on any X-windows-based MFC. Data is received simultaneously from either an existing ASW hull sonar, towed array or sonobuoys. MSTRAP's open system architecture enables easy installation, hardware/software upgrades and future improvements to be implemented.

Operational status
The first unit of MSTRAP was delivered in June 1995 only 14 months after receipt of contract (in May 1994). MSTRAP has been operationally tested and proven at sea. Over 30 units have been delivered and are installed on Spruance and Arleigh Burke Flight IIA class destroyers.

Specifications
Power: 115 VAC, 60 Hz, single phase
Size: 660 lb, 72 in high, 25 in wide, 22 in deep
Note: The AN/SLX-1 (MSTRAP) cabinet has significant excess space available. This can be used for other electronics or the cabinet can be reduced in size to fit specific needs.

Contractor
Northrop Grumman Corporation, Oceanic and Naval Systems, Annapolis, Maryland.

VERIFIED



AN/SLX-1 MSTRAP hardware comprises the processing enclosure, workstation display and interconnecting LAN equipment
0007232

AN/SQQ-28

Type
Sonar signal processing system.

Description
The AN/SQQ-28 sonar signal processing subsystem processes sonobuoy acoustic data down-linked to the ship from the SH-60B LAMPS Mk III ASW helicopter. The system provides the shipboard processing and contact management required to accomplish detection of a target and to prosecute parts of the ASW mission.

The system processes data from passive and active sonobuoys including DIFAR, VLAD and DICASS buoys. Up to eight omnidirectional or four directional/active buoys can be processed simultaneously. The processing subsystem incorporates an acoustic target tracker that automates the target tracking process. This automated tracker averages around 10 minutes to determine the target course. Multiple display formats and automated detection aids enhance operator performance.

Operational status
In service with the US Navy on board Arleigh Burke (28 units), Oliver Hazard Perry (30 units), Spruance (seven units) and Ticonderoga (27 units) class vessels and Japanese MSDF Asagiri (eight units), Murasame (nine units) and Takanami (two units) classes. The system is also in service on the Spanish Santa Maria (six units) and new Alvaro de Bazan (two units) class frigates.

Contractor
Northrop Grumman Corporation, Electronic Sensors and Systems Sector, Oceanic and Naval Systems, Annapolis, Maryland.

UPDATED

AN/SQR-17A signal processor

Type
Integrated shipboard submarine detection, classification, signal processing, display and recording system.

Description
The AN/SQR-17A is a totally integrated submarine detection and classification system for shipboard and land-based applications. The (V)2 system configuration consists of the eight channel AN/SQR-17A sonar signal processor and display unit, the 28 track RD-420B tape recording system, the AN/ARR-75 sonobuoy receiver interface unit and the antenna and microphone access unit.

The AN/SQR-17A can process signals detected by Difar, Dicass, VLAD, Lofar, active and BT sonobuoys and displays raw acoustic in either A- or B-scan format. Data is then enhanced, incorporating alphanumeric designations and graphics with human factor considerations, to aid personnel in target analysis and tactical co-ordination.

The system has a 19 in acoustic data display and two 9 in auxiliary video-monitor displays for menu prompting, for selection of the appropriate system operating mode and for monitoring the status of multiple acoustic sensors.

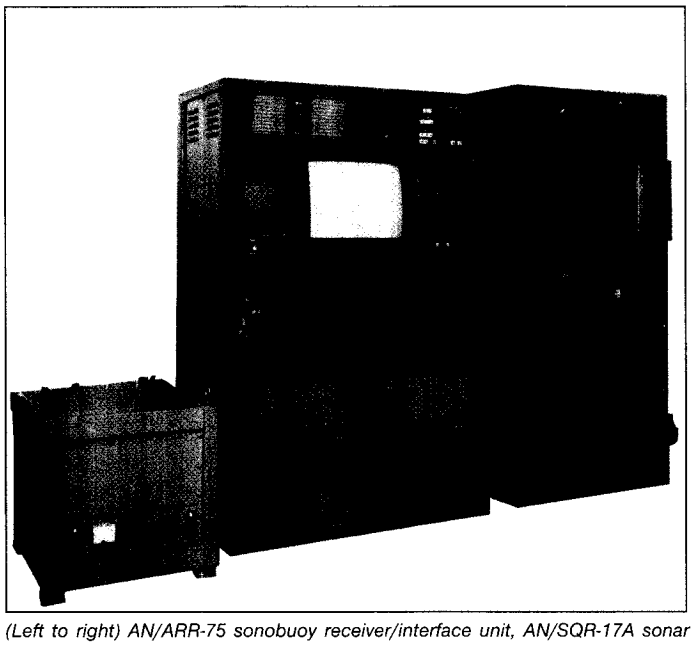
The high-density solid-state mass-memory display provides full multitarget detection, tracking and classification for ASW encounters. The display uses real-time, high-resolution, TV raster formats and is designed modularly with electrographic hard-copy capabilities in standard-gram format. The system can interface with towed arrays, hull-mounted sonars, helicopter data downlink and onboard sonobuoy receivers.

The AN/SQR-17A has gone through a series of upgrades and improvements through the (V)1, (V)2 and (V)3 versions.

Operational status
Over 100 units have been sold to the US Navy. The company has also sold units to friendly navies and continues to provide installation and refurbishment services. Upgraded systems have been supplied to the US Navy for the Mobile Inshore Underwater Warfare (MIUW) programme.

Contractor
DRS Technologies Inc, Gaithersburg, Maryland.

VERIFIED



(Left to right) AN/ARR-75 sonobuoy receiver/interface unit, AN/SQR-17A sonar signal processing system, RD-420B recorder/reproducer

AN/SQR-18A(V)

Type
Towed array passive sonar system.

Description
The AN/SQR-18A(V) Tactical Towed Array Sonar (TACTAS) was designed to enhance the air/sea warfare capabilities of the US Navy surface ship fleet. It provides long-range passive detection and classification of submarine threats. The system is a single-operator equipment, providing full azimuth coverage in both narrowband and broadband search modes.

The 222.5 m long array consists of an acoustic section, a vibration isolation module and a rope drogue. The array is 82.6 mm in diameter and is towed by a 1,706 m long cable at depths up to 366 m. In the short tow version, it is towed behind the Variable Depth Sonar (VDS) body of the AN/SQS-35V (see AN/SQS-35V entry). Preamplifiers are in the array, while signal processing and other electronics are on board the ship.

The original AN/SQR-18A was replaced by the AN/SQR-18A(V)1 version, featuring a new low noise array towed by a 730 m cable which provides increased detection range and allows effective operation at high ship's own speed. An adaptive processor provides interference cancellation, making the system virtually immune to tow ship noise, and allows operation near other noisy ships. An improved tracker provides accurate bearing data for effective target motion analysis solutions, even on weak targets. The most significant improvement made to the basic system has been the installation of an operator auto alert capability which provides target detection for operator selected frequencies. The system is capable of providing acoustic data to an external recorder and playing back recorded data.

The AN/SQR-18(V)2 critical angle towing version used the towing rig of the AN/SQR-19 aboard Knox class frigates, and was towed by a 1,524 m cable. This variant has been completely modernised and utilises EDO's Advanced Modular Signal Processor (AMSP), a programmable system using COTS technology. The processor provides additional processing capability used in conjunction with an improved operator automatic alert system that can be optimised for each individual threat and alert level.

The AN/SQR-18A(V)1 system electronics consist of three major and five small units, while the (V)2 consists of two major and six small units.

A signal conditioner provides gain, equalisation, interfacing, auto-ranging gain control and readies the hydrophone signal for digitisation. This is the only analogue part of the AN/SQR-18A(V).

An embedded trainer is included which provides realistic targets in dynamic interactive scenarios with high-fidelity classification clues that allow onboard training of both the operator and the target localisation team.

Digital signal processing techniques are used in both variants to present narrowband and broadband low-frequency information. The system may be operated in both narrow- and broadband simultaneously and can be operated simultaneously with active sonars. Tracking is provided by an automatically stabilised tracker beam. The automatic target following circuits keep the beam nulled on a target through 'own ship' and target manoeuvres. All processed data is stored in a modular electronic solid-state memory. Narrowband outputs are presented on the operator's display screens in Lofar format. The AN/SQR-18A(V)1 provides two independent display screens, while the (V)2 uses a third display to present situation summary information. Controls are provided to measure the frequency and amplitude of tonals, and harmonic ratio of target frequencies. Results of measurements, bearings of beams displayed and tag numbers are displayed in alphanumeric format.

Development of the AN/SQR-18A(V)3 has been completed. The fully digital system uses the latest COTS modular digital signal processing technology and standard computer subassemblies, combined with a standard console and colour



AN/SQR-18A console/display

displays. This architecture provides a system that can be readily reprogrammed and upgraded. The AN/SQR-18A(V)3 uses digitised hydrophone data from an array and critical angle towcable identical to the AN/SQR-19. Greatly increased performance over earlier variants is achieved.

The AN/SQR-18A(V)3 has also been reprogrammed, under contract to the US Navy, to operate as a low-frequency active receiver using the towed array as a sensor. Coherent processing of selected multiple active waveform types is easily accommodated. Digital processing, target trackers and display features are provided as aids to minimise false alarms and simplify operation. The system can be fully integrated into shipboard combat systems using standard digital bus formats. Data is fed to a tactical display, which integrates reduced false alarm acoustic data with the ship's combat information. A PC-based passive/active test set and trainer with multiple target features and active echo types is included. Up to four dynamic targets can be inserted simultaneously to enhance operator and combat system team training.

Operational status
In operational service with ex-US Knox class frigates of the Taiwanese (eight ships) and Thai (two ships) navies.

Other units deploying variants of the AN/SQR-18 system are the Japanese Shirane (two units) classes and the Taiwanese Cheng Kung class (two units).

The AN/SQR-18A(V)3 active receiver has completed initial sea trials on two US Navy FFG-7 class frigates.

Contractors
EDO Combat Systems , Chesapeake, Virginia.

UPDATED

AN/SQR-19 TACTAS sonar

Type
Passive towed array sonar system.

Description
Developed in 1976, the AN/SQR-19 is a passive towed sensor array designed to give surface vessels long-range detection and tracking of both submarines and surface ships.

It includes: a towed sensor array with improved ranging ability and reduced self-noise; a handling system which improves system performance by maintaining array position and depth; and a sophisticated signal processing and automated tracking system providing more sonar information with reduced operator workload. The 'wet end' consists of a linear array and towcable, plus the associated handling and stowage equipment. Coaxial conductors within the towcable carry the flow of telemetered acoustic signals, plus heading, depth and temperature data from the array to the ship, and also handles the commands to the array. Located below decks are the signal and data processing equipments, plus the display and control consoles. The displays are shared with the AN/SQS-53 hull-mounted sonar and the LAMPS III ASW helicopter, so that the ship is provided with a single integrated ASW system (the AN/SQQ-89).

The AN/SQR-19 provides omnidirectional long-range passive detection and classification of submarine threats at 'tactically significant' own ship speeds in seas up to state 4, using an array towed on a 1,707 m cable to provide tow depths down to 365 m.

The array features a multiple convergence zone capability. The 82 mm diameter array is 242 m long and incorporates 16 modules (eight VLF, four LF, two MF and two HF each 12 m long). Each module holds eight equally spaced hydrophones each with its own amplifier. All data is multiplexed for transmission through the towcable to the ship. Low flow noise maximises detection opportunities which are conditioned by environmental features and known or anticipated threat operating depths. Array acoustic data is processed into 43 beams and provides narrowband, broadband and demodulated noise (DEMON) signals.

The system uses computer aided detection, visual alerts, optimum search display formats, special classification display formats and complex data processing.

The TACTAS shares data processing equipment with the AN/SQQ-28 sonar signal processing subsystem and sonar displays with the AN/SQS-53C and AN/SQQ-28 to provide a single, integrated ASW combat system.

Operational status
The first operational system was installed on board the USS *Moosbrugger* early in 1982 and has completed both technical and operational evaluation. The system has been installed on about 98 USN platforms including: CG 47 Ticonderoga class cruisers; DDG-51 Flight I and II 'Arleigh Burke', DDG 993 Kidd and DD 963 Spruance class destroyers. In addition, there have been Foreign Military Sales (FMS) of the SQR-19 and AN/SQQ-28 to Spain for the Oliver Hazard Perry class frigates, to Poland for the transferred 'Oliver Hazard Perry' and sales of 'wet end' elements of the SQR-19 to Canada where it is fitted in the AN/SQR-501 CANTASS towed array on the Halifax class.

Contractors
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

VERIFIED

AN/SQS-35

Type
Hull-mounted and variable depth sonar systems.

Description
These systems were designed to detect submarines at medium ranges in both deep and shallow waters. The AN/SQS-35 entered service with the US Navy in the mid-1960s.

The US systems are improved miniaturised solid-state versions of previously developed vacuum-tube equipments manufactured for the US, Italian, Norwegian and Japanese navies.

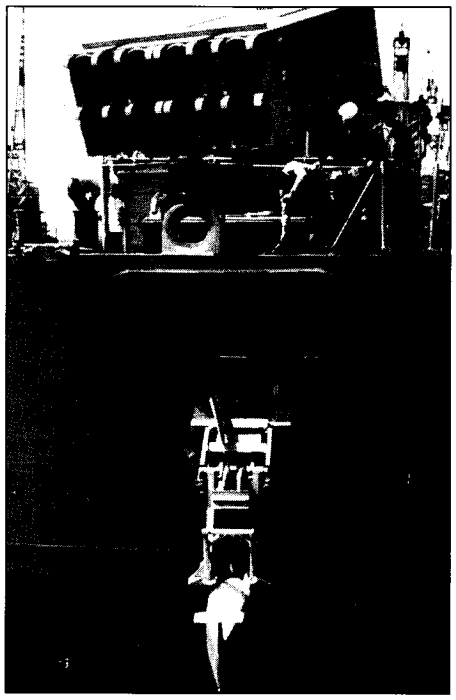
Some versions combine both variable depth capability and hull sonar capability, selectable by the sonar operator at the control console.

Weapons associated with the system are the Mk 44 torpedo and ASROC (USA).

Operational status
Operational with the four units of the Baleares class in the Spanish Navy and with the Shirane class (two units) and Yamagumo class (two units) of the Japanese Self Defence Force.

Contractor
EDO Combat Systems, Chesapeake, Virginia.

UPDATED



AN/SQS-35(V) variable depth sonar seen aboard escort ship USS Francis Hammond

AN/SQS-53

Type
Hull-mounted passive and active sonar system.

Description
Claimed to be the most advanced surface ship ASW sonar in the US Navy inventory, the AN/SQS-53 is a hull-mounted, active and passive high-power (190 kW), long-range system cylindrical bow array, evolved from the AN/SQS-26CX. Functions of the system include: the detection, tracking and classification of underwater targets; underwater communications; countermeasures against acoustic underwater weapons; and certain oceanographic recording uses. Target data obtained by the sonar are transmitted to the ship's Mk 116 digital underwater fire-control system.

The AN/SQS-53 can detect, classify and track multiple targets and is the first USN surface ship sonar designed to interface directly with a vessel's digital computers. The system has a large 1.6 m high by 4.8 m diameter cylindrical array of 576 transducer elements housed in a large bulb dome below the waterline of the ship's bow. Operating frequency is 3 kHz with a peak frequency of 192 kHz. There are 37 cabinets of signal processing, transmitting and display equipment. In the SQS-53B the AN/UYK-20 computer of the SQS-53A is replaced by the UYK-44 military reconfigurable processor.

The SQS 53C uses only 15 cabinets of electronics, which the SQS-53D replaces analogue electronics of the B/C variants with digital processing and more modern displays. Passive and active operating modes are possible.

There are three active modes:

(a) surface duct (range 10 n miles)
(b) bottom bounce
(c) convergence zone (range up to 34.5 n miles).

The surface duct mode depends upon sound energy being transmitted essentially in the horizontal plane. Due to the high level of noise introduced into the return signals near the surface, this mode is useful only for relatively short distances. Nevertheless, this method is conventional for many surface ship sonars and the high-transmission power of the AN/SQS-53 is stated to provide longer-range capability in the surface duct mode than previous sonars.

In the bottom bounce mode the sound energy is directed obliquely toward the seabed. The energy is reflected upward from the ocean floor toward the surface at considerable distances from the ship. Submarine echoes are received via a similar return path. This method is useful in waters of more than certain minimum depths and where the seabed has the requisite favourable characteristics.

Convergence zone mode operation takes advantage of the characteristics of very deep water. The sound energy is refracted downward due to the temperature and pressure conditions near the surface, but, as depth increases, these physical effects change and the sound path alters direction to cause the energy to return to the surface in a coarsely focused convergence zone. This zone can form at great distances from the ship and provides the longest range of coverage for the sonar when the water conditions are favourable for this mode of operation.

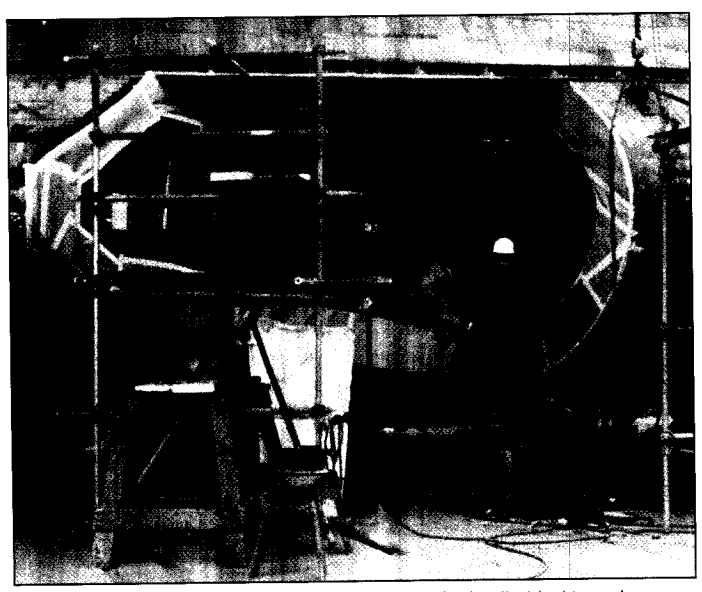
Passive detection gives the bearings of targets based on their own noise generation, rather than by echo location. It has proved a valuable method on the currently deployed AN/SQS-26 equipped ships, especially at low speed. The Spruance class destroyers and her successors have improved passive detection capabilities at higher speeds due to improved noise suppression measures. The passive mode can be operated simultaneously with the active modes.

The latest version of the system is the AN/SQS-53C Battle Group Sonar. It is a much more advanced system using 22 fewer cabinets with a consequent reduction in cabling and associated support requirements. The new version uses seven AN/UYK-44(V) computers linked together in a multiple embedded configuration. The first SQS-53C was fitted in USS *Stump* in August 1986 for evaluation purposes. Testing was completed in mid-1989. The 53C is being fitted aboard all the ships in the DDG 51 Arleigh Burke class destroyers, as well as some of the units of the Spruance class destroyers and Ticonderoga class cruisers.

The SQS-53C (which forms part of the AN/SQQ-89 combat system) incorporates a number of improvements, including a better performance in the active mode, simultaneous operation in active and passive mode, multiple target automatic tracking and improved displays. The sonar array of the AN/SQS-53C uses piezoelectric ceramic materials produced by EDO Corporation. The system's ability to provide small object avoidance capability inshore has also been enhanced by the Kingfisher system (see entry on Kingfisher). The enhancement was successfully used by a number of ships during Operation Desert Storm.



Bow housing of AN/SQS-26 sonar



Bow dome cutaway showing partial view of AN/SQS-53 cylindrical transducer

Operational status

The SQS-53 is installed in all ships of the DD 963 Spruance class destroyers and in all 27 ships in the CG 47 Ticonderoga class cruisers (either in A, B, or C variants).

In 1992, Northrop Grumman was awarded the contract for all production and system design agent services for the SQS-53C as part of its SQQ-89 integrated surface ship ASW combat system.

Contractors

Lockheed Martin Naval Electronics & Surveillance Systems, , Syracuse, New York.

Northrop Grumman Corporation, Electronic Sensors and Systems Sector, Oceanic and Naval Systems, Maryland.

UPDATED

AN/SQS-56/DE 1160 Sonar

Type

Hull-mounted active and passive sonar system.

Description

The AN/SQS-56 is a modern hull-mounted sonar developed as a company-funded product by Raytheon Electronic Systems for the US Navy's Oliver Hazard Perry class frigates. The US Navy has provided the AN/SQS-56, via the Foreign Military Sales (FMS) programme, to Saudi Arabia for its PCG ships, to Australia for its FFG-7 class frigates and to Turkey for its MEKO 200 programme. Versions commercially exported with the designation DE 1160 are operational on the Italian Navy's Lupo class frigates and the Spanish, Moroccan and Egyptian navies' Descubierta class frigates and are being considered for installation in new construction ASW ships of several other navies. The DE 1160, when configured with 36 kW transmitters, is identical to the AN/SQS-56. Outfitted with a VDS array and handling subsystem, it becomes Raytheon's DE 1164 sonar (see DE 1164 entry) and is installed in the Italian Navy's Maestrale and Alpino class ships.

The DE 1160, when equipped with a larger, low-frequency transducer array and three additional transmitter cabinets, is designated DE 1160LF and is capable of convergence zone performance. The DE 1160LF was delivered to the Italian Navy for the helicopter carrier *Giuseppe Garibaldi* early in 1984. This system has also been ordered by the Spanish Navy and will upgrade its Baleares class frigates.

A VDS version of the DE 1160LF will combine the convergence zone performance of the *Garibaldi* sonar with the environmental adaptability of the DE 1164 under the denomination DE 1164LF, a sonar system for major ASW combatants. This system is installed on the Italian Navy's De La Penne class ships (see DE 1164 entry).

The AN/SQS-56 sonar features digital implementation, system control by a built-in mini-computer and an advanced display system. Digital implementation allows packaging of the complete multifunction active and passive sonar in five medium-size electronics cabinets and one operator's console. Computer-controlled functions provide a system which is extremely flexible and easy to operate. The computer is also used to provide automated fault detection and localisation and a built-in training capability. The human-engineered display ensures proper interpretation by operators, even by those with relatively low levels of training.

Operating in the 6.7, 7.5 and 8.4 kHz bands with a bandwidth of 400 Hz the direct path DE 1160 operates in either FM or CW mode. The 36 slave transducer produces 36 preformed beams in a variety of transmission modes with pulses ranging from 5 per second to 2,180 per second over a 20 to 120° sector at source level ranging from 218 to 232 dB.

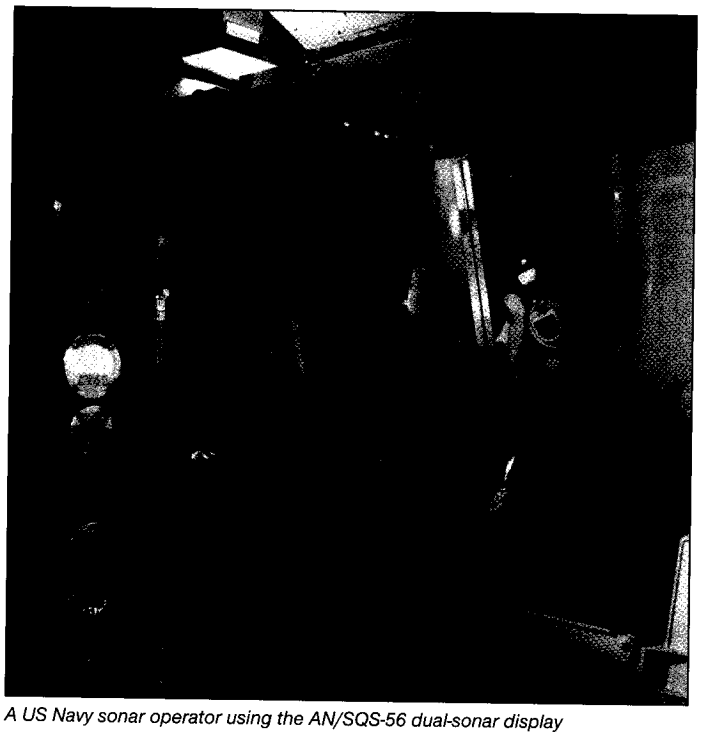
The sonar is an active/passive, preformed beam, digital sonar providing panoramic echo ranging and panoramic (DIMUS) passive surveillance. All signal processing, except transducer received signal amplification and linear transducer transmit drive, is accomplished in digital hardware, most of which is implemented using US Navy SEMP (Standard Electronic Module Programme) components in compact water-cooled cabinets small enough to allow installation through standard-size hatches. All visual data are presented on flicker-free, digitally refreshed television-type raster scan CRT displays. Complete symbol and alphanumeric facilities are included. System timing, control and interface communication are accomplished by a general purpose mini-computer which is a component of the basic system. Both 400 Hz synchro and MIL-STD-1397 Type A or C, Cat. II digital interfaces are available in the basic sonar system. Except for the 400 Hz synchro reference power, the entire sonar operates from 440 to 480 V, three-phase 60 Hz ship's power.

The basic system includes the transducer array, transducer junction box, five electronics cabinets (array interface, transmitter(s), receiver and controller), operator console, sonar dome and control unit. Options in production include a loudspeaker/intercom, a water-cooling unit, a remote display and a performance prediction subsystem.

A single operator can search, track, classify and designate multiple targets from the active system while simultaneously maintaining anti-torpedo surveillance on the passive display. Computer-assisted system control permits the operator to concentrate on the sonar data being displayed rather than on the system control.

Operational status

Approval for service use was issued early in 1980 by the US Navy following successful completion of final operational test and evaluation. By 2003, ship systems in service included 33 systems for USA (AN/SQS-56 – Oliver Hazard Perry class); four systems for Australia (AN/SQS-56 – Adelaide class); four systems for Saudi Arabia (AN/SQS-56 – Badr class); 7 systems for Turkey (AN/SQS-56 – Oliver



A US Navy sonar operator using the AN/SQS-56 dual-sonar display

Hazard Perry class);two systems for Poland (AN/SQS-56 - Oliver Hazard Perry class); one system for Bahrain (AN/SQS-56 - Oliver Hazard Perry class); four systems for Egypt (AN/SQS-56 - Oliver Hazard Perry class); one system for Italy (DE 1160 - *Giuseppe Garibaldi*)); 13 systems for Spain (DE 1160 - Santa Maria class (6 units), Baleares class (5 units)); one system for Morocco (DE 1160 - Descubierta class); eight systems for Taiwan (DE 1160P - Cheng Kung class) and eight systems for Turkey (DE 1160 - Barbaros class (4 units), Yavuz class (4 units)).

Contractor
Raytheon Company, Naval and Maritime Systems, Portsmouth, Rhode Island.

UPDATED

Improved DE 1160

Type
Hull-mounted active and passive sonar system.

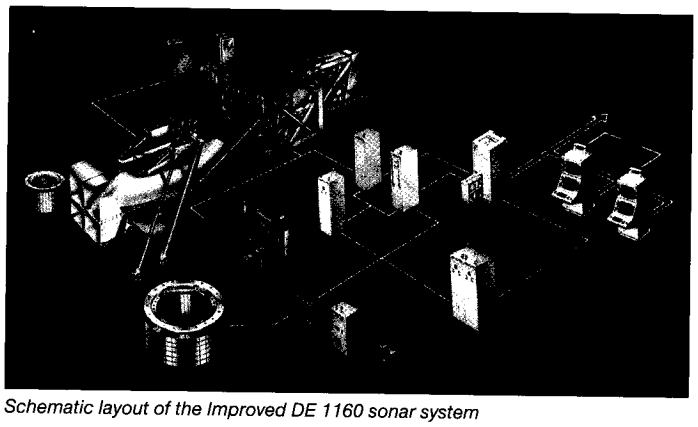
Description
The Improved DE 1160 is a derivative of the successful AN/SQS-56 and DE 1160 Series sonars produced by Raytheon. The system utilises the same active transducers and transmitters of the DE 1160 sonar and incorporates an open architecture processing and display system using colour display processing. All the systems developed under the DE 1160 and DE 1167 Series (3.75 kHz, 7.5 kHz and 12 kHz systems) can be upgraded to this newer technology. The sonar is available in 3.75 kHz, 5.0 kHz, 7.5 kHz and 12 kHz transmit frequencies and can be provided with optional active towed transmit and receive arrays. In addition to the hull-mounted systems, this system can also be implemented in a VDS mode.

The standard 7.5 kHz Improved DE 1160 features a cylindrical active/passive hull-mounted 36 stave array with 288 individual transducers. Sound pressure level is 232 dB provided by two equipment cabinets containing 36 kW transmitters. An array interface cabinet processes the signals from the transducers. A single digital processing cabinet provides all the hardware and software for signal processing. The sonar can be configured to provide total beam stabilisation. In this configuration the preamplifiers are located within the digital processor unit. There are 288 individual amplifiers, one for each transducer. The 36 staves are modified and power is applied to each individual transducer.

The 3.75 kHz hull-mounted version transmits a sound pressure of 238 dB through 216 transducers mounted in 36 staves using three additional transmitter cabinets to provide the extra power.

The VDS configuration uses an additional interface unit to process signals from the VDS array. The VDS operates at 7.5 or 12 kHz. Ships using the 7.5 kHz array usually operate with a 3.75 kHz hull mounted array to provides the best ASW coverage in all water conditions.

The Improved DE 1160 system features automatic computer-aided detection and tracking, multiple simultaneous receivers for enhanced shallow water performance, a small object avoidance capability (Kingfisher) which was demonstrated in Operation Desert Storm and colour displays. The system also integrates a torpedo detection function. Geographic stabilised PPI displays and B-scan displays are used for detection and enhanced A-scan and range-crossrange windows are used as classification aids displaying target Doppler. A rapid replay feature is provided to allow the operator to evaluate target motion and discriminate against false alarms. The system has the ability to replay up to 20



Schematic layout of the Improved DE 1160 sonar system

pings from memory for classification analysis. Optional features include sonobuoy processing, integration of non-acoustic sensors and torpedo alert.

The design of the system is implemented in ruggedised COTS hardware which can be either water-cooled or air-cooled. The Digital Processor Unit (DPU) is composed of a number of separate, dedicated processors connected with the redundant system-wide pair of Ethernet buses. Each processor within the DPU contains a multipurpose module set in a VME baseplate. Modules are designed in the 6U Eurocard format and are based on industry standards — many are available as third party off-the-shelf modules. The system runs on Motorola Power PC general purpose processors and Mercury Quad Power PC digital signal processors.

All software is developed to DOD-STD-2167A requirement and a Raytheon standardised development methodology.

Specifications
Transmit frequencies: 3.75 kHz, 5 kHz, 7.5 kHz, 12 kHz
Source level: 232 dB @ 7.5 kHz, 238 dB @ 3.75 kHz
Transmit modes: TRDT, SRDT, WRDT and OMNI
Pulse length: 12-1,000 ms
Bandwidth: 500-2,000 Hz
Beamwidth: 10°
Resolution: 1.25°
Waveform: FM/CW

Operational status
A prototype system was tested aboard the Italian frigate *Grecale* in the Summer of 1994. The Improved DE 1160 LF hull-mounted version is equipping the new Alvaro de Bazan class frigates of the Spanish Navy.

Contractor
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

DE 1164

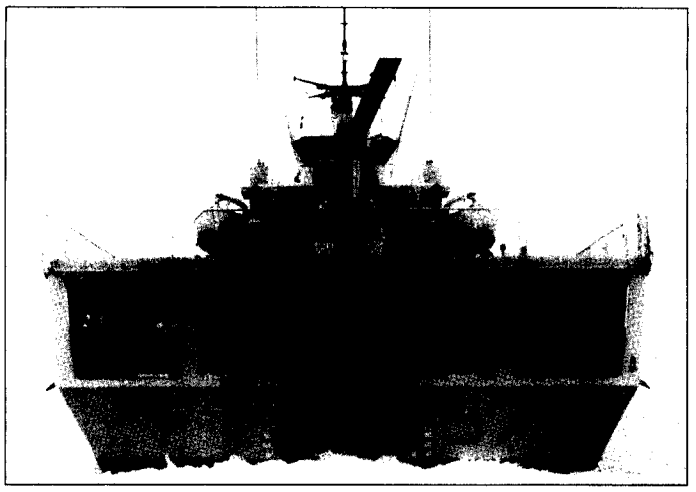
Type
Hull-mounted/variable depth sonar system.

Description
The DE 1164 sonar consists of the Raytheon DE 1160 hull-mounted sonar augmented by a fully integrated variable depth sonar subsystem. All sonar functions of the DE 1164 are identical to those of the DE 1160. However, the DE 1164 provides transmission and reception via various combinations of the hull-mounted and/or the towed Variable Depth Sonar (VDS) transducer arrays. Addition of the VDS subsystem improves overall sonar operational flexibility and allows the VDS transducer array to operate at acoustically favourable depths and in a much quieter environment.

In addition to the components of the full DE 1160 hull-mounted system, the DE 1164 includes one extra cabinet of electronics, a VDS towed body with associated cable and the electrohydraulic mechanism associated with launching, towing and retrieving the VDS body. The VDS handling equipment provides for one-man operation for launching and retrieving and unattended no-power towing. For reliability, two independent hydraulic power supplies are provided, either of which may support the entire operation; an emergency retrieval system is also available as an option. VDS body weight, cable size, length and careful attention to drag, provide a VDS depth capability of 300 m at 28 kt of ship's speed.

Both the hull-mounted (3.75 kHz) and VDS (7.5 kHz) arrays use the common set of DE 1160 transmitting, receiving, and display electronics. Selection of the particular combination of transmit/receive array functions is ordered by the operator via the sonar console input keyboard; the system computer then sets up the required sequence. Alphanumeric symbols on the display inform the operator about which particular array is in use during any specific ping-cycle.

During normal operation, the power requirements of the DE 1164 are identical to those of the DE 1160C. A maximum of 74 kW additional power is required from the 440 V, three-phase, 60 Hz power mains during VDS retrieval or launching.



VDS configuration of DE 1164 sonar on the Libeccio *of the Italian Navy*

The hull-mounted sonar may be operated as a DE 1160 when the VDS is stowed or being launched/recovered.

The sonar has been upgraded to give an improved shallow water performance and an HF active capability for mine detection.

Operational status

A total of 10 DE 1164 systems have been delivered to the Italian Navy and are in operational service on one Alpino and eight Maestrale class ships. Further deliveries include a VDS trainer and two DE 1164LF systems, which are in service aboard the Italian Navy De La Penne class guided missile destroyers. The primary electronics system for the latest DE 1164LF award were built in Italy under co-production and licence agreements. The mechanical hoist was built by Fincantieri Naval Shipbuilding Division in Genoa and part of the transmitter and transducers by Elsag and its subsidiaries.

Contractor

Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

DE 1167

Type

Hull-mounted and variable depth sonar systems.

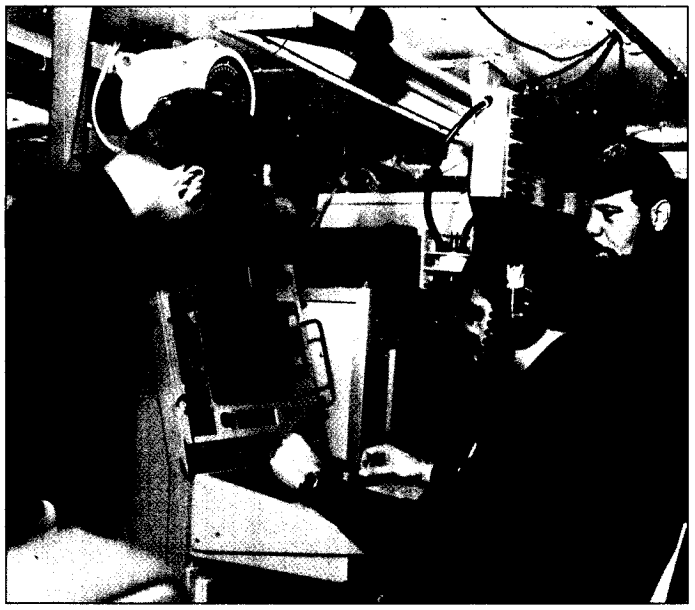
Description

Raytheon's DE 1167 family of sonars implements the proven features of the AN/SQS-56/DE 1160 systems using advanced microprocessor architecture and state-of-the-art display and transmitter technology. The DE 1167 series is based on large size modules and air-cooled cabinets, which permit the production of smaller, simpler, cheaper sonar systems and facilitate in-country manufacturing/repair participation where required. The DE 1167 family is designed to satisfy the requirements of most ASW platforms and missions. Configurations include hull-mounted, VDS and integrated HM/VDS systems, featuring a 12 kHz VDS and either 12 or 7.5 kHz hull-mounted 36 stave 122 cm transducer arrays. Configurations using 48 stave arrays or a frequency lower than 7.5 kHz are possible.

Like the Raytheon DE 1160B/C and DE 1164 sonars, the DE 1167 features primarily digital electronics and an advanced control and display system. The standard inboard electronics consist of three cabinets and a single operator console. Outboard units consist of a transducer array and 2.74 m long dome for the hull-mounted 12 kHz installation (4.17 m long dome for 7.5 kHz) and/or the VDS winch, overboarding assembly, control station, hydraulic power supply, faired cable and towed body for the 12 kHz variable depth subsystem.

The basic DE 1167 HM is an active/passive, preformed beam, omni and directional transmission sonar which uses three non-interfering 600 Hz wide FM transmission bands, centred at 12 or 7.5 kHz and has a spatial Polarity Coincidence Correlation (PCC) receiver. A half-frequency simultaneous PCC receiver (bandwidth 3 to 8 kHz) is also part of the system. The passive mode, which is selected automatically when transmissions are stopped, is primarily useful for torpedo detection. Optional items in production include: a performance prediction subsystem, an auxiliary display, a remote display and a training/test target remote-control unit. Signal reception and beam-forming are accomplished by broadband analogue circuitry followed by clipper amplifiers for perfect data normalisation. Detection processing, display processing, system control/timing and waveform generation are done digitally. Two microprocessors perform display ping history, cursor ground stabilisation and target-motion estimation functions for torpedo direction. The modular air-cooled 12 kW transmitter uses highly efficient class A/D power transistor techniques.

Several operational features are unique to a sonar of this size and range. First, the display processing incorporates a ping history mode through which the sonar data obtained in three of the previous ping cycles may be retained on the viewing surface, allowing the operator to differentiate readily between randomly spaced



Operator's display/control console of Raytheon DE 1167 sonar

noise events and geographically consistent, valid acoustic reflectors. Secondly, the clipped PCC processing permits accurate thresholding of all signals such that the false alarm rate, or number of random noise indications on the screen, remains relatively low and constant over all variations in background noise and reverberation levels, further facilitating contact detection. Thirdly, ground-stabilised cursors and target motion analysis permit rapid determination of contact motion over the bottom, an excellent clue as to the nature of the contact. These three operational features, combined with extremely accurate tracking displays, a built-in fault detection/localisation subsystem, performance verification software and test/training, result in a high-performance system which is easy to operate, maintain and support.

Operational status

Eight Minerva class corvettes of the Italian Navy are equipped with the DE 1167 sonar, and nine Ulsan class frigates of the South Korean Navy.

Specifications

Centre frequency: 12 kHz (HM and VDS), 7.5 kHz (LF and HM) (7.5 kHz in Italian ships)
Source level: TRDT 227 dB (HM), omni 217 dB
Pulse type: 600, 2,000 Hz FM sweep; 100, 200, 50, 6 ms pulse lengths
Receiver type: Spatial Polarity Coincidence Correlator (PCC) between 36 pairs of half-beams
Beam characteristics: 36 sets of right and left half-beams for active and passive detection. Selectable 10°H × 13°V sum beam for audio listening (15° horizontal × 12.5° in Italian ships). 1.25° bearing interpolation for fine search display Selectable 24° horizontal × 21° vertical passive sum beam for audio listening. 2.5° bearing interpolation for display
Active display: 300 range cells, 288 bearing cells; single and multiple echo history; 4 intensity levels; flicker-free, bit-image memory technique
Passive display: Electronic Bearing Time Recorder (EBTR) with medium time averaging. DIMUS-type LTA/STA with optional passive receiver (passive receiver fitted in Italian ships)
Track displays: Sector scan indicator (1,000 yd × 10°) and target Doppler indicator (1,000 yd × ±60 kt)
Target data: range resolution: 6.1 m. Bearing 1.25° resolution plus active search display – 0.1° and 3.3 yd on SSI display. ±60 kt of Doppler at 1 kt steps on the TDI
Data format: standard: NTDS ANEW slow (digital). Optional: NTDS slow, Fast Serial D/S synchro converters
Power requirements: passive 800 W. Active 20 kVA (pulsed) at 10% (max) (15% in Italian ships) duty cycle 440 V, 60 Hz, 3-phase, VDS launch/retrieve 75 kVA (max) 440 V, 60 Hz, 3-phase
Weights: Hull-mounted 12 kHz; 1,500 kg (nominal); VDS 10,000 kg (nominal) with 200 m cable length (Italian ships 7.5 kHz transducer 1,600 kg; GRP dome 750 kg)

Contractor

Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

DE 1191

Description

The DE 1191 sonar upgrades and improves the performance of older AN/SSQ-23 and AN/SQS-23 sonars which are being used by navies worldwide aboard numerous FRAM II destroyer class ships.

The DE 1191 features advanced inboard electronics which, when coupled with the existing AN/SQS-23 dome and array, comprise a newly configured, lightweight

system with the capability to outperform most current modern surface ship sonars. The AN/SQS-23 is a sonar of 1950s design. The system has the potential for excellent performance, with a large low-frequency transducer array situated in a quiet location and on a relatively quiet platform.

Replacement of the AN/SQS-23, inboard electronics with DE 1191 hardware, a solid-state transmitter and a modern receiver/display subsystem, eliminates weight totalling 12 tons and reduces onboard space requirements by 450 ft³.

This massive equipment reduction greatly enhances long-term reliability, maintainability and logistic support for both transmitter and receiver/display functions. Furthermore the DE 1191's computer-assisted receiver/display, a slight modification of Raytheon's DE 1167 receiver/display, has notably superior detection range and operability features, resulting in an impressive 14 dB improvement in sonar performance. Operating frequency is 5-7 kHz.

DE 1191 inboard electronics are solid-state, ensuring a longer and more economical life cycle as compared to the vacuum tubes currently used by AN/SQS-23 systems. Improved equipment and the reduction in hardware minimise the need for large and costly spare part inventories, both on board and at depot. In direct contrast to the AN/SQS-23, where spare inventories are soon to be completely phased out by the US Navy, the DE 1191 equipment is common to several other Raytheon sonars and availability is guaranteed for 20-30 years.

Modernisation can be achieved incrementally in two major stages: the Solid-State Transmitter, or SST, which is always installed first and later the receiver/display – or all at once, as time and funding permit. The DE 1191's streamlined configuration will reduce both time and expense necessary to conduct maintenance and operator training.

The modern integrated circuits of the DE 1191, proven system techniques and high-volume production have all contributed to low-cost equipment that is economical to support. It is available to the international market directly through Raytheon or, via foreign military sales (FMS) arrangements with the US government.

Operational status
In production. The DE 1191 has replaced the SQS-23 in the two Greek destroyers of the Charles F Adams class. The vessels use the existing AN/SQS-23 dome and array, but are fitted with lightweight electronics.

Contractor
Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

HAS-2154

Type
Hull mounted LF sonar.

Description
Developed from the USN AN/SQS-53C hull-mounted sonar, the HAS-2154 active/passive sonar is designed to meet multimission requirements in both open ocean and shallow water environments.

Using a 5.4 kHz transducer design, the HAS-2154 provides long range underwater search and surveillance, detection, tracking, localisation and classification, torpedo alert and mine detection and avoidance capabilities.

The system uses a number of menu-controlled operating modes and sub-modes to meet the demands of various tactical situations. Included among these are simultaneous active/passive operation, multiple frequency band allocations, and waveform signal processing and display enhancements. The waveforms can be matched to cover the type of threat anticipated and the sea state likely to be encountered. The transmit and receive beams can be steered vertically to optimise performance and are fully stabilised to compensate for roll, pitch and yaw.

Other features include computer-aided detection, automatic target tracking, and automatic contact management.

HAS-2154 (5.4 kHz) range of array sizes

Number of staves	Diameter	Total weight of transducers*	Relative performance
36	1.6 m	2,100 kg	0.0 dB
54	2.4 m	3,100 kg	+5.3 dB
72	3.2	4,200 kg	+9.0 dB

* Total weight for a 1.09 m tall, eight layer array

Operational status
Development completed.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

VERIFIED

Kingfisher

Type
Small obstacle avoidance sonar modification.

Development
Initiated in 1988, Kingfisher has been developed using COTS technology to modify hull-mounted sonars to provide command teams with surveillance data to enable them to safely navigate around hazardous small objects such as mines. The initial model of Kingfisher was an analogue hardware unit developed for the 'Oliver H Perry' (FFG 7) class AN/SQS-56 sonar in response to the mine threat highlighted when the *Samuel B Roberts* (FFG 58) struck a mine in the Persian Gulf in April 1988. The first prototype kit was successfully tested aboard the USS *Halyburton* (FFG 40) just four months after the *Samuel B Roberts* incident.

Subsequently, six copies of an enhanced second-generation AN/SQS-56 prototype were built and tested aboard Oliver H Perry class frigates in the Persian Gulf.

Description
Initial Kingfisher modification kits provided 30° of coverage in three 10° beams and modified the sonar's transmit and receive characteristics to enable own ship detection of small objects. The adaptation featured a short pulse with a high repetition rate and multiping history. An additional feature of the initial modification kit used a unique colour display format and GPS navigation that allowed the sonar system to distinguish between stationary and non-stationary objects in shallow water and high reverberation.

The system incorporates minor hardware and software modifications to adapt to COTS equipment an HP9000 Model 360 computer, modifying certain parameters to provide mine-like object detection capability.

The initial kits were followed by a further modification (referred to as SWAK – Shallow Water Active Kit) which featured additional display features and an expanded search sector covering 90°. Subsequent modifications allowed the SWAK workstation to be plugged directly into the ship's sonar system rather than having to remove parts of existing hardware to install Kingfisher.

Further modifications were then introduced to enable Kingfisher to be used with the SQS-53A and SQS-53B sonars.

The latest development is a modification to allow Kingfisher to be installed with the SQS-53C sonar integrated within the AN/SQQ-89 system. This allows all US Navy surface ships with a primary ASW mission to be Kingfisher capable. This purely software modification features a short pulse length and a wide bandwidth within the 'variable depression' mode of the SQS-53C. This modification provides 120° coverage using three overlapping 45° sectors, each of nine beams. Kingfisher allows for short range scale (2.25, 4.5, 9 and 18.3 km) selections which provide rapid display updates for close-in detection.

The latest upgrades to the SQS-53A/B and SQS-56 sonars feature a laserplot electronic navigation system. Defense Mapping Agency CD-ROM charts are fed via desk-top computer to the WRN-6 satellite navigation receiver which allows charts to be presented on colour displays on sonar consoles and on the bridge. This allows contacts/objects to be immediately localised in a position relative to own ship as well as in latitude and longitude co-ordinates.

Operational status
Kingfisher uses existing hull-mounted AN/SQS-56, SQS-26 and SQS-53 series sonars. A modification kit is operational with the SQS-53C variant and has been incorporated into the SQS-53D. It remains an informal modification kit for the AN/SQS-56. The system is being installed and is operational with the Arleigh Burke Flight I/II/IIA class destroyers and as funds are made available is being retrofitted to the AN/SQS-56 sonar on the Oliver Hazard Perry class frigates.

Contractor
Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

LBVDS

Type
Lightweight broadband variable depth sonar (LBVDS).

Development
In the United States the programme executive office for mines and undersea warfare is managing the evolution of sonar array transducer technology. It is hoped this technology will provide sufficient acoustic energy to drill through ocean layers that typically distort or refract sonar signals through changes in temperature, salinity and current flow to enable the formation and capture of high resolution, extremely precise acoustic images of underwater submarine targets.

Under this research, conceived in the early 1990s, the LBVDS is being researched in a towed body configuration. The result may be selected for the new DD-21 design currently under consideration.

The LBVDS will combine and apply three new technologies – broadband signal generation and processing, energy-dense materials and sparse receiver line arrays. The broadband waveforms of the sonar are being designed to mitigate the limiting effects of underwater acoustic characteristics resulting from bottom and

surface interactions, which lead to high levels of reverberation and mixed multipath propagation effects.

Funded by the Office of Naval research, the LBVDS design uses a new ceramic-type material (lead magnesium niobiate (PMN)) for the transducers. When an electric current stimulates this material it emits a considerably stronger acoustic signal than current PZT materials. PMN is also substantially lighter than PZT materials. Thus, it is considered that PMN will be able to generate high power acoustic signals, which would allow broadband transmission across a large number of frequencies covering approximately the 1 to 6 kHz frequency band. Not only will broadband transmission overcome the anomalies created by the ocean layers in deep water, but in shallow water (the littoral) it will also overcome the problems of interference resulting from reverberation arising from interfacing of the acoustic signal with the bottom and surface.

The Programme aims to meet a number of key performance targets including a 20 to 30 dB improvement in active sonar detection and classification against a low-Doppler sub-layer target in shallow water. Other targets include detection ranges in the 12 to 15 n miles range, combined with a large probability of detection (<0.9) and a low false alarm rate of one per day.

As part of the research Lockheed Martin, Naval Electronics and Sensor Systems at Syracuse is acting as a prime contractor for the LBVDS effort, while the Company's missiles and space unit in California is providing the array components.

A second broadband programme is underway at L-3 Communications Ocean Systems group where the Tsunami (see separate entry) sonar is being developed. This sonar is being prepared for possible selection for retrofitting to the 'Oliver Hazard Perry' class.

Operational status
A prototype LBVDS system was tested at sea during 2001-02 using the new AN/SQQ-89(V)15A towed array as the receiver.

Contractors
Lockheed Martin, Electronics and Surveillance Systems, Syracuse, New York.
Nav Sea, Naval Undersea Warfare Center, Newport, Rhode Island.

UPDATED

LFATS

Type
Low-Frequency Active Towed Sonar (LFATS).

Description
LFATS uses technology derived from the HELRAS helicopter dipping sonar and comprises a towed body integrating separate transmit and receive arrays operating at 1.38 kHz, a compact integrated winch and handling system and inboard processing subsystem. The inboard electronics comprise the transmit power amplifier providing a very high source level and sonar processing units which are designed around an open architecture configuration to allow future technology and performance improvements to be embodied using COTS components. The transmit array consists of 16 compact projector elements contained in the body of the towed vehicle. An innovative array extension and retraction mechanism enables the system to develop high transmit directivity. Return signals are received by up to four small diameter liquid filled linear towed arrays. Convergence zone capabilities have been proved and trials have shown the system to have an extended detection range capability in excess of 30 miles. Processing involves multiple ping wavetrains, multidimensional target clustering and averaging, target discrimination against high background noise in shallow water environment, own ship noise cancellation, Doppler nullification and CW and HFM wavetrain generation and processing.

Two variants are available, a heavier unit which incorporates a high-powered winch to tow the system at 15 kt for installation in frigates, and a lighter unit for installation on smaller vessels down to 100 tonnes. The array and handling system weighs 3.3 tonnes.

The low frequency results in a very long wavelength which should not be affected by any internal acoustic treatment in the submarine and is able to penetrate any currently known acoustic treatment.

The sonar is capable of very high resolution of very low Doppler.

The sonar is able to operate at depths between 15 and 300 m.



LFATS undergoing sea trials. Note the linear towed arrays extending from the fairing on top of the body (Photograph courtesy of L3 Communications) 0007235

Operational status
Contractor trials have been undertaken and a demonstration unit has begun to carry out in-water demonstrations.

Specifications
Source level: 219-222 dB/1μPa (omnidirectional)
Frequency: 1.38 kHz
Operating speed: 3-15 kt
Survival speed: 30 kt
Operating depth: 15-300 m (15-100 m @ 15 kt)
Weight: 3,250 kg (array and handling system)

Contractor
L3 Communications, Ocean Systems, Sylmar, California.

VERIFIED

Model 610 sonar

Type
Hull-mounted active sonar system.

Development
The Model 610 was developed by the EDO Corporation as a private venture starting in 1965. The first prototype was completed in 1966 and the first production model completed its sea trials in 1969. The Model 610 has been continuously improved and the 610E model is of solid-state construction.

Modernisation packages are now offered which are based on advances made in the EDO Model 780 Series and the US Navy AN/SQR-18A(V)3 active receiver. These incorporate items such as operator selectable three-frequency operation, raster displays, digital scan switches, performance prediction and new console switches.

The latest improvement package, which is identified as the Model 997, incorporates modern COTS digital signal processing and colour display technology. The Mod 1 variant upgrade replaces the receiver/processor/display portion of the system and reduces the system manning requirement to one operator. This improvement upgrade is being used to upgrade the Brazilian Niteroi class 610 sonars which started in 1998.

Description
Designed for the long-range detection of submarines in deep and shallow water, the EDO Model 610 36-stave, scanning sonar has two active consoles, enabling it to perform a search-while-track function. Facilities offered include a search capability in three 120° sectors, passive correlation, and reverberation processing. The transmitter and receiver beams are preformed. Output is available for a fire-control system. All mode changes and range scale changes are controlled by console push-buttons, and displays include a Doppler display on each of the active consoles and a passive sonar bearing time recorder display.

Operational status
Developed in 1965, the basic system is no longer in production. Model 610 systems are in operational service with: the six ex-Netherlands Van Speijk class frigates of the Indonesian Navy (as the CWE 610), the two Italian Audace (as the CWE 610), the four Peruvian Lupo class frigates, four Venezuelan Lupo class frigates (in a modified version as the SQS-29), and a modified variant is also in service on the ex-Dutch Poolster class replenishment oiler of the Pakistan Navy.

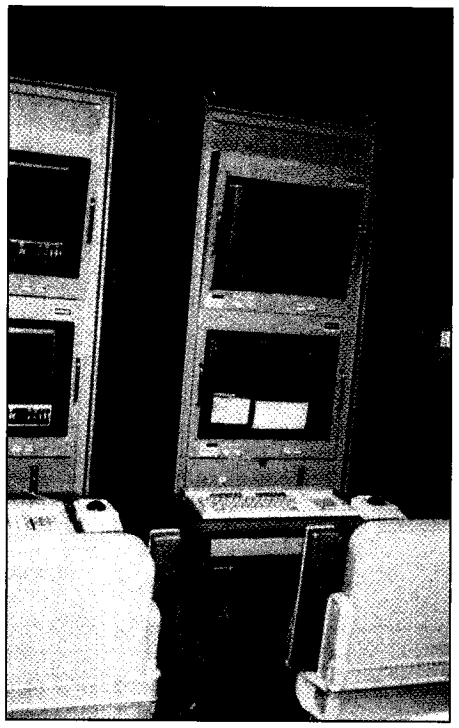
Contractor
EDO Combat Systems , Chesapeake, Virginia.

VERIFIED

Model 700 series sonars

Type
Hull-mounted and variable depth sonar system.

Development
Like the Model 610, the Model 700 series was developed by the EDO Corporation as a private venture for sale on the international market. Modern upgrades are available using the latest in digital signal processing and display hardware and software techniques. These upgrades have a high degree of commonality with the EDO Model 610E-Mod 1 sonar modernisation and have been given the designation of EDO Model 983 and Model 993.



Typical colour standard console used on new system configurations of the EDO Model 610/700/780 Series

Description
The model 700E is a medium-range hull-mounted sonar. The Model 700/702 hull-mounted VDS uses common 700E electronics with a hull-mounted transducer and a lightweight VDS hoist. Selection of hull-mounted or VDS operation is by push-button on the operator's console. The Model 700/701 is a VDS which provides a capability to detect deep targets when bathythermal conditions are unfavourable for hull-mounted sonars.

The basic equipment has a 254 mm panoramic CRT display and a Doppler display. All mode and range scale changes are made by push-button controls on the operator's console.

Operational status
The basic system is no longer in production having been replaced by the Model 997 for the hull-mounted sonar and the Model 980 ALOFTS. Model 700 sonars are in operational service with the Brazilian Navy on two ASW frigates of the Niteroi class.

Contractor
EDO Combat Systems , Chesapeake, Virginia.

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Model 780 series sonar

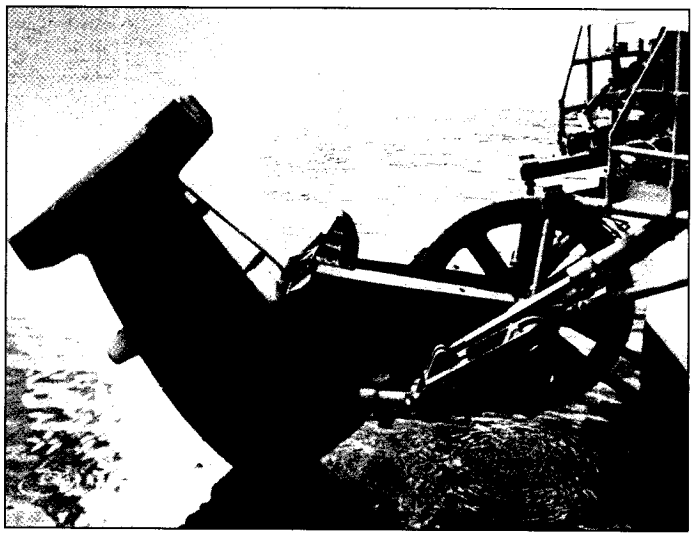
Type
Hull-mounted and variable depth sonar systems.

Development
The Model 780 series has been developed by the EDO Corporation for sale on the international market. New variants of the 780 sonar family is being offered which is designed and fabricated using latest technology COTS Digital Signal Processing (DSP) and colour display workstation hardware and software. Active sonar signal processing and operator interfaces are based on techniques developed for the US Navy's AN/SQR-18A(V)3 active receiver.

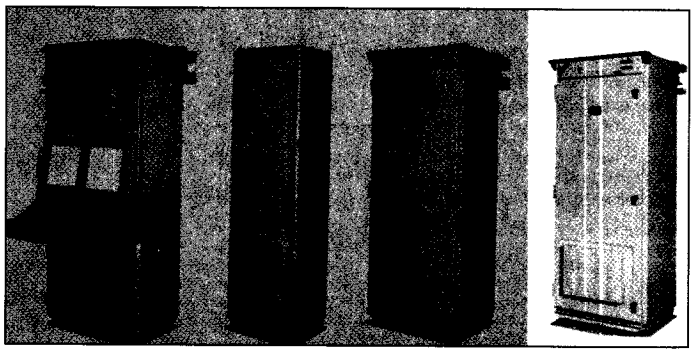
Description
The EDO Model 780 series sonar is a family of high-performance computer-based sonars designed to maximise the ASW capability of ships ranging from high-speed patrol craft to ASW frigates. Configured as a modular system, the Model 780 series can be assembled to match ship size constraints and required ASW capability for hull-mounted or variable depth sonar operation. The following models are available:

- **780:** 13 kHz Variable Depth Sonar (VDS)
- **786:** 13 kHz hull mounted
- **795:** 5 kHz hull mounted
- **796:** 7 kHz hull mounted
- **7860:** combined 13 kHz hull mounted with 13 kHz VDS
- **7867:** combined 13 kHz hull mounted with 7 kHz VDS
- **7950:** combined 5 kHz hull mounted with 13 kHz VDS
- **7960:** combined 7 kHz hull mounted with 13 kHz VDS
- **7967:** combined 7 kHz hull mounted with 7 kHz VDS.

The system features simultaneous active and passive search, tracking and classification. The operator can conduct 360° active/passive search operations while automatically tracking and analysing targets of interest. Display formats include: panoramic B-scan detection; panoramic B-scan tracking and identification; expanded range versus speed target Doppler indicator; expanded range versus bearing sector scan indicator; 360° passive bearing versus time search; expanded passive bearing versus time bearing deviation indicator; passive analysis target noise indicator; and acoustic performance ray path plots. Alerts of hostile sonar emissions detected by the integral acoustic intercept receiver are prominently presented on the displays. A variety of transmission modes allows the operator to select the appropriate transmission mode for the tactical situation.



780 series VDS



Model 780 sonar system equipment comprising sonar control console, data storage and control, transmitter/power supply and sonar receiver

At sea tests of the new linear FM coherent signal processor have resulted in exceptional long-range detections under difficult high-reverberation, shallow water conditions.

The Model 780 series' electronics are designed for flexibility. The latest Model 796 Mod 1 sonar has been adapted to use a customer furnished standard console in place of the original control console. This system incorporates the latest improvements, among which are automatic multiple target tracking, multicolour display, increased target capacity and flexible software-based display formats.

The VDS versions have exceptionally lightweight handling systems which permit installation on ships as small as 250 tons. The Model 787 features a new design compact 7 kHz transducer which has the same weight and dimensions as the 13 kHz Model 780. This provides for greater detection ranges without the weight and space penalties associated with conventional 7 kHz VDS systems. The Model 780/787 VDS tow body is very similar to the AN/SQS-35 tow body and is therefore capable of towing the AN/SQR-18A(V)1 tactical towed array system.

The combined hull-mounted/VDS systems are also single-operator systems. The combined electronics allow the one operator to simultaneously operate both the hull-mounted and VDS sonars including VDS depth control.

Operational status
Hull-mounted and VDS versions are currently deployed operationally. The Model 780 sonar has been fitted to two of the Israeli Reshef class vessels, and the Model 796 to the three Eilat class.

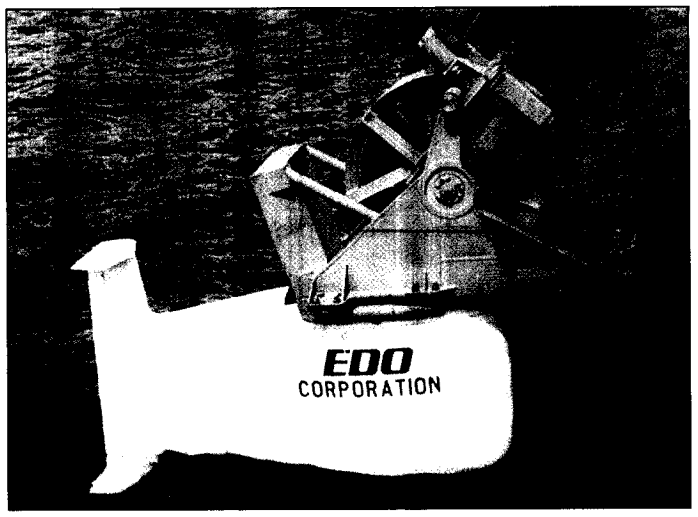
Contractor
EDO Combat Systems, Chesapeake, Virginia.

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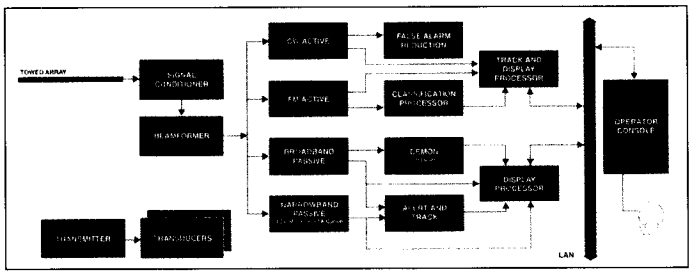
Model 980 series sonar

Type
Active LF towed array sonar system.

Development
The Model 980 Active LOw Frequency Towed Sonar (ALOFTS) Series has been developed by the EDO Corporation for sale on the international market. It uses the latest COTS/OSA hardware and software techniques. The low-frequency concept



Deployment of the towbody of Model 980 sonar (EDO Corporation) 0063177



Typical schematic configuration of Model 980 sonar (EDO Corporation) 0063176

demonstration model was developed with EDO funding and tested aboard the US Navy frigate *Aylwin* (FF 1081) in 1984. Further development was funded by the US Navy and provided as an LF triple array tow from the VDS towed body. This system was tested aboard the US Navy frigate *Glover* in 1989 and with further enhancements aboard the guided missile frigates *Vandergrift* (FFG 48) and *Clark* (FFG 11) in 1994 and 1995 respectively.

Description

The Model 980 uses the SQS-35 VDS body and a digital towed array combination which has been towed by the US Navy at speeds over 30 kt. The sonar provides simultaneous search, track and classification of targets in both active and passive modes. The systems features long range detection with observed 1st and 2nd convergence zone detections.

The Model 980 is controlled from a single console by one operator who selects one of three frequency bands from the console. Port-starboard bearing ambiguity is resolved through the use of directional transmissions. The highly directional transmissions are produced at 220 dB source level. The hardware consists of one console unit, one receiver/processor unit, transmitter units, VDS body and handling hoist, towed array and its winch. The console is a standard US Navy type workstation and is provided with two high-resolution colour monitors. Alternatively, the system can be provided with one or two flat panel type colour displays to further reduce the system footprint on small hulls. Modern COTS digital signal processors and computers are standardised for all variants. The system features simultaneous CW and FM processing and post-processing to reduce false alarms. It is optimised for both high and low-speed targets. The ALOFTS system includes automatic torpedo detection and alerting. Broadband and/or narrowband passive detection operates concurrently and utilises its own frequency band separate from the active bands, thus allowing the operator to rapidly analyse active contacts using the passive capability. The use of industry standard digital interfacing protocols simplifies the integration of the sonar with the ship's combat system.

Displays include 12 ping history active search and expanded zoom formats for each preformed beam, target classification aids, passive narrowband, passive broadband bearing/time history and tactical (geographic) format. Display overlays are provided for performance prediction, bottom topography and landmass outlines. The tactical display is formatted to easily interface to other onboard or offboard sensors using standard symbology. Full azimuth coverage is provided in broadband and narrowband. Nominal centre operating frequencies are 1.1 kHz (Model 980-1) and 1.7 kHz (Model 980-2).

Optional features include passive broadband search and track, passive narrowband search and track, passive classification using Lofar, DEMON and an onboard trainer.

High-quality COTS subassemblies are used throughout to provide a state-of-the-art system that is reprogrammable, flexible and easily upgradeable throughout its life.

Operational status

ALOFTS was recently ordered by the Singapore Navy for installation in the six 'La Fayette' frigates.

Contractor

EDO Combat Systems, Chesapeake, Virginia.

UPDATED

Model 997 series sonar

Type

Hull-mounted active sonar system.

Development

The Model 997 series has been developed for sale on the international market. The systems being offered use the latest COTS/OSA hardware and software.

Other hull sonar variants which share the identical system architecture are:

Model 993	13 kHz centre frequency
Model 993 Mod 1	13 kHz compact series
Model 995	5 kHz centre frequency
MFS-7000	7 kHz centre frequency

All variants are provided with operator selectable three-frequency band operation.

Description

The Model 997 is a nominal 7 kHz medium range, 36 stave hull sonar which is suitable for corvette and larger displacement ships. The sonar provides simultaneous search, track and classification of targets in both active and passive modes. It also offers a mine and obstacle avoidance mode and torpedo detection capability.

Three separate frequency bands are selectable from the single-operator control console providing simultaneous search, track and classification with auto tracking on up to 99 targets. A panoramic and various directional transmission modes are standard. The hardware consists of a single dual display console unit, one receiver/processor unit, a small signal conditioner interface box and two transmitter units. The console is a standard US navy type workstation and is provided with two high resolution colour monitors. All variants can be provided with one or two flat panel type colour displays to further reduce the system 'footprint' on small hulls. Major features are coherent signal processing of both FM and matched filter CW waveforms, either separately or simultaneously, demodulation of noise (DEMON) processing, mine/object detection and post-processing to reduce false alarms. Broadband passive detection operates concurrently and utilises its own frequency band below the active bands. The use of standard digital interfacing standards simplifies the integration of the sonar with the ship's combat system.

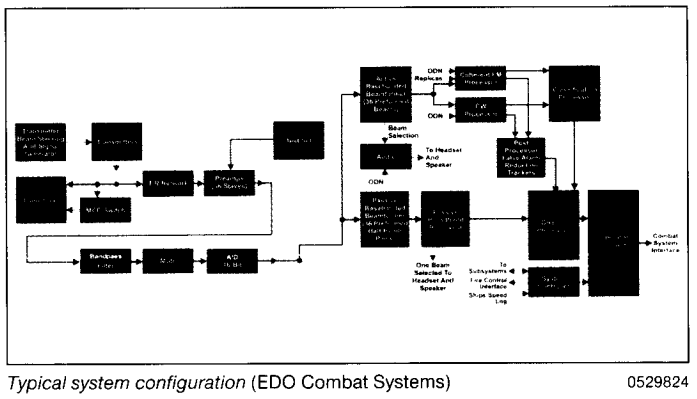
Displays include 12 ping history, active search and expanded zoom formats for each preformed beam, target classification aides, passive broadband bearing/time history and a tactical (geographic) format. Display overlays are provided for performance prediction, bottom topography and land mass outlines. The tactical display is formatted to easily interface to other onboard or offboard sensors.

Operational status

EDO, in partnership with Ultra Electronics Ltd of the United Kingdom, has been chosen by the Royal Navy to supply the MFS-7000 hull mounted sonar for the new Type 45 destroyer. The Model 997 hull sonar is also on order for four Niteroi class frigates and one Barroso class corvette of the Brazilian Navy.

Specifications (Model 997)

Parameter	**Value**
Operating frequency	
CW	6.1, 6.845, 7.9 kHz
FM (LFM/HFM)	6.418, 7.163, 7.581 kHz ± 100 Hz
FM/CW	Combined CW and ±100 Hz FM in each band
Source level	
SRDT, ARDT, TRDT	235 dB/Pa
ODT	224 dB/Pa
MCC	213 dB/Pa
Pulse length	
CM	15.625, 62.5, 250 msec
FM	62.5, 250 msec
Range scales	2, 4, 8, 16, 32 kyards
Transducer/Transmitter System	
Number of staves	36
Number of rows	10
Number of transmitters	36
Horizontal Beamwidth	10° @ 3 dB points @ 7 kHz
Vertical Beamwidth	10° @ 3 dB points @ 7 kHz
Active receiving	
Preformed beams	36
System bandwidth	963 Hz



Typical system configuration (EDO Combat Systems) 0529824

Passive receiving

Frequency	2.8 to 5.0 kHz
Preformed beams	36

Contractor
EDO Combat Systems, Chesapeake, Virginia.

UPDATED

Solid-State Transmitter (SST)

Type
Sonar transmitter subsystem.

Description
The Raytheon SST provides sonar systems with the benefits of modern, solid-state technology, offering greatly improved reliability and maintainability, plus very significant space savings relative to vacuum tube transmitters. This transmitter subsystem is made available for system modernisation or for new system applications.

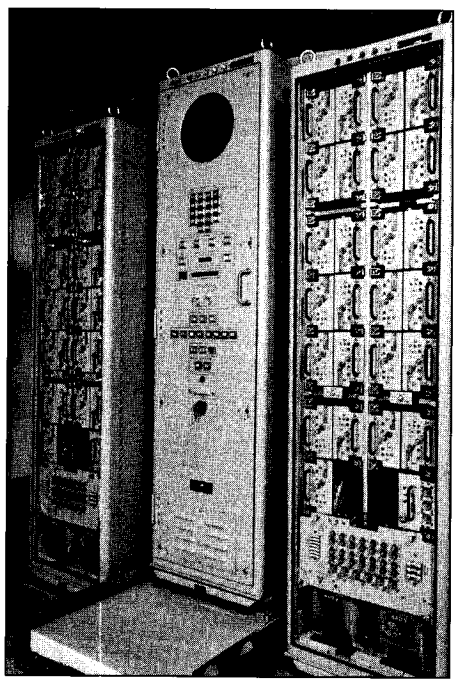
Configured to meet a specific system's requirements, the SST consists of multiple 1 kW modules with associated power supplies. As configured for the AN/SQQ-23 and AN/SQS-23 sonars upgrade, the subsystem consists of two cabinets of 24 modules each and a performance monitor/system interface cabinet. It replaces more than 30 units of the previous transmitter, including all the energy storage motor generators.

Operational status
Production includes transmitters for seven navies. Similar transmitters are used on the AN/BQS-13, AN/SQS-56, DE 1160 series and the AN/SQQ/SQS-23 sonar systems. An air-cooled version of the SST has been delivered in a programme to update the AN/BQS-4 submarine sonar.

Specifications
Standard 1 kW module (1 per channel)
Power output: 1 kW
Operating frequency: ± 1.5 kHz (nominal)
Distortion: 6% max
Load: nominal ± 100%
Duty cycle: 15%
Linearity: ± 1 dB from 0–12 dB
Gain adjustment: 3 dB
Protection: short-circuit and over-temperature
Mean time to repair: 3 min
Weight and size: 1,651 kg in 1.2 × 1.8 m of deck space
SST as manufactured for AN/SQQ/SQS-23
Power requirements: 115 V AC, 60 Hz 1-ph, 0.37 kVA, 0.92 PF; 440 V AC, 60 Hz, 3-ph, 128 kW (Max 0.9 PF)
Modes of operation
(a) transmit: same as any associated system such as omni, sector, FM or CW
(b) performance monitoring: automatic and manual
(c) self-test: receiving system not required.

Contractor
Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED



Raytheon standard sonar transmitter cabinet

SURTASS RDA

Type
Passive towed array.

Development
In December 1987, a contract was awarded for the design and development of a Reduced Diameter Array (RDA) for the SURTASS system. The aim was to provide a surface towed array with improved acoustic performance through reduced self-noise, improved dynamic range and rapid circuit recovery time to accommodate operation in the presence of strong transients. This was accomplished when the first engineering development model was delivered in May 1992 and successfully passed First Article testing.

Description
The SURTASS RDA system includes a reduced diameter towed array with multichannel digital telemetry, fibre optic towcable with fairing, deck cables, winch junction box, plug storage box and telemetry receiver unit. RDA is a centre-nested array providing longer apertures for improved frequency response. An improved coupler that connects each array module greatly reduces maintenance time at sea and increases reliability. The length of the array is 2,378 m and there are repeaters in every third module to regenerate the signal. These repeater modules, as well as others, also measure non-acoustic data such as heading, depth, temperature and current. Tuned vibration isolation modules provide rejection of towcable vibration to the array. There are fewer module types due to a universal spares concept. The telemetry receiver unit provides power to the array, performs PKL/FL functions, and conditions the signal for transmission to the beam-forming processor.

Operational status
Trials of the SURTASS RDA were carried out on T-AGOS 20 *Able*. Four SURTASS RDA systems have been delivered to the US Navy and are in operational service.

Contractor
Lucent Technologies Advanced Technology Systems, Greensboro, North Carolina.

VERIFIED

TSUNAMI

Type
Multi-function hull-mounted sonar.

Development
The Tsunami long-range sonar is being developed by L-3 Communications as a 'green' sonar in that the transmissions are harmless to whales and dolphins and so on. Dipping sonar techniques have been exploited in the development of the Tsunami to result in a slimmed down dome profile which conforms to the hydrodynamic, low-drag bulbous bow shape of a surface warship. Compared to standard long-range ASW sonars the design of Tsunami exhibits a significant reduction in size, weight and complexity.

Description
The sonar comprises a high-energy density MF (2 to 4 kHz) volumetric transmit array, a dual high-frequency obstacle mine avoidance sonar, a conformal MF volumetric receive array, and an acoustic window, integrated in a configuration suitable to allow it to be fitted into a surface combatant's hydrodynamically designed bulbous bow. The high energy density array was selected in preference to the volumetric array in order to achieve satisfactory range capability while at the same time not affecting marine life. The sonar features active/passive operation, obstacle/mine avoidance, active and passive torpedo alert and interoperability (multi-static operation) with existing MF systems.

For a typical destroyer fitment Tsunami uses 32 modern projectors mounted in two columns, surrounded by and separated from the receive array to provide the high source levels necessary for long-range detection (first convergence zone deep water) and 10 n miles shallow water echo ranging. The vertical line, transmit array design produces large time-bandwidth wave trains which are not possible with traditional sector scan sonars. These complex wave trains enhance the shallow water capability, including the use of automated information processing to reduce false contacts. The sonar uses shaped pulses including FM/CW in a train which gives a high level of energy.

The lightweight receive volumetric array comprises a vertical set of receive hydrophone staves with embedded ATM digital telemetry processing that eliminates the need for individual sensor cabling, transmit/receive switches and signal conditioning cabinets found in traditional active sonars. The MF multiplexed hydrophone channels are easily interfaced to an open architecture COTS acoustic processor. By using separate transmit and receive arrays Tsunami is able to maintain a sonar 'listening' watch while the long pulses used in the system are transmitted. This overcomes the problem experienced with conventional sonars when the receive array has to be shut down while pulses are being transmitted. Thus the longer the pulse, the longer the receiver remains shut down which may prove to be a serious disadvantage inhibiting the detection of a separate echo from an unsuspected nearby target. L-3 considers that long pulses are essential to the efficient operation of a sonar in difficult environmental conditions, enabling it to

overcome distortions caused by water layers and environmental reverberations to provide a similar level of capability as a lightweight broadband VDS.

The obstacle avoidance sensor is an existing product that is integrated into the bulbous bow-acoustic window design, and total USW processor, control and display unit.

Operational status
Under developmental contract from the US ONR to bid for the LBVDS effort for the DD-21 Programme.

Contractor
L-3 Communications Ocean Systems, Sylmar, California.

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UQQ-2 SURTASS

Type
Mobile towed array surveillance system.

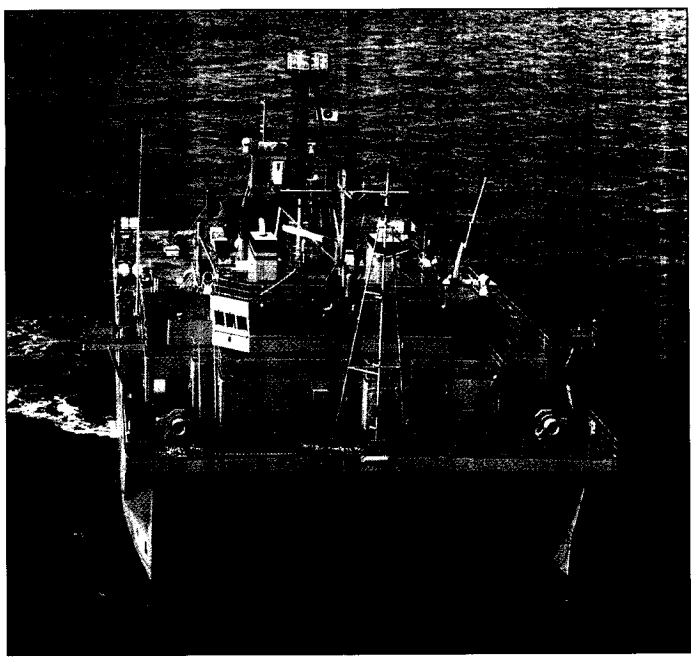
Development
SURTASS (Surface Towed Array Surveillance System) commenced full-scale development in 1976. Testing was carried out at sea in 1977. Technical evaluation of SURTASS was completed in March 1978 and operational evaluation took place in May and June 1978. The first full tests of the system, including the satellite link and data processing, took place in July 1979 and the system was declared ready for operational evaluation in March 1980. Introduction to US fleet service began in late 1984.

Description
SURTASS is the successor system to the AN/BQR-15 Towed Array Surveillance System (TASS) already in operation with the US fleet. This mobile surveillance system complements fixed networks by providing the essential flexibility to respond to changes in Soviet submarine deployment patterns and by extending coverage to remote ocean areas not monitored by fixed systems. It can also serve as an emergency reserve facility if fixed networks are disabled. There are two shore-based data processing centres (one on the east coast of the US and one on the west coast) to which acoustic target information gathered by the towed arrays is relayed by satellite. After processing, target information is transmitted back to operational ships at sea. Several ships are planned for each of the two processing centres, operating in waters to the east and west of the North American continent respectively.

Whereas the AN/BQR-15 is towed by submarines, slow surface ships will tow long SURTASS arrays back and forth over designated patrol lines. Funds have been set aside and a special type of platform to operate SURTASS, designated T-AGOS has been built. More detailed information on these ships is given in *Jane's Fighting Ships*.

The basic portion of SURTASS is a 2,500 m long hydrophone array at the end of a towing cable 1,830 m long and towed at depths between 150 and 450 m at a speed of 3 kt. Five AN/UYK-20 data processors and an AN/UYS-1 signal processor handle data processing on board the T-AGOS ships before the data is relayed via the satellite. The sonar element also includes the winch, handling equipment and associated electronics. The other three major elements include: the communication/navigation system for acoustic data transmission, command and control and vessel navigation; the T-AGOS ships themselves and the shore processing stations. It is intended that the T-AGOS ships will operate worldwide in 90 day missions.

A number of improvements has been introduced into the product line and, during 1984, a product improvement programme was implemented. This applied



One of four Victorious class ocean surveillance ships used to deploy the UQQ-2 SURTASS towed array system. The winch and array handling control position can be seen behind the tripod mast 0007231

to the AN/UYS-1 processor and other classified units and, during 1985-86, specifications and designs for classification improvements for the AN/UYS-2 enhanced modular signal processor were developed.

Details concerning the Low-frequency active Transmit Subsystem (LTS) can be found in the section on Transducers.

The latest development of the system, the SURTASS Twin line and LFA is a much shorter twin-line array that can be used for both active and VLF passive operations. The system has been tested both in very shallow water (50 m) and against high clutter. Trials have been undertaken in real operations in the Adriatic.

The twin lines are maintained at a constant distance apart by the active towing system.

Much of the electronics used in this system are based on open architecture and COTS components. Original SURTASS arrays are being upgraded with COTS technology and 180 acoustic channels for use on new surveillance vessels.

Operational status
One Impeccable, three Stalwart class, and four Victorious class ocean surveillance ships deploy SURTASS.

The Japanese Maritime Self-Defence Force has built two Hibiki class SWATH vessels, which are similar to the US T-AGOS type vessels. These ships are fitted with a complete UQQ-2 SURTASS package (designated NQQ-2 in Japan).

The SURTASS Twin-line and LFA began fleet operations during 1998.

Operational status
No longer in production.

Contractor
Lockheed Martin, Naval Electronic & Surveillance Systems, Manassas, Virginia.

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SUBMARINE SONAR SYSTEMS

Table X

Operational submarine sonar equipments

System	Manufacturer	Country	Installed on	Navy	Units
AN/BQG-4	Sperry/Raytheon	US	Tang	Turkey	2
AN/BQG-5D		US	Los Angeles	US	2
	Lockheed Martin	US	Seawolf	US	2
AN/BQQ-5D/E	Lockheed Martin	US	Los Angeles	US	23
AN/BQQ-6	Lockheed Martin	US	Ohio	US	18
AN/BQR-2B	EDO	US	Guppy II	Taiwan	2
	EDO	US	Tang	Turkey	2
AN/BQR-15		US	Ohio	US	18
		US	Sturgeon	US	1
AN/BQR-19	Raytheon	US	Ohio	US	18
AN/BQS-4	EDO	US	Tang	Turkey	2
AN/BQS-4C	Raytheon/EDO	US	Guppy II	Taiwan	2
AN/BQS-13	Raytheon	US	Ohio	US	18
	Raytheon	US	Sturgeon	US	1
AN/BQS-15	Ametek	US	Los Angeles	US	51
	Ametek	US	Ohio	US	18
AN/BQS-24		US	Seawolf	US	2
CSU 3	ATLAS Elektronik	Germany	Type 209/1,200 (Salta)	Argentina	1
CSU 3	ATLAS Elektronik	Germany	Type 209/1,300 (Thomson)	Chile	2
CSU 3	ATLAS Elektronik	Germany	Type 209/1,300 (Shyri)	Ecuador	2
CSU 3	ATLAS Elektronik	Germany	Type 209/1,200 (Angamos)	Peru	6
CSU 3	ATLAS Elektronik	Germany	Type 209/1,200 (Atilay)	Turkey	6
CSU 3	ATLAS Elektronik	Germany	Type 209/1,200 (Pijao)	Colombia	2
CSU 3-2	ATLAS Elektronik	Germany	Type 209/1,300 (Cakra)	Indonesia	2
CSU 3-32	ATLAS Elektronik	Germany	Type 209/1,300 (Sabalo)	Venezuela	2
CSU 3-4	ATLAS Elektronik	Germany	Santa Cruz TR 1700	Argentina	2
CSU 3-4	ATLAS Elektronik	Germany	Type 209/1,100-1,200 (Glavkos)	Greece	4
CSU 83	ATLAS Elektronik	Germany	Type 209/1,500 (Shishumar)	India	4
CSU 83	ATLAS Elektronik	Germany	Type 209/1,200 (Chang Bogo)	Korea, South	9
CSU 83	ATLAS Elektronik	Germany	Ula (Type P6071)	Norway	6
CSU 83	ATLAS Elektronik	Germany	Ex-Kobben Type 207	Poland	4
CSU 83	ATLAS Elektronik	Germany	Vastergotland A 17	Sweden	4
CSU 83	ATLAS Elektronik	Germany	Type 209/1,400 (Preveze)	Turkey	5
CSU 83	ATLAS Elektronik	Germany	Romeo	Egypt	4
CSU 83-1	ATLAS Elektronik	Germany	Type 209/1,400 (Tupi)	Brazil	4
CSU 90	ATLAS Elektronik	Germany	Type 209/1,100-1,200 (Glavkos)	Greece	4
CSU 90	ATLAS Elektronik	Germany	Dolphin	Israel	3
CSU 90-2	ATLAS Elektronik	Germany	Gotland A 19	Sweden	3
DBQS-21D	ATLAS Elektronik	Germany	Type 206A	Germany	12
DMUX 20 (Eledone)	Thales Underwater Systems	France	Rubis	France	6
DMUX 80	Thales Underwater Systems	France	Le Triomphant	France	2
DSUV 2	Thales Underwater Systems	France	Albacora (Daphne)	Portugal	2
DSUV 22	Thales Underwater Systems	France	Rubis	France	6
	Thales Underwater Systems	France	Delfin (Daphne)	Spain	2
	Thales Underwater Systems	France	Galerna (Agosta)	Spain	4
DSUV 61	Thales Underwater Systems	France	Le Triomphant	France	2
DSUV 61B	Thales Underwater Systems	France	L'Inflexible	France	2
DSUV 62C	Thales Underwater Systems	France	Rubis	France	6
DSUX 21	Thales Underwater Systems	France	L'Inflexible	France	2
DUUA 1	Thales Underwater Systems	France	Hangor (Daphne)	Pakistan	4
DUUA 2	Thales Underwater Systems	France	Albacora (Daphne)	Portugal	2
DUUA 2A	Thales Underwater Systems	France	Delfin (Daphne)	Spain	2
DUUA 2A/2B	Thales Underwater Systems	France	Galerna (Agosta)	Spain	4
DUUA 2B	Thales Underwater Systems	France	Hashmat (Agosta)	Pakistan	2
DUUG 1B	Thales Underwater Systems	France	Guppy II	Taiwan	2
DUUG 1D	Thales Underwater Systems	France	Type 209/1,200 (Salta)	Argentina	1
DUUX 2	Thales Underwater Systems	France	Type 209/1,300 (Shyri)	Ecuador	2
	Thales Underwater Systems	France	Type 206A	Germany	12
	Thales Underwater Systems	France	Type 209/1,300 (Sabalo)	Venezuela	2
DUUX 2A/5	Thales Underwater Systems	France	Galerna (Agosta)	Spain	4
DUUX 2C[1]	Thales Underwater Systems	France	Type 209/1,200 (Casma)	Peru	n/k
	Thales Underwater Systems	France	Type 209/1,200 (Salta)	Argentina	1
DUUX 5[1]	Thales Underwater Systems	France	Romeo Type 033	China	21
	Thales Underwater Systems	France	Santa Cruz TR 1700	Argentina	2
	Thales Underwater Systems	France	Type 209/1,500 (Shishumar)	India	4
	Thales Underwater Systems	France	Le Triomphant	France	2
	Thales Underwater Systems	France	L'Inflexible	France	2
	Thales Underwater Systems	France	Walrus	Netherlands	4
	Thales Underwater Systems	France	Han	China	5
	Thales Underwater Systems	France	Ming	China	22
Eledone	Thales Underwater Systems	France	Galerna (Agosta)	Spain	4
FAS-3	ATLAS Elektronik	Germany	Dolphin	Israel	3
Feniks	RFAS	RFAS	Romeo Type 031	Korea, North	22
	RFAS	RFAS	Foxtrot Type 641	Libya	2

System	Manufacturer	Country	Installed on	Navy	Units
Herkules[1]	RFAS	RFAS	Romeo Type 033	China	21
	RFAS	RFAS	Modified Romeo	China	1
	RFAS	RFAS	Foxtrot Type 641	Libya	2
Herkules/Feniks	RFAS	RFAS	Foxtrot Type 641	India	2
Hydra	Plessey	UK	Sjoormen A 12	Singapore	4
Kariwara	Thales Underwater Systems	Australia	Collins	Australia	2
Mouse Roar	RFAS	RFAS	Akula	RFAS	8
	RFAS	RFAS	Delta I	RFAS	1
	RFAS	RFAS	Delta III	RFAS	7
	RFAS	RFAS	Delta IV	RFAS	6
	RFAS	RFAS	Kilo Type 877E	Algeria	2
	RFAS	RFAS	Kilo Type 877E	Romania	1
	RFAS	RFAS	Kilo Type 877EKM/636	China	4
	RFAS	RFAS	Kilo Type 877EM	India	10
	RFAS	RFAS	Kilo Type 877EKM	Iran	3
	RFAS	RFAS	Kilo	Poland	1
	RFAS	RFAS	Kilo Type 877/877K/877M	RFAS	11
Mouse Roar	RFAS	RFAS	Oscar II	RFAS	7
	RFAS	RFAS	Sierra I/II	RFAS	2
	RFAS	RFAS	Typhoon	RFAS	2
	RFAS	RFAS	Victor III	RFAS	4
	RFAS	RFAS	Yankee Notch	RFAS	1
N/k	ADS	South Africa	Daphne	South Africa	2
Pelamida	RFAS	RFAS	Delta IV	RFAS	6
	RFAS	RFAS	Oscar II	RFAS	7
	RFAS	RFAS	Typhoon	RFAS	2
	RFAS	RFAS	Delta III	RFAS	7
Pike Jaw	RFAS	RFAS	Foxtrot	Ukraine	1
	RFAS	RFAS	Modified Romeo	China	1
	RFAS	RFAS	Ming	China	22
	RFAS	RFAS	Golf	China	1
	RFAS	RFAS	Romeo	Korea, North	22
PRS 3[1]	ATLAS Elektronik	Germany	Type 209/1,200 (Angamos)	Peru	n/k
	ATLAS Elektronik	Germany	Dolphin	Israel	3
	ATLAS Elektronik	Germany	Sava	Serbia & Montenegro	1
PRS 3-4	ATLAS Elektronik	Germany	Type 209/1,100-1,200 (Glavkos)	Greece	8
PRS 3-4	ATLAS Elektronik	Germany	Type 209/1,300 (Cakra)	Indonesia	2
PRS 3-4	ATLAS Elektronik	Germany	Type 209/1200 (Pijao)	Colombia	2
PSU NU	ATLAS Elektronik	Germany	Type 207 (Tumleren)	Denmark	3
	ATLAS Elektronik	Germany	Narhvalen	Denmark	2
Shark Fin[1]	RFAS	RFAS	Kilo	RFAS	11
	RFAS	RFAS	Kilo	India	10
	RFAS	RFAS	Kilo	Algeria	2
	RFAS	RFAS	Kilo	Romania	1
Shark Gill	RFAS	RFAS	Akula	RFAS	8
	RFAS	RFAS	Delta IV	RFAS	6
	RFAS	RFAS	Oscar II	RFAS	7
	RFAS	RFAS	Sierra I/II	RFAS	2
	RFAS	RFAS	Typhoon	RFAS	2
	RFAS	RFAS	Victor III	RFAS	4
Shark Hide	RFAS	RFAS	Delta III	RFAS	7
	RFAS	RFAS	Delta IV	RFAS	6
Shark Rib	RFAS	RFAS	Oscar II	RFAS	7
	RFAS	RFAS	Sierra I/II	RFAS	2
	RFAS	RFAS	Typhoon	RFAS	2
	RFAS	RFAS	Victor III	RFAS	4
Shark Teeth	RFAS	RFAS	Delta I	RFAS	1
	RFAS	RFAS	Delta III	RFAS	7
	RFAS	RFAS	Kilo Type 877E	Algeria	2
	RFAS	RFAS	Kilo Type 877EKM/636	China	4
	RFAS	RFAS	Kilo Type 877EM	India	10
	RFAS	RFAS	Kilo Type 877EKM	Iran	3
	RFAS	RFAS	Kilo Type 877E	Poland	1
	RFAS	RFAS	Kilo Type 877E	Romania	1
	RFAS	RFAS	Kilo Type 877/877K/877M	RFAS	11
	RFAS	RFAS	Yankee Notch	RFAS	1
Siass-2	Signaal	Netherlands	Hai Lung	Taiwan	2
Skat 3	RFAS	RFAS	Sierra I/II	RFAS	2
	RFAS	RFAS	Victor III	RFAS	4
	RFAS	RFAS	Akula	RFAS	8
Solarsub	SAES	Spain	Galerna (Agosta)	Spain	4
SRS M1H	ATLAS Elektronik	Germany	Type 205	Germany	2
TAS-3	ATLAS Elektronik	Germany	Preveze	Turkey	5
Tamir 5[1]	RFAS	RFAS	Romeo Type 033	China	21
TB-16	Lockheed Martin	US	Los Angeles	US	51
	Lockheed Martin	US	Seawolf	US	2
TB-23[1]	L-3 Communications	US	Los Angeles	US	n/k
	L-3 Communications	US	Ohio	US	18
TB-29[1]	Lockheed Martin	US	Los Angeles	US	n/k
	Lockheed Martin	US	Seawolf	US	2
Trout Cheek	RFAS	RFAS	Han	China	5
	RFAS	RFAS	Xia	China	1
TSM 2233	Thales Underwater systems	France	Khalid (Agosta 90B)	Pakistan	2

System	Manufacturer	Country	Installed on	Navy	Units
TSM 2233D	Thales Underwater Systems	France	Hangor (Daphne)	Pakistan	4
TSM 2233D	Thales Underwater Systems	France	Hashmat (Agosta)	Pakistan	2
TSM 2233 (Scylla)	Thales Underwater Systems	France	Collins	Australia	6
TSM 2272 (Eledone)	Thales Underwater Systems	France	Walrus	Netherlands	4
TSM 2933D	Thales Underwater Dystems	France	Hashmat (Agosta)	Pakistan	2
Type 2007	Graseby Marine	UK	Victoria	Canada	4
Type 2019[1]	Thorn	UK	Swiftsure	UK	5
Type 2019[1]	Thorn	UK	Trafalgar	UK	7
Type 2020[1]	Thales Underwater Systems	UK	Swiftsure	UK	2
Type 2026	GEC Avionics/Plessey	UK	Walrus	Netherlands	4
Type 2040	Thales Underwater Systems	France	Victoria	Canada	4
Type 2043	Thales Underwater Systems	UK	Vanguard	UK	4
Type 2046	Thales Underwater Systems	UK	Swiftsure	UK	5
	Thales Underwater Systems	UK	Trafalgar	UK	3
	Thales Underwater Systems	UK	Vanguard	UK	4
Type 2054	Thales Underwater Systems	UK	Vanguard	UK	4
Type 2072	Thales Underwater Systems	UK	Swiftsure	UK	5
	Thales Underwater Systems	UK	Trafalgar	UK	7
Type 2074	Plessey	UK	Swiftsure	UK	3
	Plessey	UK	Trafalgar	UK	3
Type 2076	Thales Underwater Systems	UK	Trafalgar	UK	4
Type 2077	Thales Underwater Systems	UK	Swiftsure	UK	5
	Thales Underwater Systems	UK	Trafalgar	UK	7
Type 2082[1]	PMES	UK	Swiftsure	UK	n/k
Type 2082[1]	PMES	UK	Trafalgar	UK	n/k
	PMES	UK	Vanguard	UK	4
ZQQ-5	Hughes/Oki	Japan	Yuushio	Japan	5
ZQQ-5B	Hughes/Oki	Japan	Harushio	Japan	7
ZQQ-5B/6	Hughes/Oki	Japan	Oyashio	Japan	6
ZQR-1	Hughes/Oki	Japan	Harushio	Japan	7
ZQR-1	Hughes/Oki	Japan	Yuushio	Japan	5
ZQR-1	Hughes/Oki	Japan	Oyashio	Japan	6

[1] In some units

UPDATED

Canada

SUBTASS

Type
Passive low-frequency towed array sonar.

Description
Thomson Marconi Sonar Ltd, under contract to the Department of Supply and Service of Canada, supplied a Submarine Towed Array Sonar System (SUBTASS) for the Canadian Oberon class submarines. The SUBTASS system is maintained and developed by Hermes Electronics in Canada. The hard-wired, low-noise analogue array can be deployed by both warships and submarines.

Based on modular Series 5 technology, the requirements for both narrowband and broadband processing, displays with provision for narrowband verniers, broadband trackers, TMA audio monitoring plus optional expansion including Demon analysis and a narrowband flank array facility, have been met using in-service modules. Commonality with CRISP acoustic analyser and CHIP concurrent high-speed integrated processor leads to reduced spares holdings and increased interchangeability.

The system consists of seven different module types and a stabilising rope drogue, the core of which is multiple acoustic apertures housed in an opaque 6.03 cm polyurethane jacket. Six non-acoustic channels provide fore and aft measurements of the array's heading, depth and temperature.

Operational status
Previously installed on the Canadian Navy's 'Oberon' class submarines, the system is now being transferred to the 'Victoria' class (refurbished ex-Royal Navy 'Upholder' class).

Specifications
Length: 266 m (including drogue)
Diameter: 6.03 cm
Weight: 957 kg
Frequency: 5 Hz - 3.2 kHz
Operating depth: 300 m
Towing speed: 5 - 15 kt

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada.

VERIFIED

France

DSUV 62C-TSM 2933/Lamproie

Type
Submarine linear towed array sonar.

Description
The DSUV 62C-TSM 2933 (commercial name Lamproie) very low-frequency passive linear towed array sonar is produced, either as a module of the TSM 2233 sonar system or, in a stand-alone configuration with its own processing, operating and interfacing facilities.

The sonar performs panoramic surveillance through simultaneous processing of broadband and narrowband in several fixed or adjustable frequency bands, and automatically initiates tracking on up to 64 targets. In addition, the operator can initiate up to eight tracks. Signal analysis is carried out using Lofar, Demon, wideband and audio with computer-aided classification. Localisation is through specific TMA second convergence zone performance. The sonar can interface with any weapons control system. Lamproie is able to track several targets concurrently, either in broad or narrowband, with a very fine bearing accuracy. Tracking can be automatic or manual. An automatic rejection system for narrowband countermeasures protects trackers from sonar jamming. Narrowband analysis can be performed concurrently on several beams, steered either under automatic tracking or manually. Lofar analysis includes refined vernier capabilities. Demon analysis demodulates signals for cavitation detection. A high-fidelity audio channel improves target identification. Automatic torpedo warning is also provided. The sonar array is handled by Angler winch.

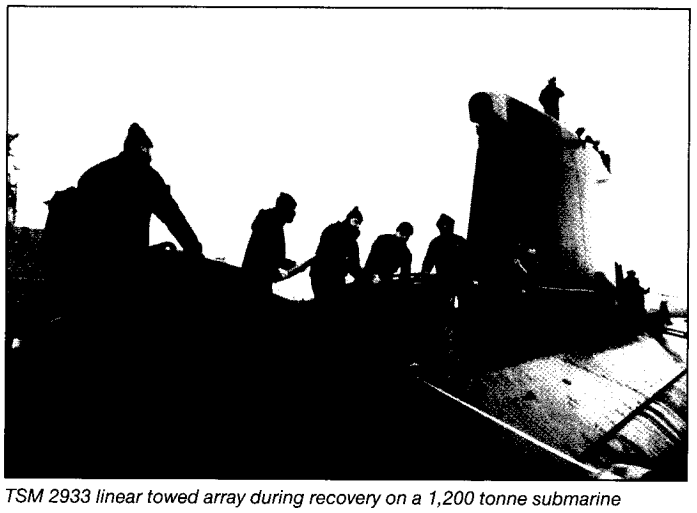
The linear array is 100 m long and 0.08 m in diameter and is towed behind a 400 m long neutrally buoyant cable. The TSM 2933 can also be fitted with a thin-line array (Narama).

The processing system is the same as in the TSM 2233 (see TSM 2233 entry).

Operational status
The TSM 2933 is currently in service in the French Navy (as the DSUV 62C in the Rubis class). The Spanish Agosta class submarine *Mistral* ran trials with the DSUV 62, but it was not purchased for the class. The TSM 2933 version designed for surface ships differs from the submarine version only in towing subassembly configuration and is in service in several navies.

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED



TSM 2933 linear towed array during recovery on a 1,200 tonne submarine

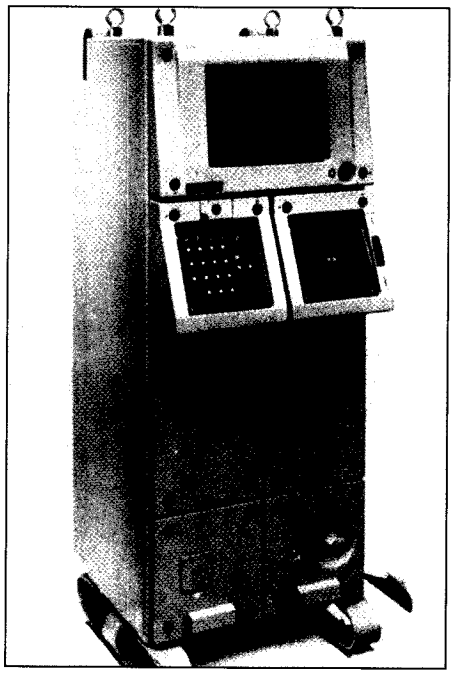
DUUX-5 (Fenelon)/TSM 2055

Type
Panoramic surveillance and direct passive ranging sonar.

Description
Developed in 1960, Fenelon is the name given to a panoramic passive sonar capable of automatic and simultaneous tracking of three targets. The equipment incorporates a passive acoustic range-finder for measuring the range of three targets within 120° sectors, and a panoramic sonar interceptor measuring the true bearing of all sonar transmissions received within the 2 to 15 kHz band.

The DUUX-5 equipment was developed by Alcatel as a successor to the DUUX-2 series, of which at least 120 equipments were built and supplied to 14 navies for fitting in eight types of submarine. The Fenelon equipment enables range and bearing information on targets to be obtained by the submarine without the need for any transmissions and with minimum delay. Speed of operation permits target course and speed to be computed rapidly, also allowing any changes in either speed or course to be detected without delay. Three targets can be tracked simultaneously (three on automatic passive radiated self-noise on either side of the boat, one on passive intercept tracking of sonar pulses), and there is a continuous panoramic bearing display over 360°. Range information is provided over arcs of 120° on each side of the submarine. Under normal operating conditions bearing accuracy is 0.3° in the medium frequencies. There are facilities for transmission of target data automatically to the ship's weapon control system and plotting table. The sonar carries out simultaneous processing in Lofar and Demon on a number of frequencies between 2 and 15 kHz.

Performance characteristics include high accuracy and discrimination, immunity against sonar pulse interference, simplified calibration, and integrated test facilities. Under normal conditions, results in the middle sector are 0.3° for bearing



Fenelon: DUUX-5 control and display console

accuracy, 2° discrimination accuracy between two targets and 5 per cent of range on radiated noise for a target at a distance of 10 km. Two types of hydrophones are available. The hydrophonic unit is composed of two bases, with three hydrophones each on the starboard and port sides of the submarine to perform detection and acoustic wavefront curvature ranging. All other technical details remain classified. The latest variant forms one of the modules of the TSM 2233 sonar suite.

Operational status
In service on 'L'Inflexible', 'Le Triomphant', 'Rubis', 'Agosta', Argentina TR 1700 and Indian Type 209/1500 class submarines. Also exported to China where locally produced to equip Xia, Han, Romeo and Ming classes. Also being supplied for Pakistan Agosta 90B class (as part of the TSM 2233 suite) and operational on the Netherlands Walrus class.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

INCA

Type
Interactive classification aid.

Description
The INCA interactive classification aid is designed to enhance classification, which is the mandatory function of passive detection and the main task of intelligence gathering. INCA therefore can form a major element in the ASW scenario, as indeed does any classification aid, aboard any type of ASW platform (airborne, surface vessel, or submarines).

INCA (INteractive Classification Aid) gathers classification parameters after spectral and/or audio analysis. Spectral analysis is performed on current or stored signals and is immediately displayed. Spectrum analysis capabilities include Lofar, vernier, Demon, Ali, and spectrogram and features an ×8 speed-up in analysis. INCA performs audio analysis in signals using a pass-band filter, variable speed (X4, 2, 1, ½, ¼, ⅛) and normal/reverse, as well as transient analysis.

INCA selects possible sources for any contact by comparison with classification statistical data stored in the database. INCA then helps in building a confidence level for every classification hypothesis. These confidence levels are then sorted to give the likeliest classification hypothesis.

Operational status
System fully developed.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

TSM 2233

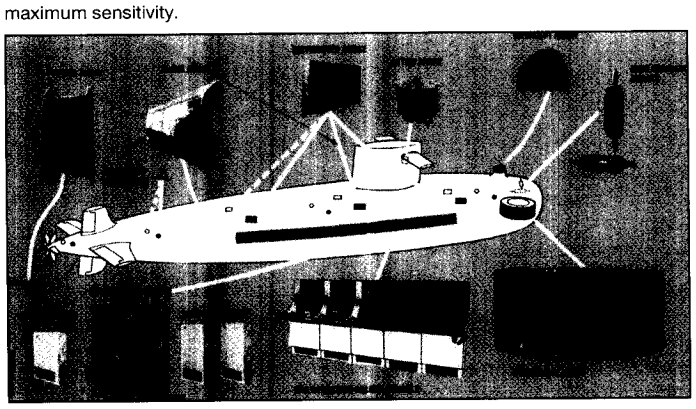
Type
Submarine passive and active sonar system.

Description
The TSM 2233 is a modular, integrated sonar system designed to fit any size of submarine and to fulfil any operational requirement.

Based on an open system COTS architecture TSM 2233 includes any or all of the following acoustic sensors: linear towed array, flank arrays, bow array (cylindrical or conformal), intercept array, distributed arrays, active array, obstacle avoidance array.

The TSM 2233 sonar system provides the following set of functions:

Passive detection: Broadband, narrowband and transient processing are concurrently performed so as to match with the noise characteristics of any vessel. For each operational function, sonar data from the various arrays and processing are gathered and associated to reduce the operator workload while maintaining maximum sensitivity.



TSM 2233 submarine sonar suite

Automatic anti-jamming: The anti-jamming feature automatically rejects narrowband jammers, thereby hardening tracks and enhancing Target Motion Analysis (CMA) performance (range, accuracy and convergence delay).

Passive adaptive processing: The adaptive processing function is based on an optimal array processing theory which minimises the effect of jamming by strong signals when listening to low-level signals. It is a particularly useful facility in discriminating between two targets in a common limited sector.

Automatic detection and tracking: By automatically initiating tracks, this feature allows the operator to avoid repetitive tasks so that he can deal with more complex situations.

Interception: This function allows interception of all active sonar pulses from low-frequency surface ship sonars to high-frequency torpedo acoustic heads. Very early warning of hostile sonars with a low false alarm rate is provided. Interception warnings are integrated on the passive listening scope. Accurate parameters of pulses are presented on digital readouts.

Active capability: Although initial bearings are provided by the passive detection function, the operator can select the active mode to determine range accurately. In this mode, reception is performed by the passive listening array, and is associated with high-detection sensitivity.

Classification: The spectrum analysis facility (Lofar and Demon) complements the audio function by providing the operator with specific data in target classification, which is computer-aided through an interactive database.

Hostile weapon alarm: A specific algorithm sorts out the contacts taking into account various target parameters and warns the operator in the event of a hostile weapon.

Target Motion Analysis (TMA): Contact localisation and motion analysis of contacts are performed automatically on all tracks.

Key features of the system are: modular signal processing which makes it possible to adapt the configuration to suit new vessel designs and modernisation (possibly keeping existing arrays); reduced operator workload due to the high level of automation of the detection, tracking and localisation functions; and the flexibility and ease of adaptability to submarine size and mission requirements resulting from the coherent set of complementary sensors.

The system uses TMS 320, C30 and 68040 microprocessors for signal processing in MIMD-type host systems communicating internally across high-speed ring networks and externally on standard VME-type buses.

Programs use structured software developed in C and Ada. Multifunction workstations are used with one or two high-definition 19 in colour monitors (Colibri or MOC consoles). The TSM 2233 forms the DSM sub-unit for the TSM 2295 SUBICS combat system.

Operational status
TSM 2233 is the latest generation of the well-known Eledone family, some versions of which are in service with the Canadian Maritime Forces (2040 Argonaute on Victoria class), the Royal Netherlands Navy (Walrus class TSM 2272) and the Spanish Navy (Agosta and Daphne classes).

Variants of the TSM 2233 are installed on the Royal Australian Navy's Collins class *(Scylla)* and French Navy Rubis class (DMUX 20). The latest unit to receive the TSM 2233 is the Agosta 90B class submarine *Khalid* of the Pakistan Navy. The TSM 2233 has also been selected to equip the new Scorpene class boats of the Malaysian Navy.

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED

TSM 2253

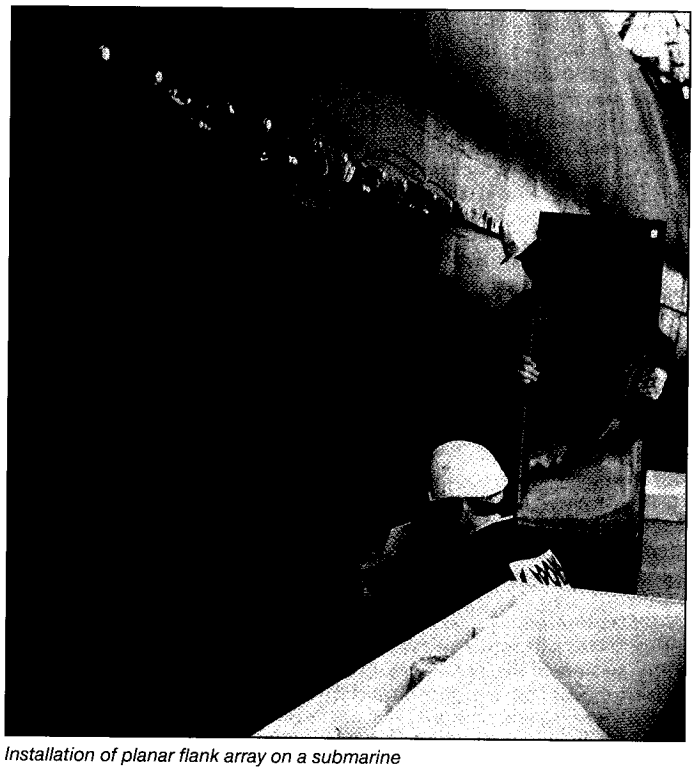
Type
Submarine planar flank array sonar.

Description
The TSM 2253 is a low-frequency passive sonar using two planar arrays installed on the submarine's flanks. Each array consists of 32 or 64 planar hydrophones each (0.5 m wide, 1 m in height, 0.1 m thick) composed of polyvinyldifluoride (PVDF) films moulded in polyurethane. The sonar operates in the 3 to 10 kHz frequency range. Compared with linear configured ceramic hydrophones, the planar array shows an excellent resistance to shocks, offers directivity in elevation, achieves noise cancellation due to the surface effect and involves very low installation overheads.

The sonar performs panoramic surveillance through simultaneous processing of broadband and narrowband and automatically initiates tracking on up to 64 targets. In addition, the operator can initiate up to eight tracks. Signal analysis is carried out using Lofar, Demon and audio with computer-aided classification. Localisation is through specific CMA. The sonar can interface with any weapons control system.

The processing system is the same as that in the TSM 2233 (see TSM 2233 entry).

Operational status
A preceding generation (TSM 2285) of the TSM 2253 is installed on a Norwegian Navy Ula class submarine. Planar flank array sonars are installed on French Navy nuclear submarines and equip the Australian Collins class.



Installation of planar flank array on a submarine

Contractor
Thales Underwater Systems, Sophia Antipolis. ***VERIFIED***

TSM 5421B

Type
Submarine mine and obstacle avoidance sonar.

Description
The TSM 5421B carries out panoramic search by scanning a 30° sector to detect moored mines and obstacles such as piers and close-range platforms. The system consists of a wet end (diameter 0.5 m, height 0.5 m) and a receiver/display cabinet (0.5 m × 0.6 m × 0.6 m).

Operational status
In service at sea.

Contractor
Thales Underwater Systems, Sophia Antipolis. ***VERIFIED***

TSM 5423

Type
Submarine mine and obstacle avoidance sonar.

Description
The sonar carries out detection and classification of any type of mine, as well as the detection of underwater obstacles. Detection is carried out in a 60° bearing and 30° elevation sector ahead of the submarine. The sonar comprises two arrays (0.6 m × 0.15 m × 0.15 m) and a receiver/display cabinet.

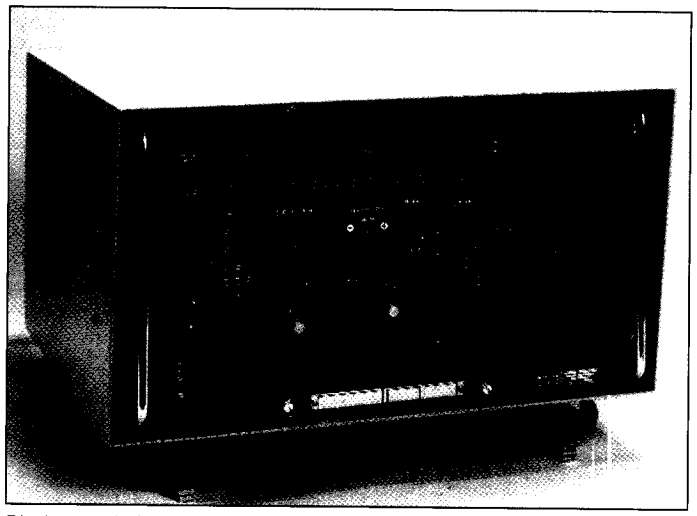
Operational status
In service at sea.

Contractor
Thales Underwater Systems, Sophia Antipolis. ***VERIFIED***

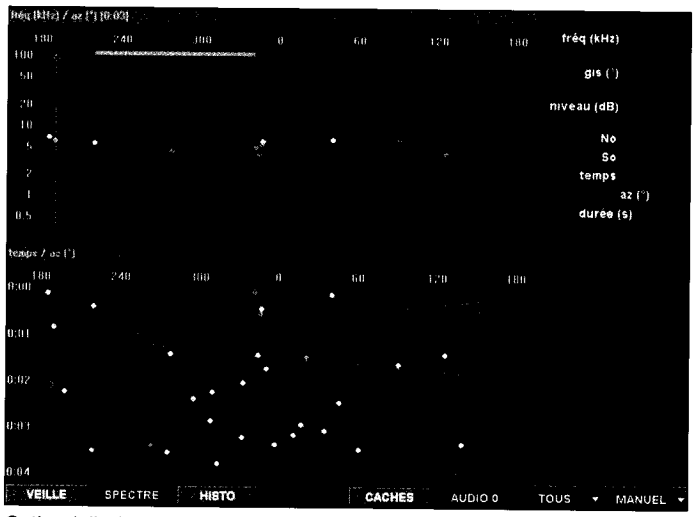
Velox M7

Type
Sonar intercept receiver.

Description
The Velox M7 wideband sonar intercept receiver is designed to intercept signals in the frequency range 2.5 to 100 kHz. Detected single or multiple pulse acoustic signals are automatically measured to provide bearing, acoustic level, frequency and pulse length and to identify recurring identical pulses for classification. The system is also capable of monitoring the noise radiated by ships. The system offers long detection ranges (up to 90 km at 5 kHz and 17 km at 15 kHz).



Display panel of the Velox M7 intercept sonar receiver



Optional display unit (Thales Safare) 0122902

The receiver uses multiband processing based on a constant false alarm rate operation and provides a permanent digital display of the parameters of the last two intercepts; synthetic analogue display of the threat direction; extensive audio facilities, including direct, compressed or heterodyned and anti-saturation features.

The display unit provides a variety of functions including waterfall projection, transient and DEMON analysis, pulse tracking and classification, and long term recording. M7 provides automatic detection and tracking on up to eight targets.

Velox M7 comprises a small receiving array and an electronics cabinet or rack drawer. A second identical array can be installed in another location for manual selection to improve the horizontal coverage.

The receiver is designed for integration into a federated combat system, or can be used in a stand-alone configuration.

As an option, the frequency range can be extended to 0.5 kHz and/or up to 250 kHz.

Operational status
In service with the French and other navies.

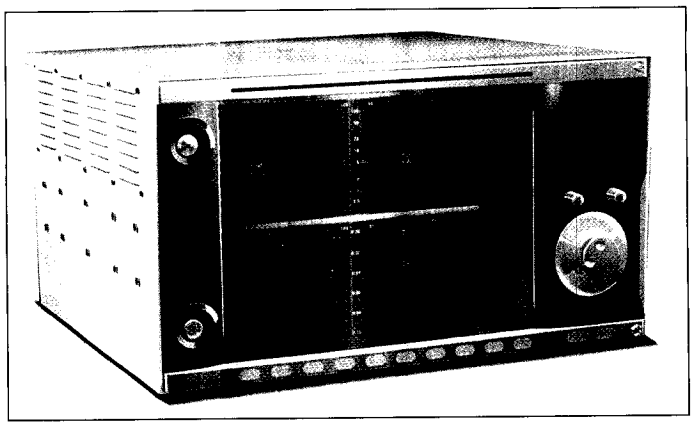
Contractor
Thales Safare, Sophia Antipolis.

UPDATED

Velox M8

Type
Sonar intercept receiver.

Description
The Velox M8 broadband (100 Mbits/s) digital sonar intercept receiver is designed to intercept signals in the frequency range 1.0 to 100 kHz. Detected single or multiple pulse acoustic signals are automatically measured to provide bearing, acoustic level, frequency and pulse length and to identify recurring identical pulses for classification. The system is also capable of monitoring the noise radiated by



VELOX M8 display unit (Thales Safare) 0593010

ships. The system offers omnidirectional long range detection (>90 km at 5 kHz and >17 km at 15 kHz).

The receiver is designed for integration into a federated combat system to form an essential complement to the boat's main sonar, or can be used in a stand-alone configuration.

The receiver uses multiband processing based on a constant false alarm rate operation and provides a permanent digital display of the parameters of intercepts; synthetic analogue display of the threat direction; and extensive audio facilities, including direct, heterodyned or synthetic features. The 15 in LCD colour monitor display unit provides a variety of functions including waterfall projection, noise analysis (DEMON), pulse tracking and classification, tracking on raw signal or on recorded sequences, and long term recording and replay.

Velox M8 comprises an acoustic antenna based on the multimode antenna concept, and an electronics cabinet or rack drawer.

The basic version comprises a control unit and standard acoustic antenna. A high performance version features a control unit, LF acoustic antenna and MF/HF acoustic antenna. Optional extras include: an HF extension acoustic antenna, an LF extension acoustic antenna, simultaneous control of two multimode antennas and broadband audio.

Operational status
Available for installation.

Contractor
Thales Safare, Sophia Antipolis.

UPDATED

Germany

CSU 3-4

Type
Active and passive search and attack sonar.

Description
The CSU 3-4 is a conventional submarine sonar designed for a single operator. It is a fast-scanning medium-range active sonar which can be used as a long-range passive device, an intercept sonar and as an underwater telephone. In its active mode, the sonar operates using a single beam. The equipment has a cylindrical transducer array with electronic beam-steering. The sonar is equipped with automatic interference suppression against acoustic countermeasures. The sonar operates in the 4 to 8 kHz frequency band.

The CSU 3-4 is able to track four targets simultaneously. The basic functions of the CSU 3-4 are described below:

Passive mode
- simultaneous azimuth coverage over 360°
- panorama presentation of target information on a CRT display with true or ship-relative bearing
- bearing/time recorder for long-term plotting of all contacts
- high-bearing accuracy and angular resolution
- automatic target tracking of up to four targets simultaneously.

Active mode
- single ping operation
- presentation of a 30° sector (waterfall) on the CRT, with continuous memory-refreshed display of target echoes
- reverberation threshold for high-detection performance
- magnified CRT display
- cylindrical transducer array with electronic beam-steering.

Intercept mode
- presentation of up to eight external pulses at the centre of the CRT
- additionally, a numerical indication of bearing, frequency, signal level and pulse duration of one of the eight pulses is provided
- determination of target elevation angle for estimation of distance and optimum sound ray path
- presentation of the received pulses on the audio channel.

Operational status
No longer in production. In service with the Argentine *Salta* (Type 209/1200) and Greek (4 Glavkos class Type 209/1200) navies.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

CSU 83

Type
Passive/active sonar system.

Description
Developed in the late 1960s, the CSU 83 (DBQS-21) submarine sonar is intended for boats of 400 tonnes and upwards. It is the primary sensor of the submarine fire-control and command system of the German Navy. It comprises a passive cylindrical bow array operating in the 0.3 to 12 kHz band, a trainable active transducer covering 8 kHz with a 30° beam, a FAS 3-1 passive ranging array covering the 2 to 8 kHz band with a range of 27 n miles and a sonar intercept array covering the 1 to 100 kHz frequency band with a range of 54 n miles, there is also a towed array covering the 100 to 800 Hz frequency band with a range of 54 n miles. In addition, two sensors to detect the submarine's own noises are included.

The packaging of the electronics is based on a modular design and provides easy access to all components for servicing, as well as low size and weight. The basic features of the CSU 83 are:
- high probability of detection over 360°
- computer-aided processing and evaluation
- discrimination of data on integrated displays
- simple operation by two operators via interactive, colour-coded control/displays
- sequential digital signal processing
- automatic fault detection and localisation.

Operational status
The CSU 83 is in service in: Argentina (two Santa Cruz as the CSU 3-4); Brazil (four Type 209/1400 as the CSU 83/1); Egypt (four Romeo); Greece (four Type 209/1100 as the CSU 3-4); India (four Type 209/1500); Norway (six Ula); Peru (six Type 209/1200 as the CSU 3); Poland (four Sokól (ex-Norwegian Kobben)); South Korea (nine Type 209/1200); Sweden (four Västergötland); Turkey (six Preveze).

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

CSU 90

Type
Attack, intercept, passive ranging, mine avoidance, active and flank array sonar.

Description
Developed in the mid-1980s, the basic version of the CSU 90 family of sonars comprises three main sonars; an attack panoramic passive sonar, an intercept passive sonar and a low-frequency flank array sonar covering the frequency band from approximately 10 Hz to 100 kHz where radiated noises and pulses of interest are detectable. The following sonar types can be combined in the CSU 90 system:
- LF sonar – flank and towed array
- MHF sonar – bow array (cylindrical or conformed), passive intercept, passive ranging
- HF sonar – active passive intercept
- Special sonars – mine avoidance, dedicated self-noise monitoring.

The attack sonar has a 2.8 m cylindrical hydrophone array and full azimuth coverage, a Demon detection facility uses the array of the attack sonar, and the flank array is used for long-range detection. Any target detected by one of these sonars initiates an automatic process of data collection.

CSU 90 is equipped with independent compound tracks each providing the warfare system with a complete set of tactical data. Tracks are automatically incorporated in a compound track and each sensor can initiate a compound track. The total set of compound tracks comprises:
- 16 ATT channels for the attack sonar
- 16 ATT channels for the Demon path, each with eight ALTs
- the Target Motion Analyser (TMA) which controls 16 compound tracks and generates a sonar tactical display
- TMA controls providing further manual tracks
- flank array sonar with 16 ATT channels and 16 MTs with eight ALTs each.

Optional extensions include a passive ranging sonar, an own noise analyser, acoustic passive classification, automatic warning channel, target motion analyser,

a disk memory unit, plotting devices and simulation facilities. The disk memory unit allows all displays and sonar data to be recorded for subsequent analysis and for training. It also handles the data, for comparison purposes, of the sonar information processor and the classification file for the intercept sonar.

The process computer is the ATLAS Elektronik MPR 2300-B which is integrated in all sub-systems where it is used as a real-time control processor. For signal processing hardware, high-speed RISC processors are used.

All electronic signal processing hardware is packaged in identical signal processing cluster frames linked by a common Ethernet bus-system. A high-speed fibre optic bus is used for sonar stave and beam data.

With regards to new development the next CSU 90 sonar suites will exhibit a move away from specific dedicated hardware towards an emphasis on functional software using international open standards. This approach allows a high level of COTS integration into the system. Other features will include new dual flat panel display consoles and digital arrays. In terms of sonars, a digital towed array sonar with a winch launching system will be added as well as an Intercept Detection and Ranging Sonar (IDRS) designed to cover intercept pulses from active sonars and torpedoes in the range of 1 to 100 kHz.

Operational status
In service aboard the Israeli Dolphin class and Swedish Gotland class, Chilean 'Oberon' and Thomson class (the latter will receive the system from the 'Oberon' type) and has been selected for the German and Italian Type 212A class submarines (referred to as DBQS-40) and to upgrade the Greek Glavkos class.

Contractor
ATLAS Elektronik GmbH, Bremen. ***UPDATED***

FAS 3-1

Type
Stand-alone flank array sonar.

Description
The FAS 3-1 flank array sonar is designed to perform long-range early detection and classification of enemy surface ships and submarines by picking up their low-frequency noise emissions and carrying out classification on the basis of evaluated Lofar/Demon/Spectrum data. For directional long-range detection, the FAS 3-1 has two flank arrays (linear arrays mounted at the sides of the pressure hull). Because of the direct coupling to the submarine, the flank arrays are specially designed for maximum decoupling from unwanted own noise. This consists of internal damping which minimises the influences of vibrations reaching the pressure hull. Additional self-noise detection is achieved by means of damping plates on the pressure hull and by the use of special damping elements for array mounting.

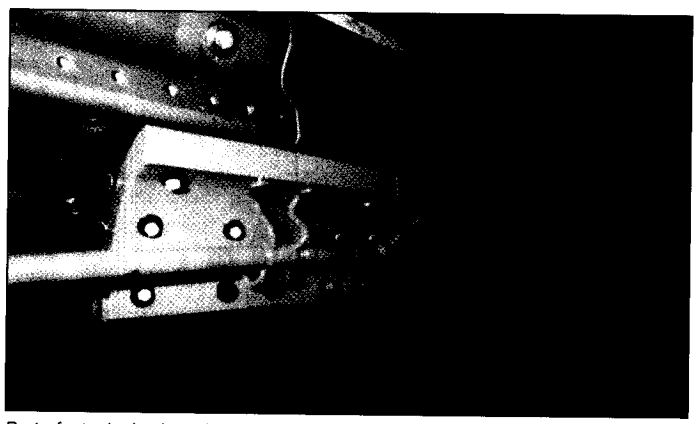
The system consists of the two flank arrays, electronics cabinet, operator's console and recording systems. The hydrophone section of each array contains 192 hydrophones uniformly distributed on a horizontal line.

FAS 3-1 covers the frequency band from 10 to 2.5 kHz. The arrays are 20 to 48 m long, depending on the length of the submarine. Bearing accuracy is 1° on a port/starboard sector of 90° between relative bearings port/starboard 45 to 135°. This can be extended with reduced performance to port/starboard 10 to 170°.

The flank array sonar can be complemented by an own noise analysis function. The main task of this element is to evaluate self-generated noise by the use of accelerometers and hydrophones. The purpose of the system is to monitor if self-generated broadband and narrowband signals exceed certain thresholds for different submarine conditions and thereby inhibit target detection and analysis of target data.

Operational status
In service on Israeli Dolphin class and being installed on the Type 212A class for Germany and Italy.

Contractor
ATLAS Elektronik GmbH, Bremen. ***UPDATED***



Part of a typical submarine flank array (STN ATLAS Elektronik) 0131457

Lopas

Type
Submarine passive sonar.

Description
Developed in the early 1990s, the Lopas (Low-cost passive sonar) is designed for the upgrading of older types of submarines with a low-cost state-of-the-art system to improve their capabilities. Special attention has been paid to achieving a minimum of mechanical and electrical disturbance on board the submarine, and most existing interfaces can be retained.

The sonar provides simultaneous reception from 96 preformed beams, and up to eight targets can be simultaneously and automatically tracked with concurrent spectral analysis (FFT), together with display and evaluation of the signals of all preformed beams.

The results of signal processing and analysis of 15 minutes of history are continuously stored and can be called off and displayed at any time. Additionally, interesting signals and data can be continuously stored by means of an integrated cassette recorder.

Other advantages include increased system flexibility (due to software adaptation), BITE and failure localisation which increases availability of the system. The control and display console allows definition of useful standard operating modes and assists the operator by offering these modes for selection via the menu.

The design of the system allows the existing hydrophone array of the passive sonar to be retained. New preamplifiers incorporating printed circuit boards are fitted inside the pressure hull, and are designed as charge amplifiers.

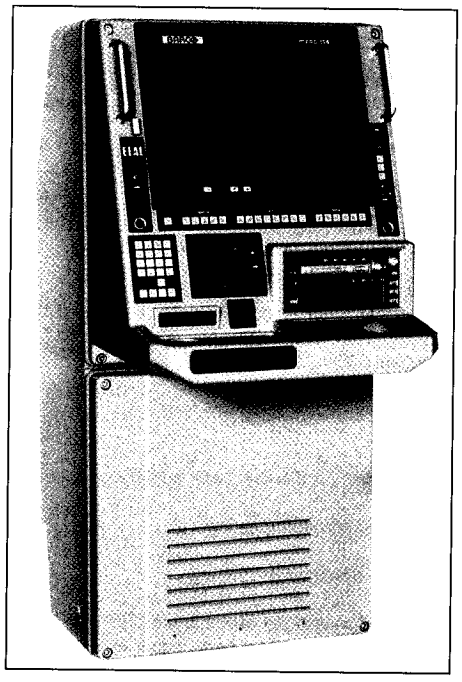
The hydrophone signals are divided into groups, combined and transmitted to a multiplex component. The beamformer is of modular design and composed of several submodules. The production of directional signals is based on fast calculation of linear-combined scanned signal values which are time-shifted. By choosing adequate stored coefficients of the linear combination, the parameters of the directivity patterns can be influenced. The signals of the 96 preformed beams are digitally sampled at the output of the beamformer.

Further processing is focused on the need to extract the parameters of significant targets from the flood of raw data.

Signal processing embraces a digital energy detector which calculates the current energy of the signal of each preformed beam. Display of the results with differing integration times allows recognition of fast alterations of time parameters and better detection due to the different frequencies of environment and own ship noises. Correlation detection can be displayed alternatively or additionally. All preformed beams are submitted to an FFT analysis with a resolution of 100 Hz. Simultaneous display of all or selected spectra is possible. Detectability of lines in the target spectrum is considerably increased by means of the reduced bandwidth (20 dB). Comparison of the stored lines of the self-noise level against the received spectrum lines can be used to eliminate the self-noise interference. An increased FFT frequency resolution (0.25 Hz) enables the determination of basic and harmonic frequencies of line families and hence classification characteristics. This extraction of target data is supported by the electronics of the signal processor in interactive communication with the operator.

Up to eight targets can be allocated to Automatic Target Tracking (ATT) channels and an ATT algorithm defines expected values for future measurements.

All control and display functions are managed by a central processor. The high-resolution 14 in colour monitor presents both graphically the results of signal processing and alphanumerically the parameters of signals and status. The system is controlled by a keyboard and trackerball. Fixed programmed operating and display modes can be selected. The sound velocity profile can be displayed and input of sound velocity parameters can be accomplished manually or via interface directly from a sound velocity sensor, if installed. Displays include: polar diagram; bearing/amplitude; bearing/amplitude history; bearing/frequency history; and FFT



Console MP90 for Lopas
(L-3 Communications ELAC Nautik)
0594114

bearing/frequency presentation of all 96 preformed beams; and FFT analysis of a single channel (for example ATT or cursor).

Operational status
Installed on German Type 206 submarines and on midget submarines for special operations.

Contractor
L-3 Communications ELAC Nautik GmbH, Kiel.

UPDATED

PRS 3-15

Type
Stand-alone passive ranging sonar.

Description
The PRS 3-15 is a submarine passive ranging sonar covering the 2 to 8 kHz frequency range with a 20° beam and designed to be operated in conjunction with the CSU, or as an independent system. It can be used for passive detection of targets and for passive range-finding of submarines. The 15 stave array (60 hydrophones) with a high-directivity index provides a good signal-to-noise ratio, and suppression of adjacent targets that are not of interest. Six individual arrays are mounted along the hull, three on the starboard side and three on the port side.

The PRS 3-15 performs the following functions:

- panoramic detection with high-array gain
- measurement of target bearing
- automatic tracking of target bearing on up to four targets simultaneously
- range measurement on up to four targets
- calculation of target course and speed without the need for manoeuvres by the host submarine
- narrowband audio channel via PRS array or CSU cylindrical array
- automatic calculation of a confidence factor for the range data.

The signals received by the arrays are correlated with each other, the sampling values of the correlation function are integrated according to range and target dynamics, and are then analysed by the processor in order to estimate the time delays of the signals. From the time delay measurements the range is calculated. In addition, the variance of the time delay estimations is determined and converted to a confidence factor of the range value.

Operational status
No longer in production. In service aboard some Peruvian Angamos class Type 209/1200 submarines and the three Israeli Dolphin class submarines. The PRS 3-4 is fitted to Type 209 boats of the Colombian Navy and to the Sava class of the Serbia and Montenegro Navy.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

PSU 83

Type
Passive surveillance and detection sonar.

Description
The PSU 83 is designed for new submarines of small and medium sizes, and can also be retrofitted to older submarines to improve their detection facilities. High-technology preprocessing units with newly designed preamplifiers and filter units ensure sensitive and undisturbed reception.

The very good detection performance is achieved in two independent detection channels: one for surveillance tasks with short integration times, and the other for long-range detection using longer integration times. Both detection results are displayed simultaneously to provide a comparison facility. The sonar is equipped with eight independent automatic target tracking channels.

For redundancy purposes and to improve performance, the preprocessing unit and the beamformer are split into two independent electronics units. Additionally, a redundant beamformer and a separate direct signal path to the operator's console are provided. A built-in target data analyser and a bearing prediction facility improve the operational value of the sonar.

All the signal processing electronics of the PSU 83 are combined in one operator's console and two preprocessing units. The operator's console consists of software-driven buttons, trackerball for accurate cursor movement, high-resolution raster scan colour display and a video output for slave display. For extended functions the operator's console is available with two displays.

The PSU 83 can be extended with a number of options, including:

- intercept sonar
- flank array sonar including Lofar detection, tracking and analysis
- Demon detection, tracking and analysis
- mass storage unit for target data and display recording
- sonar graphic recorder
- onboard training simulator
- own noise analysis.

When combined with a fire-control system, the PSU 83 forms a complete submarine warfare system.

Operational status
In service in three Tumleren class submarines of the Royal Danish Navy and two Pijao class of the Colombian Navy.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

Scout

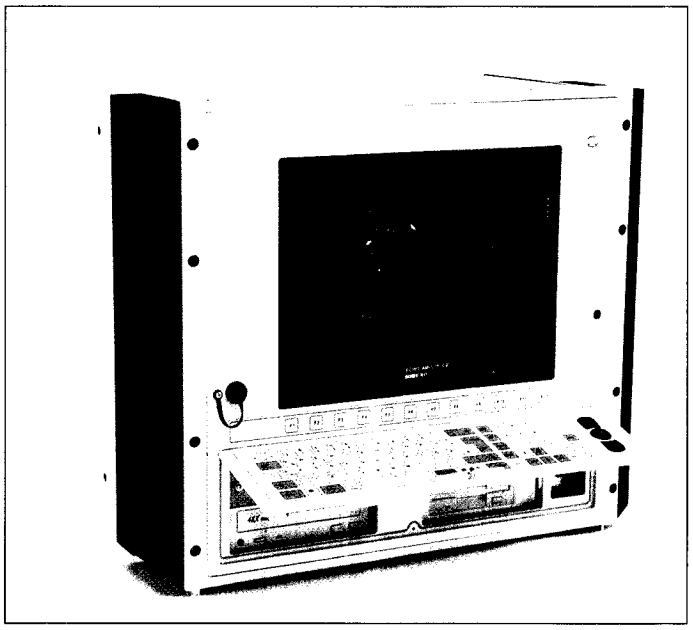
Type
Multipurpose sonar.

Description
More than 70 years of experience in sonar system development has led to an innovation that will increase the safety of surface vessel forces in war and peacetime, even under bad conditions. The German and other navies will use this new system to increase the survivability of their submarines and surface ships.

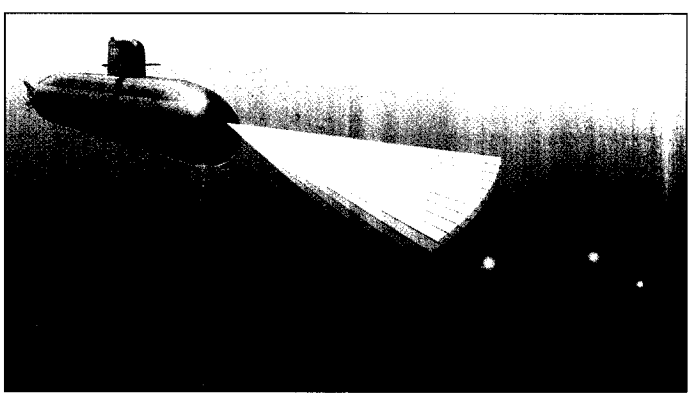
The navigation and detection sonar Scout (NDS 3070) is a versatile active/passive sonar system conceived for use on submarines and other submersible vehicles. The system is designed primarily to detect mines, but will also be used to detect other moving or stationary underwater objects.

The system can be used as a navigation sonar during a submarine's surfacing manoeuvre, or as a navigational aid in narrow or dangerous waters. In addition a passive mode is also available to detect and receive sonar signals and underwater noise over a wide frequency range.

The dual frequency sonar provides navigation, detection, collision avoidance, obstacle avoidance and mine avoidance. The long range LF mode is combined with a high-resolution HF mode with 2-D LF and 3-D HF forward looking active



Display and control console for Scout and Vanguard sonars (L-3 Communications ELAC Nautik) 0129741



Coverage of Scout sonar (L-3 Communications ELAC Nautik) 0129740

sonar. The system interfaces with log, compass, sound velocity, roll and pitch and a printer. Scout can operate as a stand-alone system or be integrated into combat systems.

Specifications
Frequencies: active - 30 kHz (LF) and 70 kHz (HF)
Measurement Ranges: 100, 500, 1,000, 2,000 and 4,000 m
Detection ranges (Typical):
mines - 1,700 m at 30 kHz; 850 m at 70 kHz;
obstacles - 2,800 m at 30 kHz, 1,200 m at 70 kHz;
small submarines - 3,600 m at 30 kHz, 1,450 m at 70 kHz
Bearing accuracy: LF <1.5°, HF <1°

Contractor
L-3 Communications ELAC Nautik GmbH, Kiel.

UPDATED

Security Eye

Type
Short-range sonar system.

Development
This short-range sonar system has been developed to provide submarines operating near the surface or in the process of surfacing with the ability to illuminate the water level above the submarine to detect surface vessels as small as yachts, tugs and fishing vessels to prevent underwater collisions. Security Eye is designed as an add-on to a submarine's existing sonar sensors.

The system can also be used for minehunting, ship-monitoring against covert underwater sabotage and as hand-held sonar for divers.

Description
The sonar uses a broadband active transducer array producing three phase-shifted signals (+120°, 0°, and −120°), which are used to drive a broadband source receiver array. The pulse illuminates the area with uniform energy with the same time duration and over the same bandwidth for all directions. The frequency dependent interference pattern is interpreted as an angle dependent transfer function. Neighbouring angles show orthogonal behaviours, enabling the distinguishing of different directions.

The transducer array receives the echo, so the frequency dependent transfer function is used again. This results in patterns, which are associated one to one to the direction of the reflecting body.

Security Eye is of simple mechanical and electrical design which makes it relatively easy to integrate the system with other sensors on board submarines during a mid-life refit.

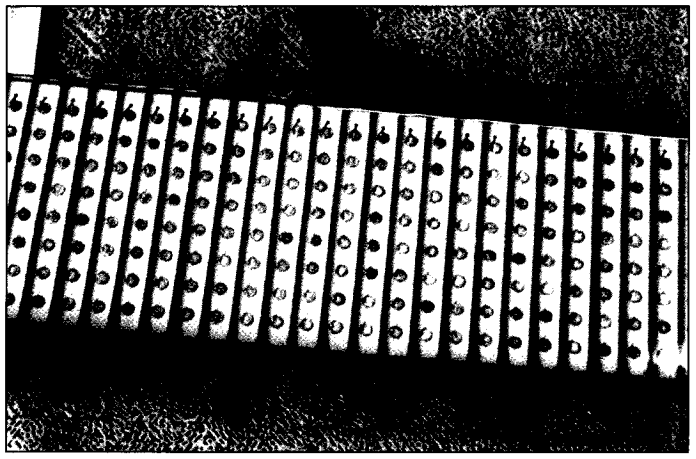
Because the system uses only thin cables, pressure hull glands with small diameters can be used (about 1 m × 1 m × 20 cm) and can be mounted on the upper deck of the submarine.

The experimental array consists of 27 staves with an operating frequency of 20 to 95 kHz, depending on the limitations of the ceramics. The array size is 428 × 144 × 58 mm. Production versions will incorporate more staves. Each stave is hard-wired to one of the three signal channels in a random order, which results in an angle dependent transfer function, that is, there is a one-to-one coding of emitted signal to the direction. Each stave comprises eight mechanically and electrically connected piezoceramics.

Operational status
Under development.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED



Front side of the Security Eye transducer, not covered with polyurethane. The vertical staves are clearly visible (STN ATLAS Elektronik GmbH) 0132791

TAS 90

Type
Very low frequency towed array sonar system.

Description
The low frequency TAS 90 meets the requirements of submarine sonar for long-range detection, target classification and target motion analysis.

The main features of the sonar are:
- early detection of targets
- independence of bathythermal conditions, in which the towed array is operated in the optimum layer
- detection of the acoustic spectral lines of quiet submarines
- detection of transients
- detection of low-frequency noise by cavitating surface vessels
- target motion analysis computed by algorithms specially adapted to the towed array sonar.

To perform the above tasks the array can be fitted with different 'wet ends' of various diameters, and task-oriented electronics. The optimal arrangement proposed by STN ATLAS involves an array of channels working in four frequency ranges. Two octaves covering the lower frequency band are important for ASW. Two more octaves covering the upper frequency band support surface vessel detection and classification. Signals received are fed to a north-stabilised beamformer which creates 192 different beams over the azimuth. Separate paths are used for signal enhancement for the detection display and audio channel. Up to eight targets can be tracked automatically and a separate signal path is used for frequency analysis, using Lofar techniques. Automatic multiline trackers can be set on characteristic frequency lines of the target's signature. Together, the automatic target tracker and multiline tracker can follow a target even at long ranges or under extremely severe conditions such as target crossing or convoy acoustic environment. The built-in multipoint divider, cursor and other support measures assist the operator in defining and classifying the type of engines, gearbox ratio and other information. This is achieved using Lofar transient noise detection, audio analysis/classification and bearing/time record.

The winch for the array is mounted externally to the pressure hull at the stern of the submarine and can handle the complete array including the tow cable. All winch controls are mounted inside the pressure hull and managed from the sonar operator's console.

The array is also available as a clip on unit with mechanical fastening of the array to the submarine via the tow cable. The latter is passed through a guide tube, the plug-in connection being made manually. In an emergency the array can be released using a manually controlled hydraulic value in the control centre and hydraulic cylinders.

Operational status
In service on board Turkish Preveze class and being installed on Type 212A boats.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

Japan

ZQQ series

Type
Various submarine type sonars.

Description
Most early Japanese ASW submarines were fitted with various types of US sonar systems. Based on these US sonars, the Japanese have developed a series of indigenous sonars. These use state-of-the-art digital processing and display technology as developed in Japan. The ZQQ 1 passive sonar manufactured by Hughes/Oki was comparable to the US BQQ-2. It comprises a bow cylindrical array with three sets of staves mounted on top of each other. The ZQQ 2 (a modified ZQQ 1) built by Hughes/Oki was a cylindrical bow array which equipped the Uzushio class, now out of service. The passive/active search and attack sonar is a medium-/low-frequency system which can also operate in an acoustic intercept mode. The ZQQ 5 built by Hughes/Oki is a modified BQS-4, medium-/low-frequency, bow-mounted spherical, passive/active search and attack sonar which equips the Yuushio class. The latest sonar is the Hughes/Oki ZQQ 5B medium-/low-frequency, active/passive search and attack sonar comprising spherical bow and flank arrays. The sonar also incorporates a retractable towed linear passive intercept array. The sonar is fitted in submarines of the Harushio class and is also being retrofitted to the Yuushio class.

The ZQR 1 is a very low frequency, clip-on, passive, towed array sonar similar to the US AN/BQR-15 and forms part of the ZQQ 5B system.

Operational status
Sonars are operational in Japanese submarines: ZQQ-5 on Yuushio class and ZQQ-5B on Harushio and Oyashio classes. The ZQR 1 TAS equips the Harushio, Yuushio and Oyashio classes.

Contractor
Oki Electric Industry Ltd, Tokyo.

UPDATED

Netherlands

SIASS-1 and 2

Type
Passive and active attack and surveillance sonar.

Description
The Submarine Integrated Attack and Surveillance Sonar (SIASS), developed by Thales Nederland in 1978, is available in two versions: SIASS-1 and SIASS-2. The former is a stand-alone system with its own sonar consoles interfacing with a submarine data handling and fire-control system. SIASS-2 is an integrated part of the Thales Nederland Submarine Sensor Weapon and Command System (SEWACO).

Both SIASS-1 and SIASS-2 perform and integrate the following tasks:

- low (long-range) and medium (medium-range) surveillance of noise radiating targets through the use of broadband and multichannel narrowband signal processing for surveillance, analysis and tracking (Lofargrams, ZOOM-FFT, Demon, ALI displays)
- passive range detection
- automatic target tracking for a multitude of targets, including automatic line tracking
- contact motion analysis (position determination on bearings-only information)
- active sonar
- LF, MF and HF intercept
- classification
- noise level monitoring and cavitation indication.

The sonar suite is divided into three groups of equipment, each with its own processing cabinet:

- a cylindrical passive bow array performing the functions of narrowband and broadband operation in the medium-frequency band, low-frequency acoustic intercept, and active operation by means of an associated active transmit array
- port and starboard flank arrays to carry out narrowband and broadband passive operations in the low-frequency band
- port and starboard passive ranging arrays, together with a HF intercept sonar.

The bow sonar comprises the cylindrical passive array of 96 staves each with four transducers producing 96 pre-formed beams (and which also carries out LF intercept functions) and an integral active cylindrical array. The passive ranging array consists of six elements (three on each flank) producing 32 pre-formed beams and the HF intercept array consisting of four elements.

Each sonar can operate autonomously, in combination with one or more display consoles, if other parts of the system are unavailable. This allows, for example, the passive ranger to operate as a back-up for the cylindrical array sonar. A flank array sonar which performs low-frequency coverage and full primary sonar operations is available.

SIASS can store 35 tracks and performs automatic contact motion analysis on each sonar target being tracked, up to the maximum of 20 that can be handled by the system. There are 28 broadband tracking channels. The broadband subsystems of the cylindrical array and flank array sets, each have four operating channels with eight preselected frequencies. The high-frequency and low-frequency acoustic-intercept sonars each have 16 channels, and the active sonar has four; in these cases tracking is based on the use of associated algorithms. The electronic classification for each sonar can hold information on up to 300 specific platforms including 100 ship classes and 100 sonar types.

The cylindrical array sonar acts as the primary attack sensor. A combination of broadband and narrowband processing is used to extend detection ranges, to enhance tracking, and to provide quick and accurate classification of contacts. Simultaneous panoramic coverage is achieved by the use of preformed beams.

The flank array sonar is a low-frequency passive equipment using 24 acceleration cancelling type hydrophones that can act as the primary attack sonar within its frequency range. The port and starboard line arrays, used in conjunction with real-time delay beam-forming, provide coverage of large bearing sectors on each side of the submarine. The processing chain is similar to that of the cylindrical array sonar and can be matched to interface with a towed array if required.

Each of the preformed beams produced by the cylindrical array sonar and the 64 beams produced from the flank array undergo online spectral analysis in parallel, a complex FFT (Fast Fourier Transform) technique being used to give reliable detection and tracking of noise emitted by a contact. The frequency-analysed preformed beam signals from the cylindrical array processor are used as a low-frequency intercept sonar that can associate a large number of different transmissions simultaneously, and incorporate extensive algorithms to reduce false alarms.

The cylindrical array and flank array sonars also have enhanced classification channels for high-resolution vernier analysis, and to enable frequencies below 100 Hz to be measured. They can also provide multichannel automatic tracking.

The active sonar can be operated in directional single ping, and omnidirectional single ping or multiping modes. Return echoes are detected and processed by the cylindrical array sonar, and when operating in the multiping mode, the active sonar can automatically track multiple targets.

The passive ranging sonar operates in the lower part of the frequency band and is normally slaved to the cylindrical array. In this slaved operating mode, range is automatically calculated once a broadband contact that is being tracked on the cylindrical array has entered the ranging sector. The passive ranger's signal processing uses a method of frequency-domain correlation to measure wavefront curvatures and thus provide range information.

The high-frequency intercept sonar provides coverage up to 100 kHz and employs a fully digital compressor using FFT techniques to detect, correlate and classify intercepts of torpedoes or sonars against a threat library, and to warn the operator automatically.

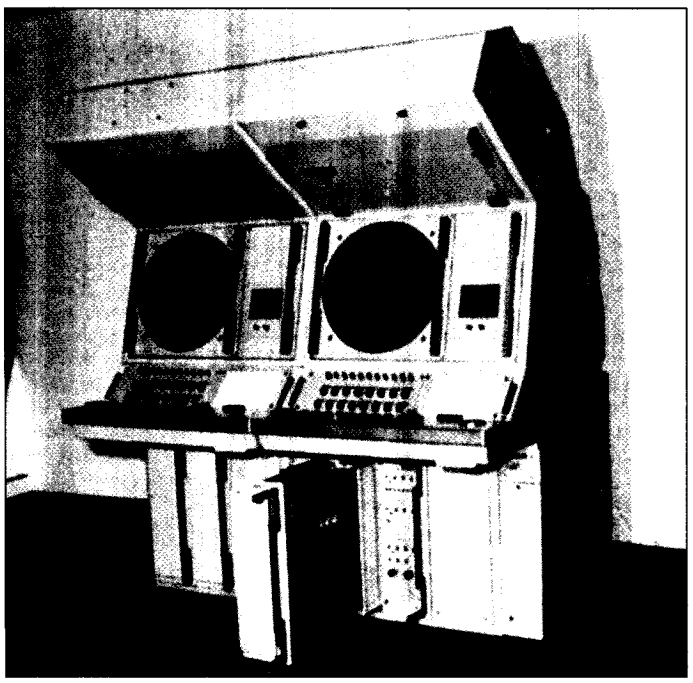
Control is exercised from four or five multipurpose consoles which may be integrated parts of a total SEWACO system. These consoles are multifunction operator workstations equipped with a high-resolution raster scan colour display. As an optional extension, signal processing for a towed array can be offered.

Operational status
No longer in production.

In operational service on the Taiwanese Hai Lung class.

Contractor
Thales Nederland, Hengelo.

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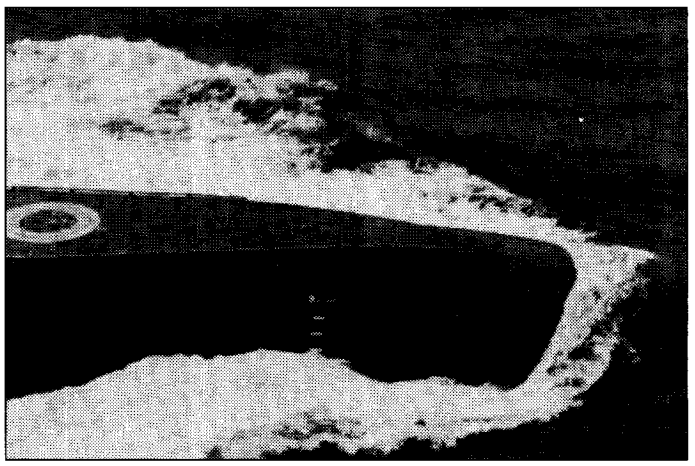
SIASS display and computer consoles

Russian Federation

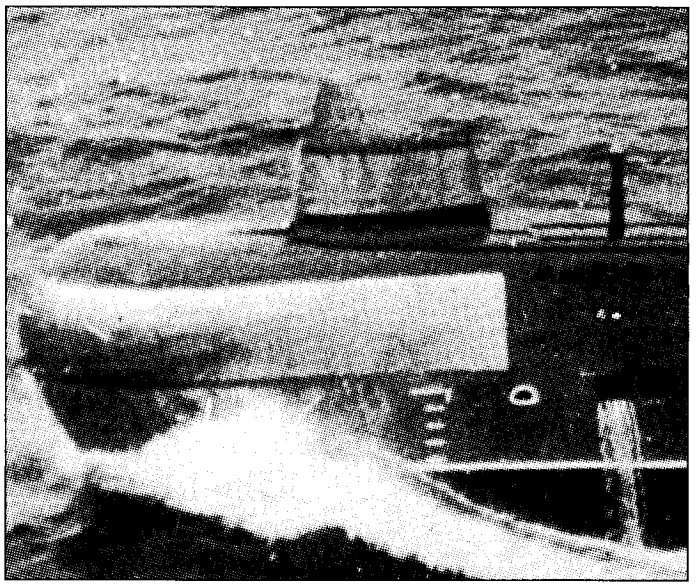
Introduction

Early sonars appeared during the Second World War. By 1958, the Feniks sonar system appeared and became the standard on all following classes of diesel electric submarines for nearly two decades. Other acoustic systems included a 'top-hat' looking underwater telephone, codenamed Fez and the Sviiaga (MG-15) communication sonar. The wraparound Feniks HF bow array required at least a crude compensator switch to steer listening beams.

Four submarine classes had a larger size topside sonar dome and, since these classes all carried new 16 in ASW torpedo tubes aft, this dome was probably related to the fire-control computers for these tubes. Since passive fire-control solutions require triangulation, it is quite likely that the vertical fin aft on many later submarine classes may include sonar hydrophones.



Bow sonar on Kilo class submarine



Sonar window on Foxtrot class submarine for Feniks system

The November class SSNs were the first with a rakishly streamlined bow array, although this was probably of a medium-frequency type. The first low-frequency sonar appeared in the early 1960s on the Echo II and Juliet classes, and by 1967 streamlined bow shapes with sharply sloped low-frequency bow array windows had appeared.

The Victor III, Sierra and Akula classes have a teardrop shaped pod on top of the aft rudder fin. Most references state that it houses either a towed array indicating a high level of signal processing power and beam-steering, or perhaps a wire communications antenna. The later Oscar class also has a vertical aft fin that has towed array capability.

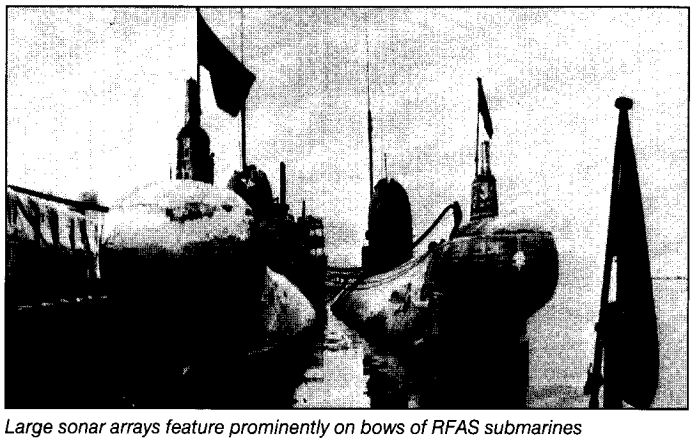
The Kilo class is fitted with the MGK-400 EM digital sonar system. This is a passive/active sonar with UWT and telegraph capabilities over both long and short ranges. Echo ranging is provided over a ±30° sector of the target's relative bearing.

The accompanying list is considered to be the most up-to-date covering the earlier First and Second Generation Soviet sonars. Later generations of Soviet sonar will be updated as further details become available.

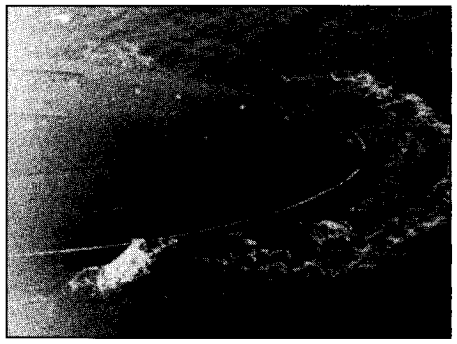
Plutonii
Type: HF active/passive sonar
Development: Plutonii was developed in 1951-54 for medium-sized modernised submarines. The system entered service in 1955.
Description: The sonar used a flat array with dimensions of less than 1 m. Its main function was to measure the range of a target using the bearing acquired by the Feniks sonar and a mine detection system. The sonar incorporated telegraphic communication.
Operational status: No longer in production or service.
Contractors: ZNII Morfizpribor, St Petersburg (design)
Vodtranspribor, St Petersburg (serial production)

Anadyr'
Type: HF active/passive sonar
Development: Developed in 1953-55 for the Quebec (Project 615) class submarines. The system underwent trials in the Baltic in 1955 and entered service in 1956.
Description: The sonar featured a 1.0 m square array with magnetostrictive transducers/transmitters which operated on 17 to 19 kHz frequency band. The electrically driven array was rotated automatically or manually.
Operational status: No longer in production or service.
Contractors: ZNII Morfizpribor, St Petersburg (design and experimental model)
Vodtranspribor, St Petersburg (serial production)

Kerch' MGK-100
Type: LF/MF passive/active sonar



Large sonar arrays feature prominently on bows of RFAS submarines



Sierra class SSN bow with missing plates behind bow sonar belt

Development: The Kerch' was developed in 1958-64 for the Echo (Project 675) class submarines. It was later installed on Yankee class (Project 667A) and Delta (Project 667B, BD, BDR and BDRM) class boats. The system underwent sea trials on board an Echo class submarine in the Japan Sea in 1966 and entered service later that year.
Description: The Kerch' featured two main bow-mounted arrays. The active hydraulically driven rectangular array measured 2 m high and 2.5 m wide. The transmitter units were placed on both sides of the array, which could be tilted +10° to −55°. The transmitter operated on two frequencies of 4.0 and 8.0 kHz. The cylindrical passive array mounted above the active array, measured 3.8 m in diameter and 2.5 m high and used magnetostrictive nickel transducers. Passive detection was carried out using 5.0 to 7.5 kHz diapason. Kerch' was reported to have a range of 2 n miles in active mode and 4 n miles in passive mode. The flank array (NATO codename Shark Hide) was not effective.
Operational status: No longer in production or in service with the Russian Navy.
Contractor: Vodtranspribor, St Petersburg (design and serial production)

Rubin (MGK-300)
Type: LF passive/active sonar
Development: Rubin was initially developed in 1959-64 for the Papa (Project 661) class submarine. It was later installed on Victor I (Project 671) and Victor II (Project 671 RT) class submarines. Initial sea trials were conducted in 1965 in the Japan Sea and the Pacific Ocean on 'Zulu' (Project 611RU) reconstructed class submarine B-65, due to long delays being experienced with the Papa and Victor I class submarines. A second sea trial was carried out on a Victor I class submarine in the White Sea and Barents Sea in 1967-68. The sonar entered service in 1968.
Description: This was the first powerful Soviet sonar and was developed primarily for the detection of carrier battle groups at ranges of 800 to 1,000 km in convergence zones. Rubin featured one main cylindrical passive/active array in which the lowest ring was used for LF telegraph coded communication and interception. The cylindrical array was 6 m in diameter and 3 m in height. It contained more than 400 piezoelectric ceramic reversible active/passive transducer modules. Each transducer comprised a ring on which were mounted 120 small prisms in the form of a parallelepiped. It used the 3 kHz frequency band for active detection (65 kW radiated power) and 4.0 to 6.5 kHz for passive detection. Search and detection functions were performed by rotating three preformed beams (each of 120°) that could tilt between +12° and −50°. The MGK-300 used more modern sonar technology offering various operating modes (CW, FM, bottom bounce, convergence zone and so on), lower operating frequency, improved gain, and an ability to adapt to changing environmental conditions (for example salinity, temperature and so on).

Signal processing electronics, transmitting and display vacuum tube equipment was contained in 65 cabinets. The HF telephone communication arrays and interception arrays were mounted in the sail.
Operational status: No longer in production or service.
Contractor: Morfizpribor, St Petersburg (Design and prototype manufacture)
Priboi, Taganrog (serial production)

Enisei
Type: LF/MF passive/active sonar incorporating communication and interception functions
Development: Enisei was designed as the main system of 'komplex' Okean in 1960-65 for the Alfa (Project 705) class submarine. The first sea trial was carried out in the Sea of Japan in 1967 on the 'Zulu' (Project 611) class submarine B-68.
Description: The sonar comprised two main arrays – a cylindrical passive array 4.5 m in diameter and 1.5 m high and a rectangular active array measuring 3.8 m × 2.4 m. The preamplifiers of the passive array were mounted in the transducer module. The active array radiated on 4.2 kHz at 35 kW. The transmitter and transducer modules were constructed of piezoelectric ceramic material. The hydraulically driven active array rotated horizontally, and tilted vertically between +25° and −55°. Submarine detection was carried out using the 5.0 to 7.5 kHz frequency range. Multibeam reception in passive mode covered 360° with sector scanning in active mode. The dimensions of the cabinets and electrical power were non standard (electrical power rated at 400 Hz instead of the normal 50 Hz).
Operational status: No longer in production or service.
Contractors: Morfizpribor, St Petersburg (design and production of two prototypes)
Vodtranspribor, St Petersburg (serial production)

MGK-500 Series Skat
Referred to by NATO as Shark Gill, this passive VLF TAS is a fully digital system that is integrated with a passive VLF/LF flank array sonar. The system forms part of a much more comprehensive sonar configuration including noise monitors, obstacle

avoidance sonar, depth (both above and below the hull) sounders and a prediction system. In its latest configuration the MGK 500 Series is fully automated, detecting and tracking targets in both broadband and narrowband with classification performed using a wide variety of measured parameters against a signature library to identify the target. The hull mounted element comprises a two-ring configuration of horizontal staves circling the pressure hull with a bow-mounted transducer (shape conforms to the hydrodynamic configuration of the boat) of about 30 staves, each carrying nine hydrophones.

First observed in Victor II class boats. The system is currently operational in Akula (Typhoon) and Delta IV classes of SSBNs and Akula, Oscar and Victor III class SSNs.

Ajax/Irytysh

This is an integrated sonar system comprising a large LF passive/active search and attack spherical bow array, VLF flank arrays, towed array and so on, developed for the new Yasen class SSN. The volume of space required for the bow array has resulted in the need for the bow torpedo tubes to be moved further aft and to be inclined outwards as in American Seawolf class submarines.

Due to become operational on board the submarine *Severodvinsk* when that boat finally enters service.

Akula

Codenamed Shark Rib by NATO, this is a large passive LF flank array originally developed for the Victor III class SSNs. The array is said to extend for about a third of the length of the boat.

In service aboard Akula (Typhoon) class SSBNs and Sierra, Oscar, Victor III class SSNs.

Pelamida

Referred to by NATO as Shark Tail, this passive VLF TAS is reported to operate on a frequency of around 20 to 200 Hz. The array is of considerable size (as can be understood from the size of the 'Pod' at the stern of Victor III class SSNs which houses the array) and is estimated to be 80 m in length housing about 50 hydrophones mounted at the end of a 750 m towing cable.

In service aboard 'Delta III' and Delta IV SSBNs and Victor III and Oscar class SSNs.

VERIFIED

Arktika (MG-100), Arktika-m (MG-200)

Type

HF, MF active/passive sonar.

Development

The Arktika was developed in 1952-54 for the first Soviet nuclear submarines, the November (Project 627, 627A) class, and for the Golf (Project 629), Foxtrot (Project 641) and 'Romeo' (Project 633) class diesel electric submarines. The Arktika-M was an upgraded version of the Arktika, which it replaced from 1957 on the same class submarines. Trials of the upgraded sonar were carried out in the Black Sea in 1957 on board a Romeo class submarine. The upgraded sonar entered service in 1958.

Description

The analogue Arktika (NATO codename Pike Jaw) system initiated target detection and auto-tracking (or auto-tracking on target detected by Feniks) and then carried out range measurements on the target. The array comprised a metal reflector 1.3 m in diameter, on the axis of which were set cylindrical a magnetostrictive transmitter and four transducers. The electrically driven array carried out omni or sector scanning automatically (or manually). The transmitter operated on a frequency of 15 kHz and was integrated with the fire-control system Leningrad, the first Soviet submarine sonar to be so linked. This enabled the boats to discharge torpedoes against a target without the need to come to periscope depth to verify firing parameters. Bearing was measured using phase discrimination. The sonar is reported to have a range of 2 n miles under good conditions.

The upgraded variant, Arktika-M, was developed in 1955-56 and featured a hydraulically driven array and a special block of filters to provide improved echo discrimination against background reverberation. The upgraded sonar used piezoceramic transmitter and transducer.

Operational status

No longer in production or in service with the Russian Navy. Remains in service aboard some Foxtrot and Romeo class submarines, and on Chinese navy Golf and Ming class boats.

Contractor

Morfizpribor, St Petersburg (design and prototype manufacture).
Vodtranspribor, St Petersburg (serial production).

VERIFIED

Feniks (MG-10), Feniks-M (MG-10M)

Type

MF passive search sonar.

Development

Feniks was developed between 1949-53 for the Zulu (Project 611) and November (Project 627) class submarines. It was also mounted on Foxtrot (Project 641), 'Romeo' (Project 633) and 'Golf' (Project 629) class submarines. Entered service in 1953 and was modernised in 1956-58.

Description

Codenamed Shark Teeth/Trout Cheek by NATO, Feniks featured a 2.0 m diameter cylindrical array 1.2 m high, with 120 magnetostrictive transducers. The sonar operates in the 7 to 9.5 kHz frequency band. Bearings are acquired using phase discrimination. The modernisation programme (Feniks-M) provided the sonar with an automatic search and tracking capability.

Operational status

No longer in production, but remains in service in Foxtrot class submarines around the world and Romeo class submarines of North Korea.

Contractor

Vodtranspribor, St Petersburg (design and serial production).

VERIFIED

Rubikon (MGK-400)

Type

Passive/active sonar with communication and passive intercept.

Development

Rubikon was initially developed in 1968-72 for the Tango (Project 641B) class submarines. Later Rubikon replaced Rubin on the Victor I (Project 671) and Victor II (Project 671RT) class submarines, and possibly the Kerch on the Delta III (Project 667BDR) class. An export version of Rubikon has been developed for export Kilo class submarines. Sea trials were carried out on a diesel submarine in the Black Sea in 1973.

Description

The main passive array is cone-shaped, with a diameter of 4.5 m and height of 3.5 m. Three flat active arrays are mounted in the sail. The LF passive bow element is said to incorporate seven transducers on each stave. The number of cabinets of electronic equipment has been reduced to 10 because the compensators and preamplifiers are sited in a hermetically sealed capsule that forms a container for the passive array. This was the first Soviet sonar to use micro modules in digital and analogue equipment. It is reported that beam forming is carried out using analogue while signal processing is performed using digital technology. The sonar operates in the frequency range 5.0 to 8.0 kHz, with active search and detection performed at 4.0 kHz. It is considered that the sonar features improved frequency discrimination and Doppler shift measurement, leading to improved TMA solutions. Further developments have resulted in a full digital system with much improved range but using the same array.

The MGK-400EM incorporates advanced receiving elements, while the hardware features modern, high-speed data processing computers and multifunctional displays. Upgraded processing algorithms allow an expanded range of functions including target classification, LOFAR and DEMON tracking, automatic tracking of up to 12 targets, active search using new complex waveforms, upgraded communications and IFF signals, active homing torpedo detection capability across an extended frequency range, signal measurements and so on. Detection range and positioning accuracy have both been significantly improved and the system is capable of measuring and controlling self-generated noise, burning through jamming noise and providing sonar prediction capabilities. The sonar also has bite and fault diagnostic equipment. The sonar is being further upgraded with the introduction of a low frequency echo ranging channel using a flexible trailing antenna or additional onboard antennas.

Operational status

The latest digital version is currently in production. In service on some Russian and other navies' submarines.

Contractors

Morfizpribor, St Petersburg (design and prototype production).
Vodtrasnpribor, St Petersburg (serial production).

UPDATED

Spain

Solarsub

Type
Submarine towed array sonar.

Description
The LF Solarsub towed array sonar is designed to complement submarine hull-mounted sonars and offers greater range of detection and easy platform integration as stand-alone equipment.

The system offers wide area surveillance; long-range detection; multiple track capability; and improved classification aids.

The modularity of the system with its small footprint components and low power consumption enables the system to be easily installed on board any type of submarine.

Solarsub comprises an antenna and junction box, input signal conditioner, operator console, and optionally an outboard winch for deployment and recovery of the antenna, depending on operational requirements.

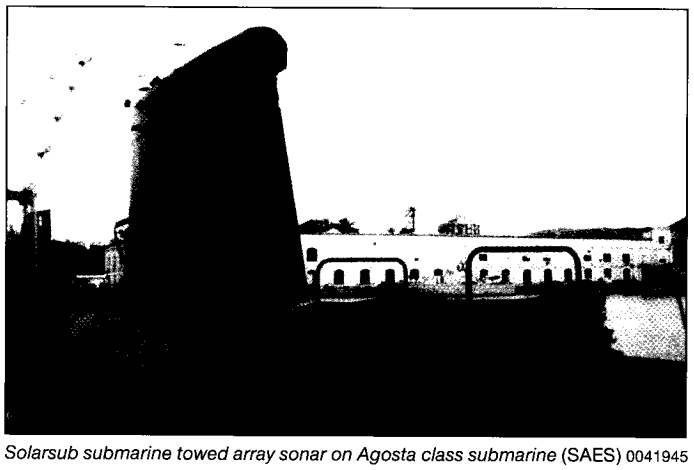
The system uses COTS hardware components and a new generation streamer that, due to its reduced diameter, allows a wide range of towing speeds.

The sonar is fitted for standard interface with combat systems.

Operational status
In service with the Spanish Navy aboard Galerna (Agosta) class submarines.

Contractor
SAES, Cartagena.

VERIFIED



Solarsub submarine towed array sonar on Agosta class submarine (SAES) 0041945

United Kingdom

SAWCS

Type
Submarine Acoustic Warfare System (SAWCS).

Development
SAWCS is under development to meet a UK Royal Navy requirement to provide a subsystem for the next generation torpedo defence system for its submarine fleet.

Description
SAWCS is intended to provide detection, classification, localisation, threat evaluation and automatically generate tactical evasion advice against torpedo threats. SAWCS will automatically select programmes and launch appropriate countermeasures. This is achieved by processing sonar data and using algorithms which can separate torpedo tonals from all other known sea sounds, and is supported by other known and recognisable sounds such as tubes opening, torpedoes being discharged or aircraft flying overhead. Northrop Grumman's Oceanic and Naval Systems division has been awarded a contract by UK Alenia Marconi Systems to design and manufacture the system which will locate and classify sonar signals.

Much of the technology for the detection, classification, localisation and threat evaluation subsystem will be based on Northrop Grumman's work for the US/UK SSTD programme and the AN/SLX-1 MSTRAP system. DRS Technologies has been awarded a contract by Northrop Grumman to design, test and manufacture the enclosure for a system processing unit for the SAWCS. This will enable SAWCS to classify a sonar detection and pinpoint its location.

Operational status
Currently under development with deliveries commencing in 2001. The programme will run to the end of 2006 by which time a prototype trials system, five partial fit systems, three full fit systems and an operator/maintainer trainer will have been delivered. Being installed on Trafalgar and four Swiftsure class submarines.

Contractors
AMS (prime), Camberley.
Northrop Grumman Corporation, Oceanic and Naval Systems (subcontractor).

UPDATED

SCTAS

Type
Reelable thin-line towed array sonar.

Description
The SCTAS (Submarine Compact Towed Array System) has been developed to provide non-nuclear submarines, both new build and retrofit applications, with a lightweight, compact reelable system which will fit into the confined space beneath the casing of a non-nuclear submarine.

SCTAS is a short aperture (up to 250 m) variant of the Crustacean thin-line array. The modular, open construction Crustacean system features a foam-filled thin line (38 mm in diameter) with peripheral strengthening members but no bulkheads. The array uses low-cost, low-power digital 24-bit telemetry with dual redundancy and module interchangeability. The tow cable and array are of the same diameter and incorporate a new-design high-strength flexible electro-optic termination. This permits full reeling and simplifies the layering process.

The full system comprises a tow cable and array storage drum, vertical axis winch and integrated spooler and transfer mechanism. Electric is used throughout the system, offering cost, reliability and controllability benefits over hydraulic actuation.

Operational status
The Crustacean technology demonstrator was completed in mid-2000 and three at sea trials and handling tests have been conducted. The design has been kept up-to-date and is available to selected nations.

Contractors
QinetiQ, Farnborough.
J & S Marine, Barnstaple, Devon.
Strachan & Henshaw, Bristol.

NEW ENTRY

Type 2007

Type
Passive search and detection sonar.

Description
The Type 2007 is a conventional submarine sonar which uses preformed steerable beams, enabling the submarine to maintain a straight course while the beams are steered to search the waters for detection and tracking of hostile submarines. It consists of a linear array of 24 hydrophones mounted on either flank of a boat. The Type 2007 search beams listen at a frequency of between 1 and approximately 3 kHz and are used for initial long-range target detection and for gaining a bearing resolution. The sonar listens for propeller cavitation, nuclear cooling pumps and turbine reduction gears for initial target detection.

The Type 2007 is a more modern version of the original Type 186 passive conformal hydrophone system. This latter equipment consisted of a series of hydrophones evenly spaced along both sides of the hull.

Operational status
No longer in production. Still in operational use. The Type 2007 is installed in the 'Victoria (ex-'Upholder') class boats of Canada.

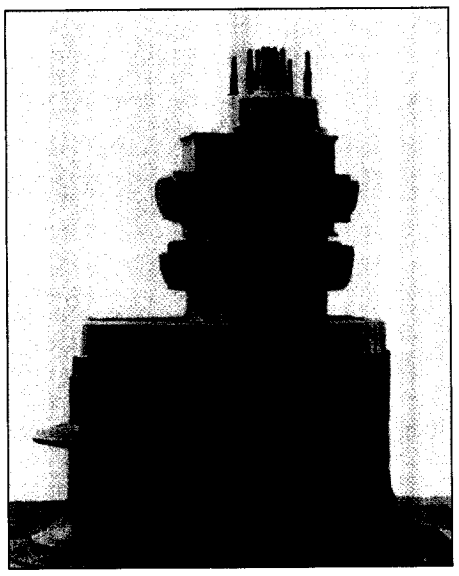
Contractor
MARCOM Defence, Chichester.

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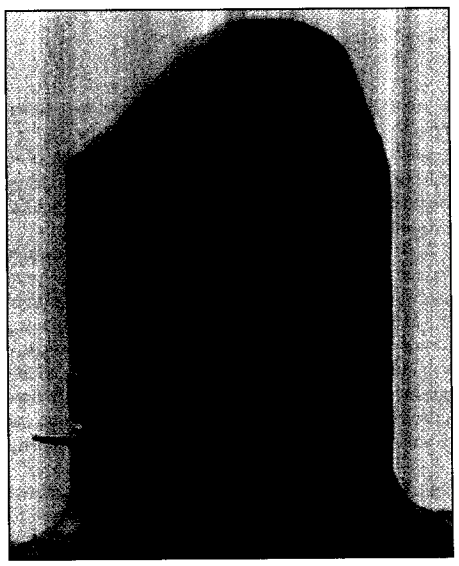
Type 2019

Type
Submarine intercept sonar.

Description
Developed in 1973, the Type 2019 is the standard passive intercept sonar mounted on Royal Navy submarines and is designed to give warning of surface vessels,



Array configuration for replacement Type 2019 array
(Cogent Defence and Security Networks)
0024707



New free-flooding carbon fibre dome for Type 2019
(Cogent Defence and Security Networks)
0024708

submarines, dipping sonar, sonobuoys and torpedoes, thus covering HF, MF and LF sonar frequency bands. The system was developed from the PARIS (Passive Active Range Intercept Sonar) system. In its original configuration Type 2019 was estimated to cover the 1.75 to 14.5 kHz band using a power of 3 kW.

Under a contract awarded in 1993, 12 Type 2019 sets have been upgraded with interactive plasma panel displays, new faster processors and improved recording facilities. These offer the operator a greatly enhanced operability with the option of automatic transfer of target data to the boat's combat system highway. These improvements to the MMI are important details relating to the human factors programme. Ergonomically designed consoles and easy-to-read colour displays minimise operator fatigue and enhance operator performance.

Cogent has provided a replacement array for the 2019 referred to as Hull Outfit 51R. Housed in a free-flooding carbon fibre dome, the array comprises individually replaceable HF transducers mounted beneath a compact replaceable LF array unit. The broadband passive array is a multi-octave system providing bearing and azimuth coverage through 360°.

Operational status
Two prototype arrays and 10 production 51R arrays have been delivered and installed on Trafalgar and Swiftsure class boats.

Contractors
Ultra Electronics, PMES, Rugeley, Staffordshire.
Thales Underwater Systems, Sophia Antipolis.
Cogent Defence and Security Networks, Newport.

UPDATED

Type 2020

Type
Passive and active bow- and fin-mounted sonar.

Description
Developed in 1974, the Type 2020 sonar is fitted in some Royal Navy Swiftsure and Trafalgar class submarines. It provides both passive and active detection capabilities with an enhanced tracking facility from its bow- and fin-mounted arrays. Although considerable emphasis is placed on passive detection and tracking, the equipment has a highly powerful active capability.

The passive sonar provides high detection performance with 360° of sonar coverage within a frequency range reported to be from 2 to 16 kHz for passive operation using bottom bounce and convergence zone methods of operation. Detection is subdivided into low- and high-frequency bands with information presented on computer-enhanced displays with an aural output capability and incorporates a recorder back up facility. The system is intended primarily for operations in computer enhanced mode, but can be automatically reconfigured to a fallback mode of operation without any loss of sonar data.

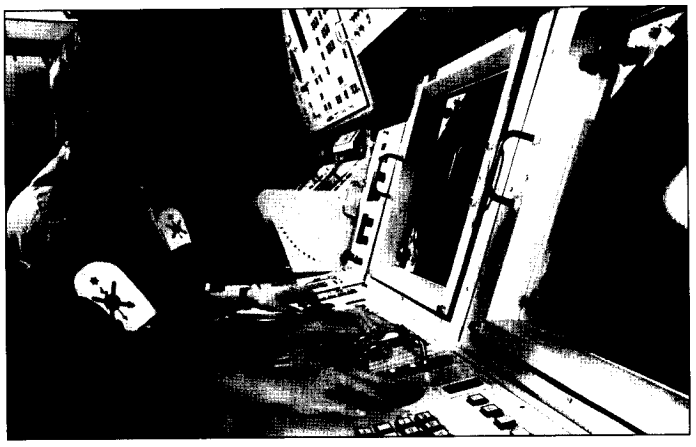
The active transmitter system uses automatic beam steering with manual override, transmitting in the low to medium frequency bands reportedly between 3 and 13 kHz. It can also transmit in low- and high-power modes that give a very broad range and detection capability.

A computer-controlled automatic monitoring system is incorporated with a central monitoring unit, driving local monitoring subsystem units within each individual equipment cabinet. Also, diagnosis of computer defects is accelerated by the use of laptop computers.

Operational status
The Type 2020 sonar was accepted into service in October 1982 and has been replaced by sonar Type 2074 LRE and sonar Type 2076 in Trafalgar and Swiftsure class submarines. The only systems remaining in service are aboard *Spartan* and *Splendid* of the Swiftsure class.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED



Display/console of Type 2020 submarine sonar

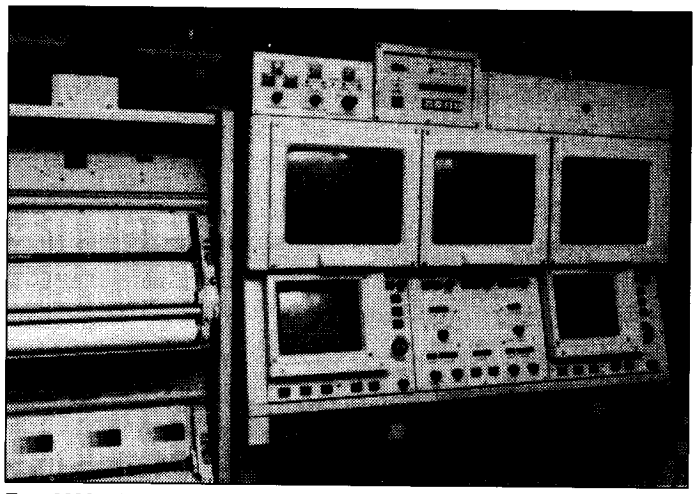
Type 2026

Type
Passive towed array sonar.

Description
Developed in 1977, the Type 2026 sonar is a submarine passive towed array sonar and consists of a three-octave towed array, a towcable and an inboard processor and display system. The system provides surveillance and classification on data from both towed and flank arrays. It contains tracking, combat information system interface, data recording, Demon, aural and hard-copy facilities. The signal processor may also be used to provide a signal analysis and display function for data from other sonars.

The sonar may be operated by one or two operators and is controlled using a touchscreen, joystick and switches. It includes BITE and may be reconfigured in the event of a fault to minimise its effects.

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juws.janes.com



Type 2026 submarine sonar

Data is displayed on three acoustic data displays, with comprehensive cursor and annotation facilities. Other facilities for driving remote displays (such as in the submarine's control room) or external video recorders are provided. The signal processor is cooled by an onboard chilled water supply, with an optional heat exchanger. The operator's console may be fitted in the sound room, with the signal processor in a remote cabinet space. The tow cable is clipped onto the port fin at the stern of the submarine.

The Type 2026 sonar was developed in conjunction with the Admiralty Research Establishment by GEC Avionics and Plessey Naval Systems, both part of Thomson Marconi Sonar Ltd, now called Thales Underwater Systems. GEC Avionics manufactured the signal processor and display system, Cogent, the towcable and Plessey, the array and terminal unit.

Operational status
A variant has been supplied to the Royal Netherlands Navy and equips the four Walrus class boats.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

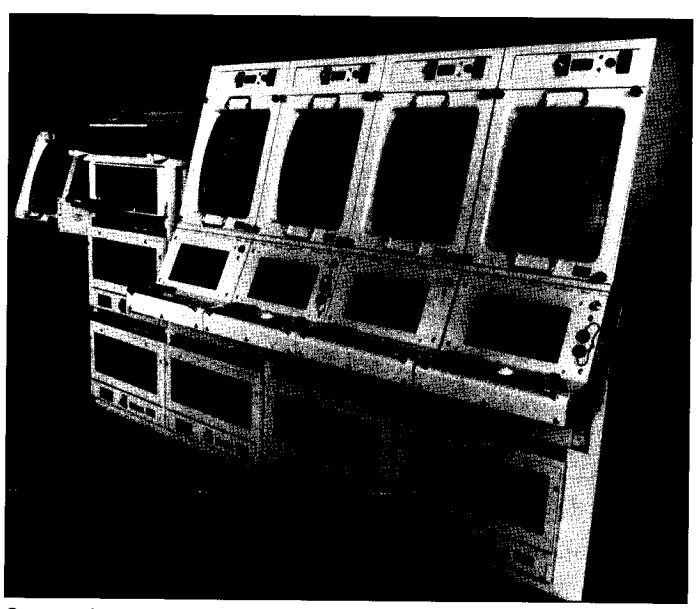
UPDATED

Type 2046

Type
Passive towed array sonar.

Description
Development commencing in 1985, the Type 2046 sonar is a very low frequency integrated, passive sonar suite designed for the Royal Navy nuclear-powered attack submarines, and was also fitted into the Type 2400 Upholder class of conventional submarines.

Developed from advanced 'Curtis' digital signal processing technology, and including FMS 12 display processing with Ferranti M700 Argus processors, the Type 2046 provides long-range target detection, classification and tracking information.



Operators' interface console of Type 2046 sonar

The system provides 360° bearing cover, multiple beam resolution and broadband surveillance with a high-resolution narrowband frequency expansion facility. The operator interface consists of four-colour displays in a two-operator console suite with touch-sensitive plasma panels. Displays presented to the operator include waterfall (detection) and Lofargrams (classification).

The Type 2046 is built to a modular design to make maximum use of the latest technology, to save space and cost, and to assist through-life enhancement of the system. It is also equipped with fully integrated built-in test equipment for ease of maintenance.

Operational status
A total of 27 systems were ordered for Royal Navy submarines together with a follow-on order for a further two systems for training purposes. All systems have been delivered. Forms part of the 2054 sonar suite on Vanguard class SSBNs, and equips Trafalgar (five boats) and Swiftsure class SSNs.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester. ***UPDATED***

Type 2054

Type
Passive/active intercept and towed array sonar suite.

Description
Development commencing in 1983, Sonar 2054 is the major sonar for the Royal Navy Vanguard class Trident ballistic missile carrying submarines. The complete equipment, which is the largest system in the Royal Navy, consists of a multifrequency sonar suite incorporating passive, active, intercept and towed array sonars. These include the Type 2043 active/passive; Type 2046 towed; Type 2082 intercept; and Type 183 underwater telephone arrays.

The former GEC-Marconi, Sonar Systems Division (now Thales Underwater Systems), the prime contractor and system design authority, supplied the LF bow-mounted array with the necessary beam-forming and signal processing equipment for narrowband, broadband and active; the passive ranging conformed flank array; intercept array; sonar controller's equipment; sonar maintainer equipment; and the passive towed array with narrowband and broadband capability. Major subcontractors were: the former Ferranti-Thomson Sonar Systems (also now Thales Underwater Systems) for the consoles, displays and data processing for broadband, narrowband and active, and Cogent for the towed array handling system.

The processing in the Type 2054 is almost entirely digital, the arrays being sampled by the pre-processor and immediately digitised before being passed to the beam-forming/signal processing. The system provides surveillance and classification on data from all arrays, which include bearing, range, target motion and torpedo detection capabilities. The total system comprises 18 cabinets and seven consoles (two broadband, two narrowband, one passive ranging, one intercept and one sonar controller, with the option of either a broadband or narrowband being used for active). The cabinets are interconnected by a 1553 standard data highway, which also provides the interface to the outside world.

Operational status
A total of six systems was ordered, four of the Vanguard class SSBN and two being used as shore-based systems. All have now been delivered.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester. ***UPDATED***

Type 2074

Type
Passive and active hull-mounted sonar system.

Description
Development began in 1988. The Type 2074 passive and active, low-frequency bow sonar is being fitted to eight of the Royal Navy's nuclear-powered hunter-killer submarines. It replaces the Types 2001 and 2020 in these vessels. The sonar makes full use of the advantages of Series 5 family of modular sonars.

The Type 2074 provides improved sonar performance and is significantly smaller (by a ratio of 5:1) than the sonar it replaces.

Due to the modular flexible nature of its design, the sonar can be readily configured to suit a customer's particular requirements and offers stretch potential for future enhancements. The total system consists of five cabinets and five multifunction consoles.

Operational status
The 2074 LRE is the main active and passive bow sonar in some Swiftsure class submarines (*Sceptre*, *Sovereign* and *Superb*) where it replaced the Type 2020.

Contractor
Thales Underwater Systems, Templecombe, Somerset. ***UPDATED***

Type 2076

Type
Integrated passive/active sonar.

Description
Development began in 1990. The Type 2076 comprises a federated suite of sonar subsystems integrating passive/active search and attack sonars and designed originally as a mid-life update for the Royal Navy Swiftsure and Trafalgar class submarines (the S&T Update).

The integrated sonar suite incorporates a conformal bow, long towed array, a multi-site intercept array and dedicated obstacle avoidance sonar as well as a comprehensive set of new large-aperture flank arrays with three passive ranging spots on each side, together with associated processing, which feeds the command and control system. Installation of the system will occur during normal refit periods without interruption to the normal operational cycle. The development programme has encountered some technical problems, notably with the towed array and its handling system, but these are being addressed. An enhancement programme known as Stage 5 will provide for the partial replacement of legacy processing architecture with COTS products. This will 'open up' the architecture to allow rapid insertion of new software functionality.

Operational status
The initial contract was for four systems with options on a further two, with a second order for three systems placed in 2002 for the first three boats of the Astute class.

Delivery of a shore-based trial integration system was concluded by the end of 1995.

Type 2076 is replacing Types 2074 and 2046 on Trafalgar class submarines. Sea trials with the wide aperture flank array element of the Type 2076 sonar suite were carried out aboard HMS *Torbay* in 2002. The second ship to receive type 2076 is the *Trenchant*. Full Stage 4 capability is not expected to be reached until May 2004, some two years later than originally planned, due to technical problems experienced with the software engineering and associated signal and data processing.

Contractor
Thales Underwater Systems, Cheadle Heath, Stockport.

UPDATED

Type 2082

Type
Passive intercept and ranging sonar.

Description
Developed in the 1980s, the Type 2082 is the replacement for Type 2019 mounted on Royal Navy submarines.

Under a contract awarded to Ultra Electronics PMES in 1993, eight systems have been produced as part of the 'Swiftsure' and 'Trafalgar' Class Update. Type 2082 is an advanced DSP-based intercept system offering enhanced sensitivity and analysis facilities, extended frequency coverage and intercept auto-tracking capability.

The company has also conducted studies into advanced intercept and transient capture systems for the UK MoD and associated agencies.

Operational status
The Type 2082 equips the Vanguard class SSBNs of the Royal Navy.

Contractor
Ultra Electronics, PMES, Rugeley, Staffordshire.

VERIFIED

United States

AN/BQQ-5

Type
Hull-mounted and towed array.

Description
Developed in the late 1960s, the AN/BQQ-5 sonar, the US Navy's first active/passive digital sonar system, is the principal sensor system of the Los Angeles class nuclear attack submarines. The AN/BQQ-5 is a digital, multibeam system employing hull-mounted, active/passive spherical (BQS-11/12/13), bow conformal and AN/BQR-25 towed acoustic hydrophone arrays. The polyethylene covered towcable has a maximum length of about 800 m, is 9.5 mm in diameter, and the array at the end of the cable, where the hydrophones and electronics are located, is 8.25 mm in diameter. The array is tapered fore and aft to minimise flow noise. Drag is stated to account for a maximum reduction in speed of 0.5 kt, with no serious inhibition on submerged manoeuvres and little adverse effect on surface manoeuvres, with the one exception of those entailing going about. The AN/BQQ-5 features DIMUS (Digital Multibeam Steering) technology which allows a sonar operator to view through 360° of azimuth simultaneously to provide passive classification with improved displays.

During the late 1970s, the US Navy became concerned that the AN/BQQ-5 would not be able to handle the developing threats and embarked on a programme to update the capabilities of the system. An improved control display console has been developed and sonars that have been upgraded with the new consoles are known as the AN/BQQ-5B. A further modification to the system developed under this programme is the AN/BQQ-5C(V) Expanded Directional Frequency Analysis and Recording System (DIFAR), which replaces the original signal processor with the AN/UYH-1 standard signal processor. The AN/BQQ-5D uses a TB-16 array and utilises some of the technology common to the AN/BSY-1 system. It became operational in 1988. A contract for the development of the AN/BQQ-5E was awarded in December 1988. A new thin-line towed array (TB-29) for passive ranging has been integrated with the AN/BQQ-5E LF bow spherical array, and went to sea in 1993/4.

The US Navy has been developing a thin-line tow array and handling system and other modifications for the AN/BQQ-5 system. The thin-line towed array, known as the TB-23, forms part of the AN/BSY-1(V) combat suite. It is a lightweight system which can be reeled into the vessel's main ballast tank, instead of being housed on the side of the submarine, and will replace the TB-16 array currently employed in the AN/BQQ-5 and which is stowed in a pressure tube running fore and aft outside the pressure hull, with cable winch and reel in the forward main ballast tank.

The AN/BQQ-5E provides improved detection, tracking and classification of low-frequency data. The system features LF active interference rejection, dual towed array processing and full spectrum processing. The latest development also provides processing capability for the new TB-29 towed array and interfacing to the new fire-control system CCS Mk 2. The combining of the AN/BQQ-5E, TB-29, and CCS Mk 2 will result in a system referred to as QE2 underwent technical evaluation in 1993.

The AN/WLR-9A acoustic intercept receiver has been successfully evaluated and forms an integral subsystem of the AN/BQQ-5 and AN/BQQ-6 on new attack and Trident missile submarines. The subsystem features a CRT display, a digital readout and a remote unit for the submarine commander. A sensitivity improvement kit for the AN/WLR-9A has been developed by Norden and deliveries to the US Navy are in progress.

The AN/BQQ-5 series is being further upgraded with the Acoustic Rapid COTS Insertion (ARCI) AN/BQQ-10 system.

Operational status
The AN/BQQ-5 underwent extensive developmental testing during 1972 and 1973, and was approved for production later in 1973.

To date, 100 ship sets have been delivered — 91 for submarines, four maintenance trainers and five engineering models. In addition, eight 21B64 versions are used as land-based operator trainers.

Operational in three variants (BQQ-5A(V)1, BQQ-5C and BQQ-5D) on board Los Angeles class submarines. The AN/BQQ-5D equips the Seawolf class and incorporates three flank arrays on either side.

Contractors
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

Lockheed Martin Naval Electronics & Surveillance Systems — Undersea Systems, Manassas, Virginia.

VERIFIED

AN/BQQ-6 sonar

Type
Passive and active sonar.

Description
Developed in 1969, the AN/BQQ-6 is an advanced passive sonar suite developed for the Ohio class submarines and forms part of the Trident command and control system, which is an integrated complex of command, control, communications and ship defence equipment.

The AN/BQQ-6 incorporates the passive elements of the AN/BQQ-5 and AN/BQS-13 and has many of the same parts. The primary detection group is a digital integrated system employing spherical bow array of 944 elements covering the 0.5 to 5 kHz frequency band, two passive flank arrays of 100 transducers and towed array sensors, with an active emission acoustic intercept receiver and high-frequency active short-range sonar. In the passive mode, the system used is identical to that of the AN/BQQ-5. Support equipment has been added to provide for underwater communications, environmental sensing, magnetic recording and acoustic emergency devices. All other technical details are classified.

The sonar suite is associated with the Mk 118 torpedo fire-control system in the Ohio class submarines. A version of the AN/BQQ-5E system is currently being procured as an upgrade for the Ohio class submarines. This subsystem will represent a major upgrade to the present AN/BQQ-6 sonar. By utilising to a great extent the current AN/BQQ-5 hardware, a large improvement in logistics (provisioning, spares, training, and so on) is envisaged.

Operational status
Operational on board 18 Ohio class submarines.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems – Undersea Systems, , Manassas, Virginia.

UPDATED

AN/BQQ-10

Type
ARCI (Acoustic Rapid COTS Insertion) sonar enhancement system.

Development
ARCI is a sonar system upgrade that has been developed to integrate and improve towed, hull, and spherical sonar arrays and other ship sensor processing capability on all US Navy nuclear submarines. The improvements are incorporated via rapid insertion of COTS based hardware and software. COTS based processors and open system architecture technology and systems allow onboard computing power to grow at nearly the same rate as commercial industry systems. It is anticipated that the upgrades under the AN/BQQ-10 Programme will provide a common COTS architecture for all US Navy submarine sonars by 2005-07. This capability will facilitate regular updates to both software and hardware with minimal impact on submarine scheduling.

Description
The AN/BQQ-10 programme is a multiphased effort to provide submarines with a common sonar that is far more capable and flexible than earlier designs. An open system architecture based on Digital System Resources' multipurpose processor exploits commercial processing development allowing the use of complex algorithms that could not previously be accommodated.

Phase I of the programme provided enhancements to the narrowband and spatial vernier processing for the towed array sonar aboard two Los Angeles class submarines. This was followed by Phase II, under which the same two boats featured significant upgrades to all aspects of towed array processing. Under Phase III, processing for the spherical and hull arrays will be improved, while Phase IV will address the HF sonar processing capability.

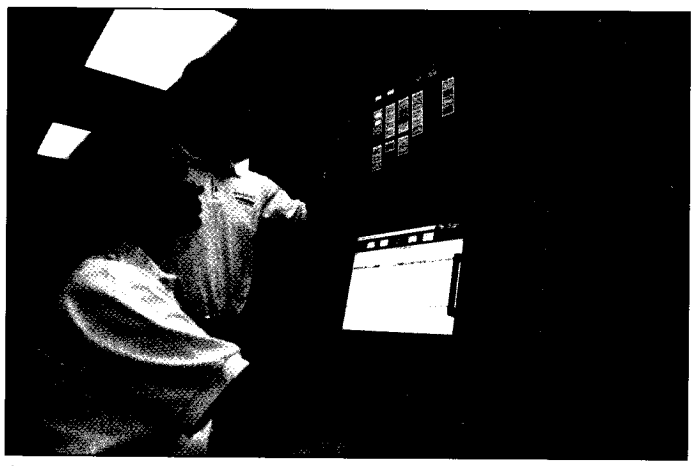
The multipurpose processors and COTS workstations communicate with each other via a LAN.

The programme will include interfaces to the legacy systems; signal processing enhancements; display enhancements; and incorporation of government furnished information algorithms.

Operational status
Phases I and II have been installed in two Los Angeles class boats. Phase III and IV is due to follow and all US Navy submarines will be equipped with the AN/BQQ-10 enhancement by the time frame of 2005 – 2007.

Contractor
Lockheed Martine Naval Electronics and Surveillance Systems, Manassas, Virginia.

NEW ENTRY



An ARCI workstation (Lockheed Martin) ***NEW***/0593890

AN/BQR-15

Type
Passive towed array sonar.

Development
The AN/BQR-15 towed array system was developed in the early 1970s for deployment on fleet ballistic missile submarines.

Description
The AN/BQR-15 HF sonar system comprises a 670 m tow cable with a 47 m long 9 cm diameter towed sonar array carrying 42 hydrophones. It provides hydrophone outputs to the shipboard electronics to facilitate target detection and classification. In addition, the sonar performs own ship noise monitoring and underwater communication. The sonar can simultaneously form 46 beams on fixed bearings, two steerable analogue beams on one of any 23 bearings and can form a beam steerable to any of 92 bearings.

Under optional conditions the array can be deployed in as little as 15 minutes.

The wet end was later enhanced to a 2.54 cm thin line array to replace the TB-23 (see TB-23 entry). A variant was developed in Japan as the ZQR-1.

Operational status
Currently in service with 18 Ohio class SSBNs and one Sturgeon class SSN of the US Navy and Japanese submarines such as the ZQR-1.

Contractor
Lucent Technologies Advanced Technology Systems, Greensboro, North Carolina.

UPDATED

AN/BQR-15 9080

Type
Passive thin-line towed array sonar.

Development
The thin-line towed array is a new generation of digital towed sonar arrays which was developed to provide high-resolution target detection at greater ranges and at higher towing speeds.

Description
The 9080 thin-line 45.7 m long array has an outside diameter of 2.54 cm in and features a wide acoustic aperture, low self-noise and reelable construction. It is towed by a 670 m long cable. It is fitted with 42 hydrophones and acoustic channels are digitised and multiplexed onto a coaxial signal path to inboard signal processing equipment. Sophisticated digital signal processing enables long-range detection, classification and bearing determination.

Operational status
In operational service aboard Ohio class SSBN submarines. A variant has been developed by the Japanese Maritime Self Defence Force, the ZQR-1 (see entry on ZQR-1).

Contractor
Lucent Technologies Advanced Technology Systems, Greensboro, North Carolina.

VERIFIED

AN/BQS-13 (BQR-24)

Type
Passive/active sonar system.

Development
Developed in 1970, acceptance testing of the AN/BQS-13 (BQR-24) multipurpose subsystem began in late 1973 and technical and operational testing were conducted aboard *Archerfish* during 1974. The AN/BQS-13 multipurpose subsystem (BQR-24) was service approved in late 1974. The extended operational test programme delayed procurement to FY75-76, when 11 systems plus support were procured for US$25.3 million. These subsystems provide interim improvement in sonar and fire-control capability for those submarines not scheduled to receive the AN/BQQ-5 sonar until late in that programme. The BQR-24 has been installed only in submarines where it will have a useful life of at least three years before receiving an AN/BQQ-5 sonar system.

Description
The AN/BQS-13 sonar system was the primary sonar in the Sturgeon SSN class nuclear attack submarines. The system was service approved in December 1971 and remains in service. A system addition, providing new functional capability, was service approved in late 1974. This addition, the AN/BQS-13 multipurpose subsystem (BQR-24), was procured for a limited number of SSNs. The LF sonar operates in the 3.5 kHz frequency band, using a 4.5 m diameter bow array. Operating modes are either FM or CW.

The system is operational on the Ohio class submarines where it forms the spherical array for the AN/BQQ-6 sonar.

Operational status
Commencing in October 1979, Raytheon was awarded a series of US Naval Sea Systems Command contracts calling for refurbishment and conversion of AN/BQS-11, 12, and 13 sonar transmission subsystems to AN/BQQ-5 transmission subsystem configuration. These subsystems are part of the AN/BQQ-5 system. The AN/BQS-13 is operational on board Ohio class SSBNs and the Sturgeon class SSN *Parche*.

Contractor
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

AN/WLR-9A

Type
Acoustic intercept system.

Description
The AN/WLR-9A acoustic intercept receiver forms an integral subsystem of the AN/BQQ-5 and AN/BQQ-6 sonar systems on Los Angeles class submarines of the US Navy.

The AN/WLR-9A is an unmanned, passive broadband system that provides automatic detection, localisation and parameter extraction of active sonar emissions. The wideband frequency coverage detects search, communications, navigation and active homing torpedo sonar emissions. Individual ping detected parameters reported to the main sonar system include: frequency, pulse width, sound pressure level, ping interval/repetition rate and bearing.

The intercepted signal can be further analysed for additional signal classification clues such as transmitted waveform type (FM, CW, FSK and so on).

The AN/WLR-9A features a CRT display, a digital readout and a remote unit for the submarine commander. A sensitivity improvement kit has been developed and deliveries to the US Navy are in progress.

Operational status
In service aboard all US Navy Los Angeles class submarines.

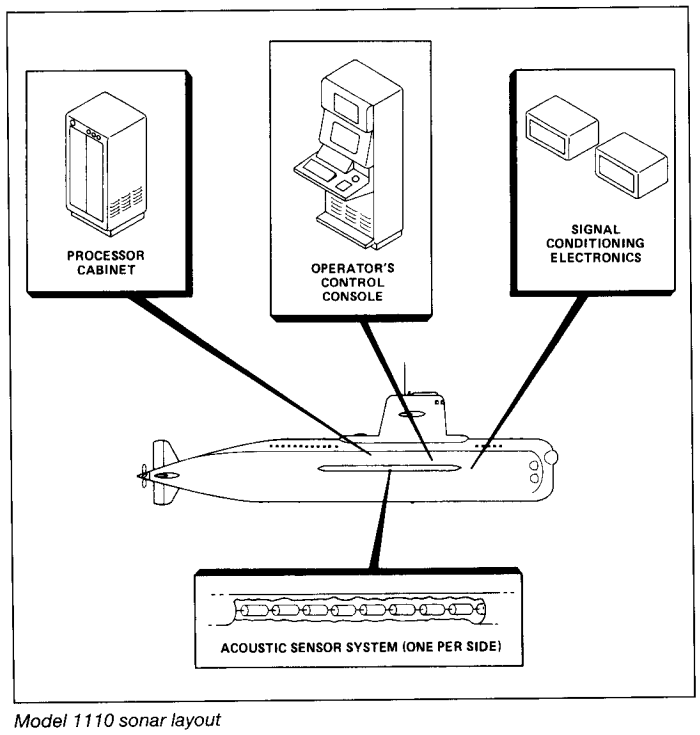
Contractor
Northrop Grumman Corporation, Electronic Systems, Melville, New York.

VERIFIED

Model 1110

Type
Passive flank array sonar.

Description
The Model 1110 uses a passive flank array to enhance the overall sensor capability of submarines. It is designed to complement an existing sonar, combat and fire-control systems already planned or installed. The Model 1110 provides for long-range detection, tracking and classification of surface and submarine targets, while the existing hull sonar can be optimised for close-in detection.



Model 1110 sonar layout

The Model 1110 is a single-operator system comprising an operator console, processor cabinet, signal conditioning electronics and acoustic sensor arrays.

The system provides capabilities for expanded target detection and analysis through use of low-frequency (300 to 1,500 Hz) beam-forming, split-beam correlation, bearing determination techniques and frequency analysis. It has the capability to track 19 targets simultaneously. The linear array forms either 96 broadband beams or 48 narrowband beams to cover a 135° sector on either flank. Target tracking is accomplished by broadband and narrowband signal processing interpolation. Track processing allows the Model 1110 to automatically track multiple targets with minimal supervision. Selected targets can be assigned to high-quality track processors for improved position solution accuracy. The trackers can maintain track even in a crossing-target environment without operator intervention. Tracking can be initiated by the operator using the cursor and soft key controls. An adaptive self-noise cancelling subsystem has been interfaced and tested at sea and has demonstrated greatly improved sonar performance. A towed array variant can be provided as an option.

The Model 1110 system single-operator console has two high-resolution colour displays. In existing submarines, the control unit can be located adjacent the host submarine sonar console and together will create an integrated sonar system. The microprocessor-based host submarine interface allows the Model 1110 to be integrated easily into the combat system of any new or existing submarine.

In the Israeli Gal class the Model 1110 has been upgraded with a noise cancellation system developed by Rafael.

Operational status
No longer in production. The system is installed on Israeli Gal class submarines which have been withdrawn from service in the Israeli Navy.

Contractor
EDO Corporation, Combat Systems Division, Chesapeake, Virginia

UPDATED

Model 1120 series

Type
Passive flank/hull array sonars.

Development
The Model 1120 Series is being developed by the EDO Corporation for sale on the international market. The systems being offered use the latest COTS/OSA hardware and software techniques. These modern sonars are new technology upgrades of the Model 1110 sonars. All variants can be provided with one or two flat panel type colour displays to further reduce the system footprint on small hulls. The use of standard digital interfacing standards simplifies the integration of the sonar with the submarine's combat system.

Description
The Model 1120 architecture is organised to allow the units to be programmed for operation in the desired mode. The multisensor variants are operator selectable for downloading in the desired configuration. Processing for simultaneous multisensor operation can also be provided.

The following models are available:

- 1121 flank array sonar
- 1122 hull cylindrical array sonar
- 1123 towed array sonar
- 1125 flank array with cylindrical hull array sonar
- 1126 flank/hull array with towed array sonar
- 1127 flank array with towed array sonar.

The Model 1121 is a single-operator system which uses a passive flank array to enhance the overall sensor capability of submarines. The new technology system is designed to match the performance capabilities of the operational Model 1110 systems. An adaptive noise canceller can be offered to reduce the effects of hullborne noise. The modernised flank array system retains the Model 1110 outboard sensor mounting and fairing arrangement which greatly reduces installation risks. Among the features offered with the Model 1121 are:

- automatic tracking with TMA
- full spectrum of broadband, narrowband, DEMON analysis
- five primary display formats

The Model 1122 sonar uses a passive 1 m diameter forward hull-mounted transducer. The COTS variant sonar design is founded on EDO's experience with the operational BQR 2B and Model 1102 sonar equipments.

The EDO Model 1123 is a passive towed array sonar which uses a dual-nested hydrophone configuration in the array.

Operational status
The Model 1121 is currently operational.

Contractor
EDO Corporation, Combat Systems Division, Chesapeake, Virginia.

VERIFIED

Model 1525 CTFM

Type
Obstacle avoidance sonar system.

Description
The Model 1525 obstacle avoidance sonar provides rapid scanning, high-resolution display of subsea objects at ranges from 3 to 1,500 m, and a full 360° area coverage. It was designed for installation on conventional submarines and manned submersibles. The Model 1525 features a TV formatted colour display with memory circuits that provide a continuous presentation of the sector scan selected until updated by the next scan. The Model 1525 is based on the design of the 500A and uses the same outboard unit. Its size and connections are compatible with that system.

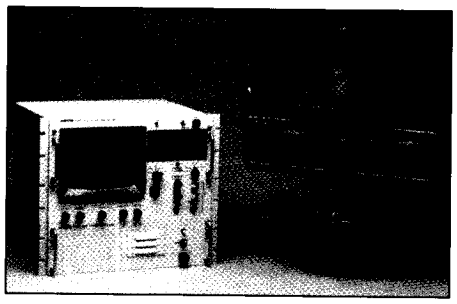
The Model 1525 features automatic sector modes and manual scan selection. Forward sectors of 60 and 120° are offset, while a 240° sector is centred on the display. In addition, a 60° sector can be positioned anywhere in 360° for higher information rate operation. Incorporated in the equipment is the latest digital analyser with 128 channels, providing 3.2 lines higher resolution than the 500A. The system operates at 72 to 87 kHz.

The system has a transponder mode for operation with CTFM transponders. The mode can be used alone or simultaneously with the regular sonar mode at the operator's choice. Transponders are used primarily as a navigation aid, but can also be dropped from submarines in a submerged condition to mark positions of interest.

Operational status
In service with the Japan, Netherlands, Norway and the US Navy.

Contractor
EDO Corporation, Combat Systems Division, Chesapeake, Virginia.

VERIFIED



Model 1525 obstacle avoidance sonar

TB-16

Type
Thick-line towed array.

Description
Developed during the early 1970s, the TB-16 is a towed array component of the AN/BQQ-5D, the AN/BQQ-6 sonar systems, and the AN/BSY-1 and the AN/BSY-2 combat systems. It is a thick-line array that is normally stowed in a tube running outside the submarine's pressure hull, with the winch, cable and reel located inside the pressure hull, although some earlier installations used a temporary clip-on array. The 75 m long, 640 kg, acoustic module is 8.25 mm in diameter and is towed at the end of a 205 kg, 800 m long, 9.5 mm diameter cable.

Various versions of the TB-16 have been developed:

- TB-16B with greatly reduced self-noise signature
- TB-16D digital version.

Operational status
In operational service aboard Los Angeles class submarines and installed on the Seawolf class. The array is also specified for the Virginia class.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

VERIFIED

TB-23

Type
Thin-line submarine towed array.

Description
The TB-23 is a towed array component of the AN/BQQ-5D and AN/BSY-1 submarine sonar systems. It is a thin-line wide aperture array that can be reeled into the boat's main ballast tank instead of being housed on the side of the pressure hull. The array is handled by the DA-9070/BQ system (see TB-29 entry).

The cable is about 915 m long with a wet end tail of about 305 m. The wet end incorporates 98 hydrophones, two vibration isolation modules, an environmental module, four LF, two MF and two HF modules.

The system is to be replaced by the TB-29A.

Operational status
In operational service on Los Angeles class and Ohio class boats.

Contractor
L-3 Communications Ocean Systems, Sylmar, California.

VERIFIED

TB-29A

Type
Thin-line LF towed array.

Description
The TB-29A is intended for use with the AN/BQQ-5E sonar system and the Combat Control System (CCS) Mk 2, AN/BSY-1 and AN/BSY-2 command systems. The TB-29A array is longer than the TB-23 (825 m as opposed to 488 m) but shorter than the TB-29 array (915 m) offering superior detection, classification and localisation performance. The 3.8 cm outside diameter 1.9 cm internal diameter array incorporates 13 × 48.8 m long acoustic modules each containing 32 acoustic channels. The array is towed at the end of a 365 m long cable (the TB-29 uses a 580 m long cable). Like the TB-23 towed array the TB-29A can be reeled into the boat's main ballast tanks instead of being housed on the side of the pressure hull. The TB-29A also features a sensor location system to determine array position and heading and beam forming compensation to correct for any deformation in the array geometry when under tow.

Versions of the TB-29A will eventually replace the TB-23 on most US submarines.

The TB29A array uses COTS technology adapted from the telecommunications industry for cost reduction. The main differences between the TB-29 and TB-29A lies in the telemetry and acoustic sensor. The telemetry system is a commercial system which has considerably helped reduce acquisition cost.

The array employs a new lightweight tow cable, which is handled and stowed by an OA-9070/BQ system that is designed for handling thin-line towed arrays. The system controls the array during deployment and retrieval and provides stowage for the tow cable and array when they are not streamed. To ensure stealth is not compromised by installation in the ballast tanks the handling system is rugged but quiet and reliable and handles the array with care and precision.

Operational status
Ten earlier TB-29 arrays are currently in operational service. The first of 11 TB-29A low rate initial production arrays was delivered on 27 September 2001 under a contract awarded in April 2000. The remaining four were delivered during 2002. The array will eventually be installed on Los Angeles and Virginia class submarines (the Seawolf class will probably retain the TB-29 array). Orders were placed for three single and one twin TB-29A arrays in 2002 with completion due in August 2004. The US Navy has predicted that it will require as many as 100 TB-29A arrays.

Specifications
Tow cable length: 365 m
Array length: 823 m
Array diameter: 3.8 cm
Acoustic channels: 416

Contractor
Lockheed Martin, Naval Electronics & Surveillance Systems, Syracuse, New York.

UPDATED

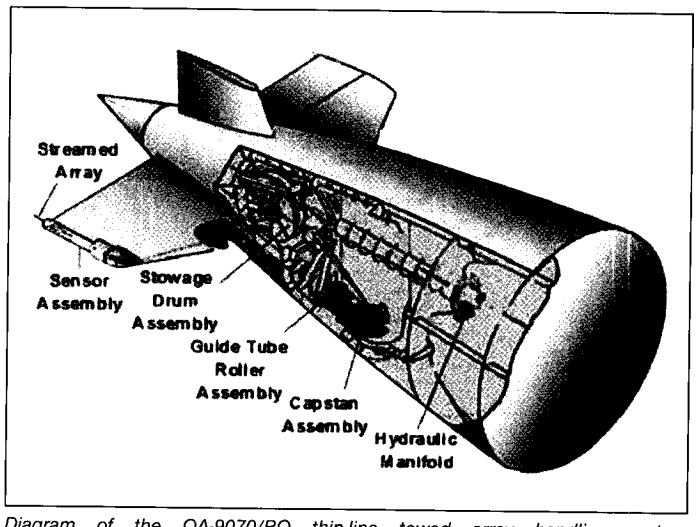


Diagram of the OA-9070/BQ thin-line towed array handling system (Lockheed Martin)

0059328

AIRBORNE DIPPING SONARS

France

DUAV-4

Type
Passive and active sonar system.

Description
The DUAV-4 is a high-frequency active/passive directive sonar designed for submarine surveillance and location (azimuth, distance and radial speed). It is specially designed for use on board light, versatile, ship-based helicopters such as the Lynx.

The DUAV-4 differs from conventional sonar in its signal processing system, which is designed to give improved detection, especially in severe reverberation conditions such as shallow waters. The sonar can be operated in either the active or passive mode: in the active mode true bearing, range, and radial speed are measured; in the passive mode only true bearing is measured. Three frequencies are used (21, 22.5, 24 kHz) in one of three operating modes: a fixed frequency around 20 kHz in active mode to determine bearing and speed; a variable frequency to detect static targets; and a passive mode between 10 and 20 kHz. Typical detection ranges are in the region of 3 n miles.

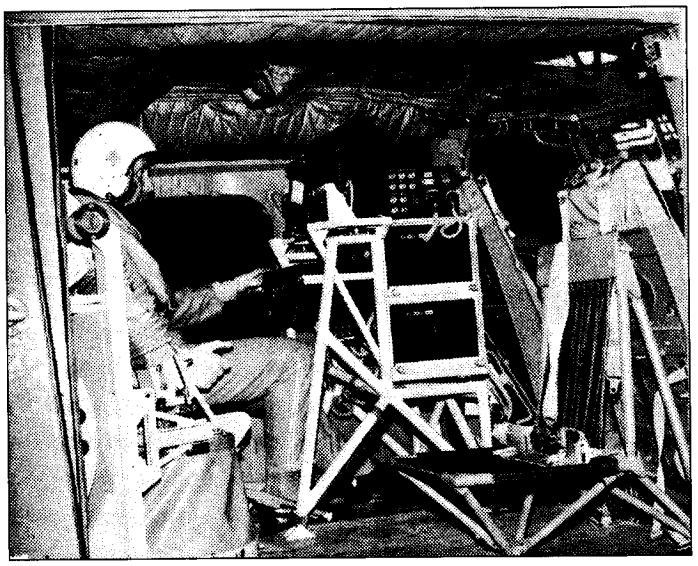
A combined display unit permits surveillance display (initial detection) or plotting display (precise azimuth determination). Total weight including electronic rack, cable and dome is 250 kg.

Operational status
The DUAV-4 sonar entered service in 1975 and over 90 systems have been produced. It is in service with the French Navy and the Royal Netherlands Navy on Lynx helicopters.

Specifications
Frequencies: 21, 22.5, 24 kHz
Transmission level: 119 dB
Total weight: 250 kg
Transducer cable length: 150 m

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED



DUAV-4 helicopter sonar installation in Lynx

DUAV-4 UPG

Type
Active and passive dipping sonar system.

Description
The upgraded DUAV-4 or DUAV-4 UPG differs from the DUAV-4 in its digital acoustic processor. This state-of-the-art system offers more power, signal and data processing, as well as improved man/machine interface.

The DUAV-4 UPG also offers specific software tools and operator aids designed to meet the requirement for detection in shallow, rocky bottom waters. It also includes specific neural functions for active classification.

Operational status
The DUAV-4 UPG is in operation in the Swedish Navy on the Chinook helicopter.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

FLASH

Type
Helicopter dipping sonar system.

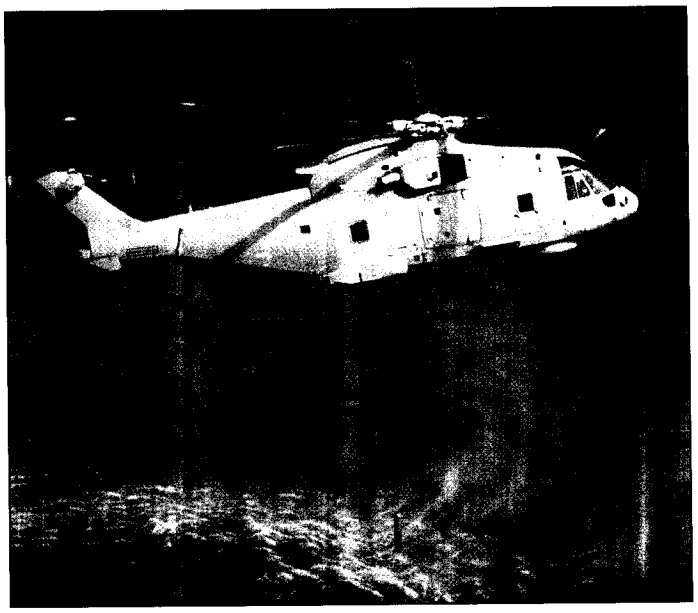
Description
FLASH (Folding Light Acoustic System for Helicopters) is a new low-frequency dipping sonar with sonobuoy processing capabilities developed by Thales Underwater Systems for a number of applications. It operates at five frequencies between 3.5 and 5.5 kHz, with 24 preformed beams. The winch is capable of lowering the dipping sonar to a depth of 750 m at a speed up to 10 m/s.

The system offers low frequency and large bandwidth in FM mode (1,000 Hz) to enable detection of low-speed targets in shallow waters and strong reverberation conditions. It incorporates high vertical rejection to filter out noise from the helicopter.

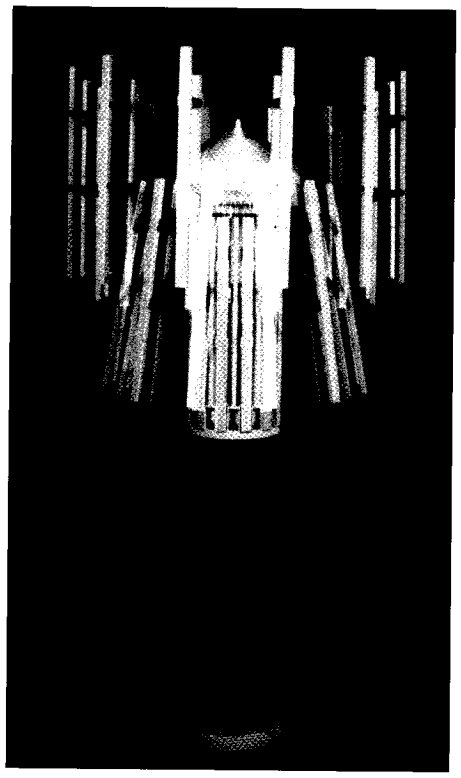
The upper part of the body houses the LF receiver array with its 12 folding arms with a diameter of 70 cm and the lower part of the body houses the eight stacked piezo-electric ceramic rings of the 1.5 m long transmit antenna. These can operate down to depths of 750 m. Pulse shape and power are managed by the operator to achieve optimum propagation in the prevailing environment. FM pulse compression offers good detection with Doppler providing accurate ranging resolution. FM and CW pulses can be combined in a single pulse. The nominal detection range is 24,500 m with range scales out to 41,000 m. With its light weight and volume, the FLASH can be fitted on board light ASW helicopters, such as the Super Lynx.

The FLASH-S SONICS system ordered for the Swedish Navy features a unique wet-end combining, in the same body, a medium frequency search array and a very high frequency classification array. The other parts of the system are either identical to the existing FLASH SONICS system (winch, cable, TMS 2000 sonobuoys processor), or modifications to the existing sonar transmitter/receiver, to meet the specific Swedish mission requirement in the Baltic Sea and the peculiar conditions experienced there with regard to ASW. The search sonar of FLASH-S will operate in the 20 to 23 kHz frequency range with the classifier covering frequencies higher than 200 kHz which will enable targets at ranges of 450 to 550 m to be relocated. The sonar will present an image of the target in shadow form, like an MCM sonar. This will enable targets to be classified according to shape, thus allowing operators to differentiate between rocks exhibiting submarine-like echoes and objects which generate no Doppler.

Operational status
FLASH is in operation with the UK Royal Navy on the Merlin helicopter (44 systems delivered designated Type 2089) and on the AS 532C Super Puma helicopters of the UAE (five sonar-only systems). FLASH has also been selected by the US Navy to equip the MH-60 R helicopters (over 200 systems are required designated AN/



Merlin, the UK Royal Navy's multimission helicopter, deploying FLASH (Lockheed Martin)
0114572



Wet end of the FLASH dipping sonar

AQS-22 - see AN/AQS-22 entry). FLASH successfully passed the operational assessment and serial production began in 2001. Four outboard arrays and reeling machines were ordered in late 2002 by Raytheon Integrated Defense Systems for four AN/AQS-22 systems for the US Navy's MH-60R multimission helicopter. The system has also been ordered for the NH-90 helicopters of France (14 units) and Norway (6 units). The system for France and Norway is based on the FLASH active dipping sonar and the Thales TMS 2000 sonobuoy processing system. Sweden has also ordered a variant (FLASH-S SONICS 5 units) of the system for their NH-90 helicopters, with first system delivery due in 2006. FLASH is also proposed for the new Canadian Maritime Helicopter which will replace the Seaking.

Contractor
Thales Underwater Systems, Sophia Antipolis. ***VERIFIED***

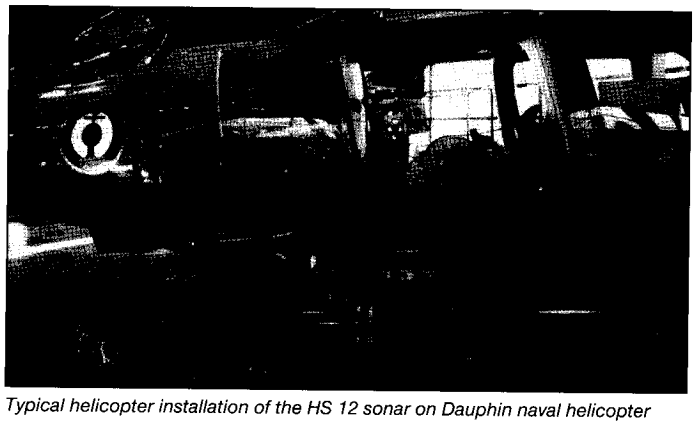
HS 12

Type
Passive and active dipping sonar system.

Description
The HS 12 is an active/passive panoramic helicopter version of the SS 12 small ship sonar and uses the same electronics as the surface vessels version. It has similar capabilities for operation in shallow/noisy waters, and has a system weight of less than 240 kg, making it suitable for installation on light naval helicopters such as the Lynx. The HS 12 transducer is raised and lowered by a hydraulic winch at a high speed.

Operation in CW and FM modes is possible and digital signal processing is employed by the system's microprocessor. Automatic tracking of two targets and transmission of elements to an external equipment, such as a plotting table, are provided.

The system operates on 13 kHz in the active mode and in the 7 to 12 kHz range passively. A total of 12 preformed beams is employed giving 30° sectors, with a minimum range of about 10 km. Adaptive signal processing is performed on each beam. The display consists of four quadrants, these being obtained by processing adjacent beams. The operator can select either a CW mode which provides target range and Doppler or FM processing. A sector mode is also provided.



Typical helicopter installation of the HS 12 sonar on Dauphin naval helicopter

Operational status
The HS 12 is currently in service in the Indian Navy where it equips Sea King helicopters and in the Finnish Navy on Cougar helicopters. The system also equips Super Frelon and Dauphin helicopters of the PRC Navy.

Specifications
Frequencies: 11.5, 13, 14.5 kHz
Transmission level: ≥212 dB/µPa/m
Total weight: 230 kg
Transducer cable length: 302 m

Contractor
Thales Underwater Systems, Sophia Antipolis. ***VERIFIED***

HS 312

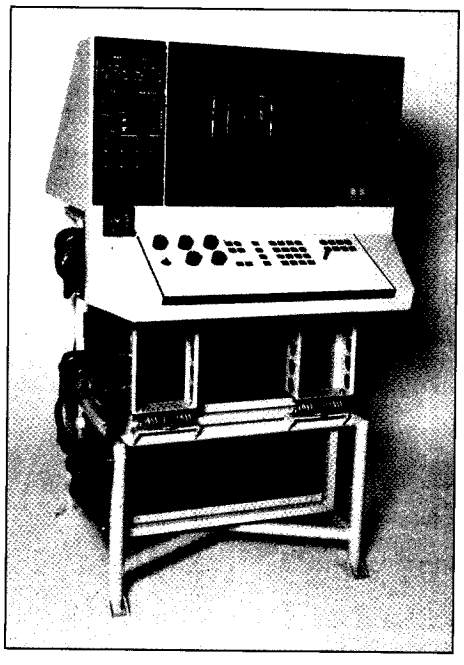
Type
Passive and active ASW system.

Description
The HS 312 is an acoustic system for helicopters incorporating the facilities of the HS 12 system and the SADANG new-generation acoustic processor. The equipment functions in both passive and active modes (CW and FM) and has a longer range than the HS 12.

Only a single operator is required and the light weight and compactness of the system means that the HS 312 can be fitted to any type of light or medium-size helicopter. The performances of the basic components have been improved by integration of the processing units, integration of a standardised keyboard and the use of only one display screen. The MF system can simultaneously process up to 16 buoys.

Operational status
In service with the Chilean Navy where it equips seven Cougar helicopters and the UAE Navy (seven Cougar helicopters).

Contractor
Thales Underwater Systems, Sophia Antipolis. ***VERIFIED***



HS 312 helicopter acoustic system control/display

International

AN/AQS-22 ALFS

Type
Next-generation low-frequency dipping sonar.

Description
Development of ALFS (Airborne Low-Frequency Sonar) began as a US Naval Air Systems Command project in 1992 for a new-generation dipping sonar to replace the existing AN/AQS-13F, on board the MH-60R. The sonar allows the helicopter to



AN/AQS-22 ALFS undergoing trials on an SH-60 Seahawk helicopter 0006973

perform assigned missions of submarine detection, tracking, localisation and classification as well as acoustic intercept, underwater communications and environmental data acquisition.

The LF sonar operates in one of five selectable frequency bands within the 1.2 to 5.6 kHz frequency range, with up to 24 beams formed at a fixed angle of depression. The sonar generates high power waveforms – CW, LFM (linear FM) and HFM (hyperbolic FM). FM and CW pulses may be combined within a single pulse. The projector uses piezo-electric ceramic rings and cardioid beamforming is performed. A system to control the angle of depression is under development. The associated acoustic processor will be the UYS-2A. The UYS-2A has operator selectable full-band, eighth-band and quarter-band verniers, and constant resolution modes are available for up to eight omni or four directional sonobuoys over their full bandwidth. These processing options are available concurrently with the active or passive modes of the dipping sonar. The processor can handle eight or 16 sonobuoys.

The sonar, which is being developed by Raytheon, Portsmouth, Rhode Island and Thales Underwater Systems, uses the expandable sonar array and reeling machine subsystem of the Thales FLASH (Folding Light Acoustic System for Helicopter) system (see FLASH entry) with 24 staves on 12 folding arms.

The design integrates via the 1553B databus with existing display subsystems. The sonar is controlled by the operator using menus on the existing control display unit. A dedicated control panel provides fail-safe control of the reeling machine.

Operational status

In January 1992, the consortium of the former Hughes Aircraft Co and Thomson Marconi Sonar SAS was awarded a US$31.3 million contract to develop the ALFS system. The five year contract, awarded by Naval Air Systems Command, provides for full-scale development and a follow-on production option of up to 50 systems.

The AQS-22 successfully completed its operational test phase in early 2000. The system will be fitted to the MH-60R multi-mission helicopter.

Contractors

Thales Underwater Systems, Sophia Antipolis.

Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island

UPDATED

Italy

OTS-90

Type

Avionic sonic system.

Description

The OTS-90, selected for the NH-90 helicopter, is a sonic system comprising two integrated main sub systems: a LF dipping sonar and a sonobuoy system.

The LF dipping sonar subsystem has its origins in the Helras LF dipping sonar, jointly developed by L-3 Communications Ocean Systems of the US and FIAR of Italy for the Italian EH-101 programme and the Italian Navy.

The system provides simultaneous dipping sonar and sonobuoy processing in both passive and active operating modes with both digital and analogue sonobuoy processing. In the active mode signals can be transmitted in both CW and FM, with broadband and narrowband DEMON passive processing. The system provides automatic alert and tracking and data is presented in various display formats/modes including PPI, A and B scans. Both single channel passive analysis and multichannel passive display is also provided. The system incorporates graphic computer aids and performance prediction functions together with record and playback features.

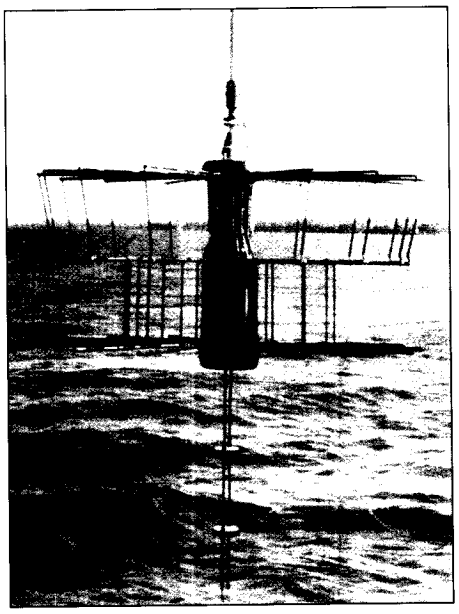
The dipping sonar is claimed to be the world's longest-range airborne attack and surveillance sonar, achieving three to four times the range of the world's finest sonars in many environments.

The sonobuoy capability can be tailored to meet customer cost and weight requirements. Processing solutions between 8 and 32 sonobuoys can be chosen by adding one or more sonobuoy receivers connected to the common acoustic processors.

A sonobuoy location capability is also available.



OTS-90 helicopter sonic system
(Galileo Avionica)
0593687



Wet end unit of the dipping sonar of the OTS-90 sonic system
(Galileo Avionica)
0593688

Operational status

The HELRAS system has been tested in many environments and in every case met or exceeded its predicted performance. Trials have been conducted in the North Sea (1980), the Mediterranean (1982, 1987), at AUTEC for the Italian Navy ALFS demonstration trials (1989), in the shallows of the Timor Sea, North Australia (1993), in the Tasman Sea off Eastern Australia (1993), in Vestfjorden, Norway (1994) and in Italian operational trials (1995). In all cases the system was trialled against submarine targets.

Contractor

Galileo Avionica SpA , Campi Bisenzio

VERIFIED

Russian Federation

Oka-2, VGS-3

Very little information on airborne submarine warfare equipment has been made public. There are at least two types of dipping sonar carried by helicopters. The photograph shows a shore-based Mi-14PW 'Haze-A' helicopter which is equipped with both MAD and dipping sonar. The dipping sonar operated from the Mi-14 is almost certainly a medium-frequency type and is deployed from a clamshell door at the rear of the fuselage. The dipping sonar used in the 'Hormone-A' helicopter is the Oka-2, a dual-mode, active/passive sonar. It apparently operates at a frequency of about 15 kHz and has a maximum range of about 5,000 m. The sonar is housed in a compartment at the rear of the main cabin and immediately forward of the tail boom. The Kamov Ka 27 and 28 (Helix A/D) deploy the VGS-3 (also referred to as



Mi-14PW of the Polish Air Force showing the towed MAD 'bird' stowed against the rear of the fuselage. A dipping sonar is also fitted

Ros-V) dipping sonar from the rear of the fuselage through open clamshell-type doors.

The RFAS uses large numbers of sonobuoys, and airborne processing and analysis/display equipment must therefore be fitted to both helicopters and fixed-wing ASW aircraft, but no information is available.

Operational status
The Oka-2 is in service with the Russian Navy and Polish Mi-14 ASW helicopters for which it has recently been upgraded. The VGS-3 is in service with the PLA Navy and Indian Navy Ka 28 Helix and Russian Navy Ka 27 Helix helicopters.

UPDATED

United Kingdom

Type 2069

Type
Active helicopter dipping sonar.

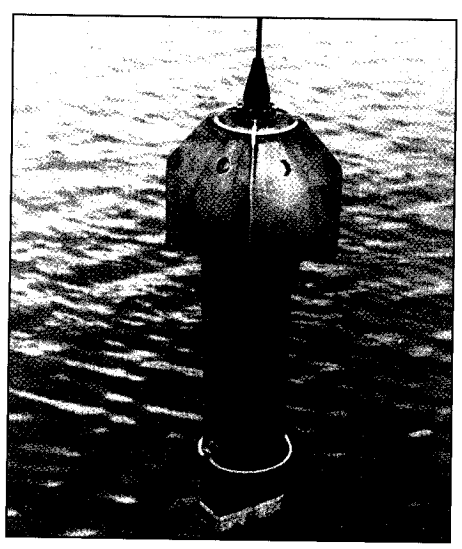
Description
The Type 2069 sonar is an upgraded Type 195M. It employs solid-state transmitters and a longer cable. The sonar transducer has been re-engineered to permit operation at greater depth. The sonar is now integrated with the AN/AQS-902G-DS acoustic processing system.

The sonar provides full 360° coverage in progressive 90° arcs. It can be programmed for automatic search, or the operator can manually select a particular search sector. The operator is provided with audio, Doppler and visual sector sonar information.

The sonar may be employed in either surveillance or attack control modes, or both simultaneously. Pulse length and detection ranges are operator selectable to optimise the system according to the prevailing conditions or tactical requirements. Effective range is understood to be in the region of 4 n miles. Operating depth is around 300 m.

The Type 2069 has been upgraded to provide enhanced performance at close ranges and greater immunity to interference.

Operational status
Type 2069 was withdrawn from operational service with the Royal Navy Sea King HAS Mk 6 early in 2004 when the last Sea King Mk 6 was withdrawn from ASW operations. The sonar remains in service with the Sea King Mk 45 of the Pakistan Navy where it is integrated with the AQS-928G acoustic processor.



Type 2069 dipping sonar sensor

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

United States

AN/AQH-4(V)2

Type
Mission recording and playback system for fixed-wing aircraft.

Description
The AN/AQH-4(V)2 recording and playback system is designed for use on board ASW maritime patrol aircraft such as the P-3 Orion. In its standard configuration, the system records data transmitted from sonobuoys together with a time code to chronologically reference any given segment of data. The system can also be operated remotely and, with an optional interface unit, can communicate directly with a Central Processing Unit (CPU).

High-density digital data is recorded with bit densities up to 34 KBPI per track, at 7.5 ips. The recorder accommodates a mixture of FM, direct and digital inputs simultaneously or independently on data Printed Circuit Board (PCB) selections. With the availability of various multiplexing schemes and interfaces, the recorder offers considerable flexibility in choice of recording methods. The system records and monitors acoustic signals on 28 active tracks and records all tracks simultaneously. Hard-wire provision is made for monitoring four channels (including time code information) and one switchable output to monitor any of the 28 recorded tracks.

The unique tape transport assembly floats on its own shockmounts within the main frame, allowing hard installation without the need for additional vibration isolation. The AQH-4(V)2 is designed to permit the interchanging of electronic data cards (PCBs) between systems without adjustments. This overcomes the need to normalise the electromagnetic characteristics inherent in the design of magnetic heads.

Operational status
Approximately 300 units have been sold to the US Navy and to other navies, including Australia, Canada, Japan, Netherlands and Norway.

Contractor
DRS Technologies Inc, Oakland, New Jersey.

VERIFIED

AN/AQH-9

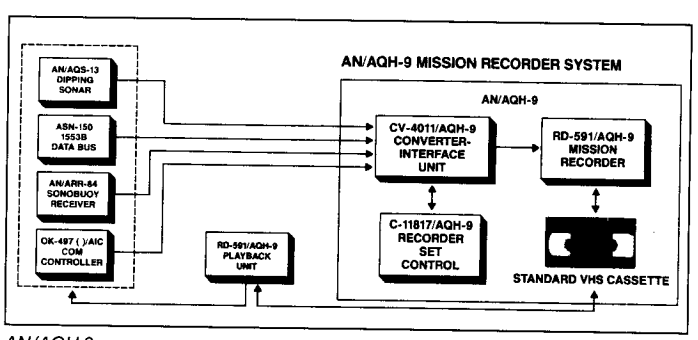
Type
Helicopter mission recording and playback system.

Description
The AN/AQH-9 Mission Recorder System records ASW data for contact validation, post-mission analysis and crew training. The equipment can be readily reconfigured for rotary-wing, fighter/attack and reconnaissance aircraft, and for Remotely Piloted Vehicle (RPV) missions.

The system consists of a mission tape recorder interface unit, a VHS video cassette data recorder, a remote-control unit and a video cassette. The video cassette links the airborne equipment to a ground station playback system.

As configured for the SH-60F helicopter, the AN/AQH-9 will record any mix of four channels of raw sonobuoy data, voice communications and time code data, processed acoustic display data and avionics information via a dual-redundant MIL-STD-1553B database.

To keep weight and volume to a minimum for critical applications, the equipment was configured to 'record only' using standard VHS tape cassettes. Other configurations are available to record and provide in-flight playback facilities. The unit is shockmounted near the sonar operator's console.



AN/AQH-9



AN/AQH-9 mission tape recorder system (left to right) interface unit, remote-control unit, data recorder

The rotary head data recorder is a helical scan unit which accepts a modified digital datastream for recording black and white video signals. The recorder incorporates two side tracks (time code and auxiliary voice) for expanded capabilities. User data rate using a modified RS-170 format is 3.3 Mbits/s for a 2 hour recording.

The ground element of the system is provided by the RD-591/AQH-9 Mission Data Playback System which is capable of reproducing all the data from the mission recorder system. It recalls acoustic, tactical, communications and avionics data from a standard 1553B databus. It contains an IRIG 'B' time code generator which allows the playback system to provide real-time, post-mission analysis reconstruction of mission data, as well as high-speed search for specific information.

The acoustic data is recorded from four sonobuoy receiver channels, maintaining precise phase information, and presented in analogue form for analysis by the AN/SQR-17A. Intercom and UHF radio are reconstructed and made available both as analogue electrical outputs and in audible form through a front panel loudspeaker.

The man/machine interface consists of a high-resolution, full colour display, presented to the operator as three interactive windows. The operator interface is accomplished primarily via a trackball located next to the keyboard. The real-time graphics display window provides symbolic reconstruction of the mission's tactical scenario. Two supplementary windows are provided for additional data relevant to the current status of the aircraft and the significant events logged during the mission. Interactive data filtering is provided to control the type and extent of the data displayed in these windows.

Operational status

The recorder system has been manufactured for operational use on board the US Navy SH-60F CV carrier-based helicopters and other rotary-wing aircraft, with over 100 sold. Playback systems have been provided to the US Naval Air Development Center. Also in service aboard SH-60F helicopters of the Taiwanese Navy.

Contractor

DRS Technologies Inc, Oakland, New Jersey.

VERIFIED

AN/AQH-11

Type

Helicopter digital mission recorder system.

Description

The AN/AQH-11 compact, lightweight, high-density, rotary-head digital mission recorder system is designed for ASW helicopter operations. The AQH-11 is a variant of the AQH-9 system (see AQH-9 entry) currently deployed on the SH-60F CV inner zone ASW helicopter. The low-power, ruggedised recording system is equipped with a dual-redundant MIL-STD-1553 databus interface. Using standard commercial S-VHS tape cassettes, the system is fully integrated with a portable digital mission data playback support system for post-mission analysis. When configured in a single-channel mode, the system captures 2 hours of data at a user rate of 8.3 Mbps.

The AN/AQH-11 can be configured to acquire a variety of datastreams, from wideband acoustics to raster video. The AQH-11 features four sonobuoy input channels from the AN/ARR-84 sonobuoy receiver with a frequency response of 5 to 17.5 kHz. Other inputs include four ICS/UHF voice audio channels and two sonar audio signal channels which are provided to the sensor operator's headset.

Operational status

The system has been manufactured for the US Navy under a contract worth approximately US$8 million and for the navies of Taiwan and other countries.

Contractor

DRS Technologies Inc, Oakland, New Jersey.

VERIFIED

AN/AQS-13 helicopter sonar

Type

Active and passive helicopter dipping sonar.

Description

The AN/AQS-13B system is a long-range, active scanning sonar which detects and maintains contact with underwater targets through a transducer lowered into the water from a hovering helicopter. Opening or closing rates of moving targets can be accurately determined and the system also provides target classification clues.

The sonar has significant advantages in operation and maintenance over earlier systems. To aid the operator, some electronic functions were automated to eliminate several controls. Maintenance was simplified by eliminating all internal adjustments and adding built-in test (BITE) circuits.

To enhance detection capability in shallow water and reverberation-limited conditions, while essentially eliminating false alarms from the video display, Bendix (now L3 Communications Ocean Systems), developed an Adaptive Processor Sonar (APS) for the system.

The APS uses digital processor Fast Fourier Transform (FFT) techniques to provide narrowband analysis of the uniquely shaped CW pulse transmitted in the APS mode. The display retains the familiar PPI readout of target range and bearing but APS adds precise digital readout of the radial component of target Doppler.

With APS, processing gains of greater than 20 dB with zero false alarm rates have been measured for target Dopplers under 0.5 kt.

The AN/AQS-13E was the first system to integrate adaptive sonar (APS) and sonobuoy processing in a common processor, the Sonar Data Computer (SDC). This improved sonar performance by 20 dB in reverberation limited shallow water or by 13 dB in deep water exhibiting high ambient noise. Improvements of this system led to the AN/AQS-13F.

The higher energy transmitted with the longer pulse APS mode, combined with the narrowband analysis, also substantially improves the Figure-Of-Merit (FOM) in the non-reverberant conditions more typical of deep water operation. Measured processing gains for APS under ambient, wideband noise-limited conditions exceeded 7 dB.

The AN/AQS-13F has been designed to provide rapid tactical response against the most advanced submarine threats. It is a sister equipment to the AN/AQS-18 and is identical in many respects. A new state-of-the-art transducer, when lowered to depths of up to 442 m, permits instantaneous range improvements of over 100 per cent compared to previous systems. High-speed reeling allows a dip, cycled to maximum depth, to be completed in approximately 3 minutes. The powerful omnidirectional transducer providing 216 ± 1 dB source level is integrated with a sensitive directional receiver array providing azimuthal resolution in a small rugged unit. The search beam width is 180°. The sonar data computer offers digital matched filter processing for 200 and 700 ms sonar pulses, as well as sonobuoy control and processing (four lofar or three difar buoys). The azimuth and range indicator and receiver provides a video display for the operator.

The 13F can be upgraded through replacement of the receiving, processing and display units. This upgrade offers a 14 dB improvement and features an improved beamformer, longer pulses, an FM mode and the potential for embedded training, performance prediction and a further option of upgrading to a LF transducer system offering a performance capability comparable to a surface ship sonar.

Operational status

The AN/AQS-13 is widely used by American forces and over 1,000 sets have been supplied or ordered for naval helicopters of 15 foreign navies in Europe (Italy), Asia (Japan), the Middle East and South America. The AQS-13F was selected by the US Navy and is now in operation on the SH-60F carrier-based ASW helicopters.

Specifications

Frequencies: 9.23, 10, 10.74 kHz (AQS-13F)
Sound pressure level: 113 dB/µPa /yd (13B); 217 dB/µPa /yd (13F)
Range scales: 1, 3, 5, 8, 12, 20 nm
Operational modes: active 3.5 or 35 ms, MTI, APS, passive, voice communications, key communications (13A only). The 13F has the following operational modes: active — 3.5 m/s and 35 ms rectangular pulse, 200 or 700 ms shaped pulse FM; MTI; passive — 500 Hz bandwidth between 9-11 kHz; communicate SSB at 8 kHz (voice)
Visual outputs: (13A) range, bearing; (13B) range, range rate, bearing, operator verification
Audio output: (13A) single channel with gain control; (13B) dual channel with gain control plus constant level to aircraft intercom
Recorder operation: bathythermograph, range, aspect, MAD self-test
System weight: (13A) 373 kg; (13B) 282 kg; (13F) 280 kg
Operating depth: 440 m (13F)

Contractor

L-3 Communications Ocean Systems, Sylmar, California.

UPDATED

AN/AQS-18

Type
Active and passive helicopter dipping sonar.

Description
The AN/AQS-18 is a helicopter-borne, long-range active scanning sonar developed by L3 Communications Ocean Systems to detect and maintain contact with underwater targets through a transducer lowered into the water from a hovering helicopter. Active echo-ranging determines a target's range and bearing, and opening or closing rate, relative to the aircraft. Target identification clues are also provided.

The AN/AQS-18 is a digital AQS-13G sonar with a lightweight body. It consists of a small high-density transducer with a high sink and retrieval rate, a built-in multiplex system to permit use of a single conductor cable, a 440 m cable and compatible reeling machine and a lightweight transmitter built into the transducer package. The Adaptive Processor Sonar (APS), which provides enhanced performance in shallow water areas, is an integral part of the system.

The AN/AQS-18 offers a number of improvements over earlier dipping sonars. These include increased transmitter power output giving longer range, high-speed dip cycle time and reductions in weight of all units. Improved signal processing techniques include multi-ping correlation. Other features of the latest variant the AN/AQS-18(V) include longer pulses (up to 4 sec), higher source level, a ray trace capability and an FM capability. The maximum range scale has been doubled to 20 n miles.

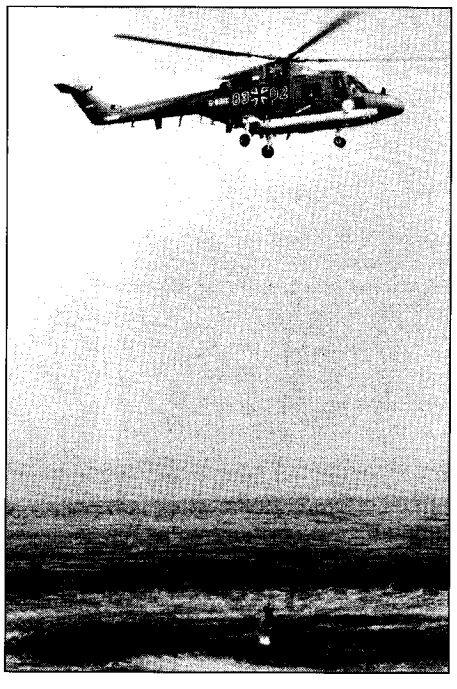
The APS increases detection capability in shallow water and reverberation-limited conditions, while essentially eliminating false alarms from the video display. The APS is a digital processor which uses Fast Fourier Transform (FFT) techniques to provide narrowband analysis of the uniquely shaped CW pulse transmitted in the APS mode. The PPI display retains the normal readout of target range and bearing.

The APS processing gain improvement over the normal AN/AQS-18 analogue processing is 20 dB for a 2 kt target and 15 dB for a 5 kt Doppler target. The higher energy transmitted with the longer pulse APS mode, combined with the narrowband analysis, also improves operation in the non-reverberant conditions more typical of deep water. The gain improvement outside the high-reverberation zone (10 kt or greater) under wideband noise-limited conditions exceeds 7 dB. The latest version is the AN/AQS-18(V) which is available with both 300 and 450 m length cables.

The AN/AQS-18(V) has significant commonality with the Helras system to the extent of some 80 per cent (excepting the transducers). For the two systems to provide fully integrated operations requires only the changing of one or two electronic cards.

Operational status
In production and/or operational use with the Brazilian, Egyptian, German, Greek, Italian, Japanese, South Korean, Portuguese, Taiwanese and Spanish navies, and in use by the US Navy in a similar version, the AN/AQS-13F, on the new SH-60F carrier-based ASW helicopter. Greece and Portugal have also ordered the system for their helicopters. The AN/AQS-18 is in production for and operates in the Lynx, SH-3, SH-60J and S70C(M)-1 helicopters.

Specifications
Operating depth: 440 m
Operating frequencies: 9.23, 10, 10.74 kHz
Sound pressure level: 217±1 dB/µPa/yd (0.9 m)
Range scales: 0.9, 2.7, 4.6, 7.3, 11, 18, 29 km
Operational modes: 3.5 or 35 ms pulse (energy detection) and 200 or 700 ms pulse (narrowband analysis)
Visual outputs: range, range rate, bearing, operator verification
Audio output: dual channel with gain control, plus constant level to aircraft intercom system
Recorder operation: bathythermograph, range, ASPECT, MAD, BITE
System weight: 252 kg plus 13.3 kg for APS



AN/AQS-18 sonar deployed from German Navy Westland Lynx Mk 88 helicopter

Contractor
L-3 Communications Ocean Systems, Sylmar, California.

VERIFIED

AN/AQS-18A helicopter sonar

Type
Active and passive helicopter dipping sonar.

Description
The AN/AQS-I 8A system is a lightweight modern helicopter dipping sonar system (using L-3 Communications Ocean Systems' next generation dry-end processing equipment) designed for active, long-range search, localisation and attack of submarines in both shallow and deep water environments. The sonar detects and maintains contact with underwater targets through a transducer lowered into the water from a hovering helicopter. Active echo ranging determines the bearing, range and range rate of the target relative to the position of the helicopter. Aids in target identification are also provided.

The AQS-18A wet-end consists of proven AQS-13/18 components, which include a small high-density transducer assembly with a high sink and retrieval rate, a built-in multiplex system to permit use of a single conductor cable, a 440 m cable and compatible reeling machine and dome control. The new dry-end consists of the sonar interface unit, cable interface power supply, and sonar control unit. Optional dry-end sub-systems include cable payout indicator, bearing-range indicator and multifunction display.

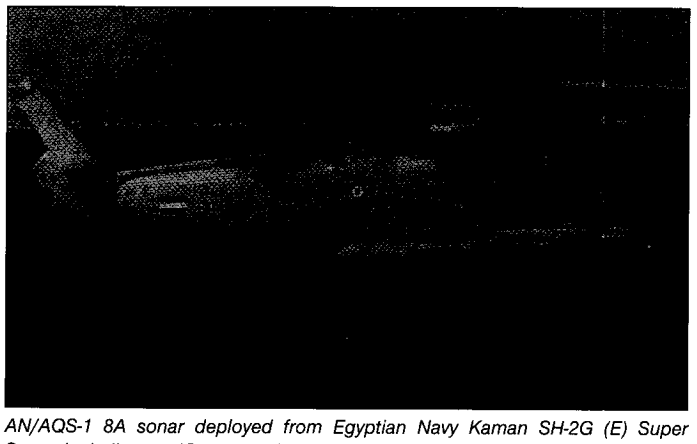
The MF (10 kHz) AQS-18A dipping sonar has significant performance improvements from the AQS-18 sonar. These include longer pulses (1.6, 3.2 and 4 second shaped pulse lengths in addition to the previous 0.2 and 0.8 shaped and 3.5 and 35 msec rectangular); higher source level (217 dB/µPA/0.9144 m); an FM capability (0.625 second); 16 beam signal processing; display integration; increased coverage range (to 20 n miles); simplified operator interface. The longer pulses allow more acoustic energy to be directed at the target, providing higher Doppler resolution for improved performance in waters exhibiting high reverberation, for example shallow water situations. The FM mode (bandwidth 2 kHz) is for extremely low Doppler target detection and maximum range resolution. The total ASW system improvement of the AQS-18A system is 14dB Figure Of Merit (FOM) over current systems and can provide more than four times the area search rate of the AQS-18.

The system is fully compatible with MIL-STD 1553B databus architectures and has a built-in databus which can facilitate integration with aircraft subsystems and components. Interfaces are also provided to accept input data and provide graphic and data output to a sonics data recorder, as well as video for sensor data display.

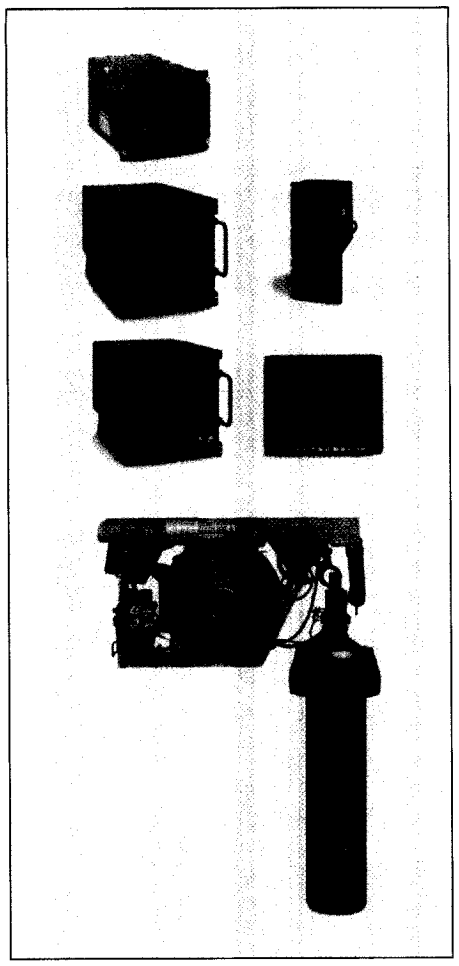
The sonar interface unit has powerful signal processing algorithms specifically designed for the increased pulse lengths and spare processing space for additional processing features such as computer aided detection and classification, multisensor target fusion, embedded training and performance prediction based on environmental data collected during past or current missions.

The cable interface power supply provides the electrical coupling of the sonar cable to the uplink/downlink signals from the transducer assembly, develops high-voltage power for charging the transducer assembly battery pack between transmission periods and modulates and passes voice communication signals to the unit.

The sonar control unit provides the operator with simple interface menus for operator command and control of the sonar system. These menus have been developed with the co-operation of sonar operators from various countries during flight trials and provide a simple interface that greatly reduces the operator's workload.



AN/AQS-1 8A sonar deployed from Egyptian Navy Kaman SH-2G (E) Super Seasprite helicopter (Courtesy of Kaman Aerospace Corp) 0024706



AN/AQS-18A sonar system
(Courtesy of L-3 Communications Ocean Systems)
0024705

The new dry-end weapon replaceable assemblies (WRAs) of the AQS-18A have a significantly higher Mean-Time-Between-Failures (MTBF) than current systems. The WRAs also provide, through the systems internal 1553B databus, built-in-test data for each WRA that eases support and boosts the availability of the system.

The AN/AQS-18A and HELRAS have significant commonality (some 80 per cent, excepting the transducers). This enables a navy operating both large and small helicopters to easily combine the operation of both types in a bi- or multistatic operation.

The AN/AQS-18AC was developed to meet a Swedish requirement. In this model the wet-end is equipped with an additional HF (192 kHz) mode for identification/classification imaging of submarines resting on the seabed. It uses a Reson Seabat sonar with a range resolution of 0.25 m and identification range of 1.1 km. It can also be used for mine detection or avoidance. The set uses the same pulse lengths as the ASQ-18A model, which make it suitable for use in conditions of high reverberation in shallow water. Short CW pulses offer high range resolution, localisation and attack capability with two FM modes offering extremely low Doppler target detection and maximum range resolution. The processing system provides for concurrent active and passive processing including up to eight DIFAR buoys. The area search rate is claimed to be twice that of the original AN/SSQ-18 sonar, while maximum operating depth has been increased to 500 m.

Operational status

The AQS-18A is in production and in operational use with the Ecuadorian, Egyptian, Italian and Turkish navies, using the 412EP, SH-2G (E), SH-3D/H and AB-212 helicopters respectively.

Specifications

Operating depth: 440 m
Operating frequencies: CW 9.23, 10.003, 10.774 kHz; Fmlo 9.485 kHz, Fmhi 10.520 kHz
Sound pressure level: 217 dB/µPa/yd (0.9 m)
Range scales: 1, 1.5, 2.5, 5, 7.5, 10, 12.5, 15, 20 nm
Operational modes: Active 3.5, 35 ms rectangular; 0.2, 0.8, 1.6, 3.2, 4 s shaped: 0.625 s FM; passive; UQC
Weight: 88.9 kg (transducer assembly); 122.7 kg (dome control, reeling machine, cable and reel); 51.8 kg (sonar interface unit, cable interface power supply and sonar control unit); 264 kg (total)
Optional components: 0.5 kg (cable payout indicator); 0.6 kg (bearing and range indicator); 14 kg (multifunction display)

Contractor

L-3 Communications Ocean Systems, Sylmar, California.

VERIFIED

Helras

Type

Helicopter long-range dipping sonar.

Description

L-3 Communications Ocean Systems has developed the Helras (Helicopter Long-Range Active Sonar). The sonar is a deployable low-frequency (1.38 kHz active centre frequency) volumetric array based on the company's experience with previous dipping sonar arrays. The wet end comprises a receiver array of eight hydraulically driven arms, which expand to a diameter of 2.6 m when deployed, and a transmitter array of eight projector elements (including an underwater telephone transducer). These projectors form a vertical array 5.2 m long that descends from within the wet end central body during deployment. The projectors radiate at high power levels over 360° in azimuth and the transmitted beam can be vertically steered from −15 to +15°. A range of some 75 km has been demonstrated in favourable weather conditions.

Helras employs a unique transducer design (LF flex disc technology) in the wet end to provide very high acoustic power levels in a lightweight array. The high-efficiency vertical line projector radiates in a narrow beam to reduce boundary interaction and couple efficiently into long-range propagation modes. The highly directional receive array discriminates against noise interference and provides maximum sensitivity of the return echo for high detection ranges.

The sonar is capable of operating at depths down to 550 m and although primarily a direct path detection sonar, has Figure-Of-Merit sufficient to achieve second convergence zone detection in deep water (range is claimed to be better than 35 n miles), and transmission/receive characteristics optimised for extremely long ranges in shallow water. The low frequency offers multiple boundary interactions and reduced reverberation interference of the received signals. The use of high-resolution Doppler processing and shaped pulses achieves detections of targets even at speeds below 1 kt. The coded pulses are transmitted in long CW form. Extended duration FM pulses are available to detect the near-zero Doppler target as well.

The sonar interface unit has powerful signal processing algorithms specifically designed to take advantage of the wide area search capability of Helras. The unit performs demultiplexing, beam-forming, and signal processing functions, and provides an output for presentation on the aircraft display. Reverberation suppression techniques such as manipulation of waveform design of the transmitted pulse, Doppler filtering, ping-to-ping analysis and analysis of the pulse length in space or time, make the sonar suitable for shallow water operations.

The advanced reeling machine is derived from the AQS-13/18 series and has considerable commonality of parts with the series. It allows automatic deployment and retrieval of the wet end to depths substantially below the deepest mixing layers for detection of the deepest diving submarines with minimum dip cycle time. The reel lowers the wet end at 2.1 m/s and raises it at 4.6 m/s.

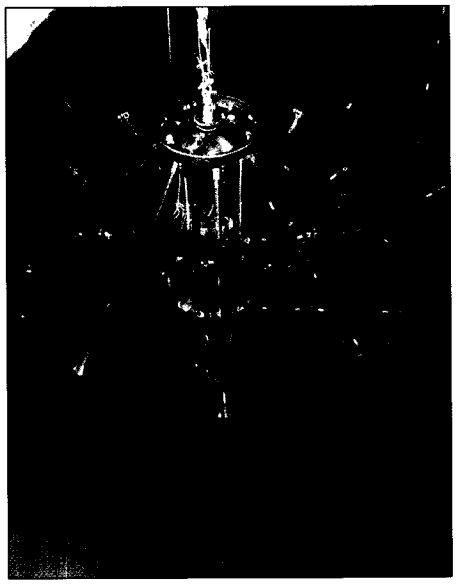
The dome control commands remote deployment and retrieval, and continuously monitors the wet end status. The automatic control ensures flight safety by varying the speed during raising and lowering operations. Cable angle and cable payout signals are provided for the automatic flight control system to assist helicopter stabilisation during hover.

The system is fully compatible with MIL-STD 1553B databus architectures. Interfaces are provided to accept data input and provide graphic and data output to a sonics data recorder, as well as video for sensor data display. The power for the wet end electronics is derived from a battery pack within the body, which is recharged between transmission periods.

Operational status

Advanced development has been completed and flight trials have been conducted with the system by the US Navy, Australian, Italian and Norwegian navies.

Ten Helras systems are in production for and operate in the Italian EH101 helicopter. The sonar has also been selected by NAHEMA (Netherlands, Germany, France and Italy) for the NH90 helicopter.



Array arms of Helras deployed
(Courtesy of L-3 Communications Ocean Systems)
0024704

Eight systems have also been ordered by the Turkish Navy to equip their S-70B helicopters and Greece has ordered four Helras for its S-70B helicopters.

Specifications

Operating depth: 500 m
Projector: 8 elements, array length 5.2 m
Operational modes: active CW to 10 s pulses, FM to 5 s pulses, FM triplet, combined CW/FM; passive, UWT
Operating frequencies: CW - 1.311, 1.380, 1.449 kHz
FM - 1.330 to 1.430, 1.280 to 1.480, 1.230 to 1.530 up or down sweep
Passive - 800 Hz to 2.000 kHz
Source level: 219 dB/µPa/yd
Beamwidth: vertical –15° to +15°
Receive beams: 32 half beams, 16 full beams
No of target tracks: 10
Range scales: 1, 1.5, 2.5, 4, 6, 10, 16, 25, 40, 60 n miles
Range accuracy: 25 m
Bearing accuracy: 1.9°
Receive array: 2.6 m diameter × 1.2 m high
Operating depth: 550 m
Weight: 152 kg (wet end); 115 kg (dome control, reeling machine, reel and cable); 45 kg processing; 14 kg (sonar control and flat panel display) 326 kg (total)

Contractor

L-3 Communications Ocean Systems, Sylmar, California.

UPDATED

SONOBUOYS

Australia

RASSPUTIN

Type
Low-frequency active sonobuoy.

Description
The RASSPUTIN (Rapid Area Search Sonar Projector Used Tactically In Narrowband) currently under development is an active low-frequency sonobuoy designed to perform multistatic shallow and deep-water operations in co-operation with standard passive sonobuoys. The 'A' size buoy is launched from an aircraft and is designed to detect, track and localise submarines using active sonar controlled via UHF link from the aircraft. The received echo is replayed to the aircraft by passive receiver sonobuoys arranged in multistatic configurations. Range and bearing to the target is derived through the co-ordinated tactical management of the passive sonobuoys.

The buoy features a high transmission level within a narrow acoustic band. The array incorporates a new type of transducer, the Diabolo, developed by Thales Underwater Systems that provides a high Q at low frequency. Hence, the expected detection range is greatly increased when used in bistatic/multistatic modes.

The buoy can be launched from helicopters or fixed wing aircraft and following launch a parachute is automatically deployed to retard the descent and stabilise trajectory.

On entering the water the depth selection mechanism is activated, the parachute jettisoned and the RF command/control unit surfaces while the active sonar array assembly deploys to the preselected operating depth (either 20 or 120 m).

The buoy is then ready for control from either the aircraft or using autonomous mode as selected on the electronic function select prior to deployment. The buoy can be commanded by ping type (FM or CW), length and interval.

The buoy has an operating life of up to 4 hours and includes an optional GPS.

Operational status
Under development. The buoy has carried out trials in a multistatic system.

Specifications
Length: 91.72 cm
Diameter: 12.38 cm
Weight: 16 kg
Frequency: 1,500 Hz
Bandwidth: 300 Hz
Source level: 205 dB
Vertical beam pattern: 20°
Operating depth: 20 or 120 m

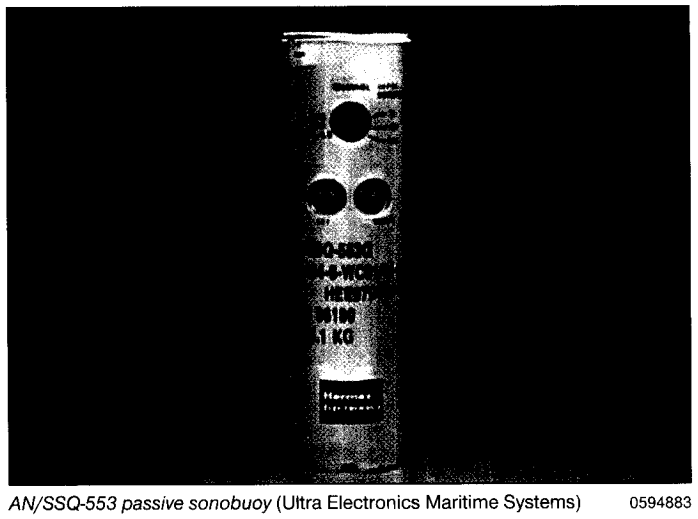
Contractor
Thales Underwater Systems, Rydalmere, New South Wales.

VERIFIED

Canada

AN/SSQ-553G

Type
Directional passive sonobuoy.



AN/SSQ-553 passive sonobuoy (Ultra Electronics Maritime Systems) 0594883

Description
The AN/SSQ-553G is a 'G' size DIFAR sonobuoy. The buoy is qualified for gravity launch and can be deployed from a wide range of airborne and shipborne platforms. The microprocessor-controlled passive directional buoy features an enhanced low frequency capability. The EFS allows the operator to select one of 99 VHF-FM channels; one of four operating periods; and sensor deployment to one of three depths prior to launch.

The buoy uses a saltwater-activated battery as its main power source and a lithium battery for the EFS display and memory.

Operational status
The AN/SSQ-553G has been produced for the Canadian Armed Forces' ASW helicopter fleet.

Specifications
Length: 419 mm
Diameter: 124 mm
Weight: 5.1 kg
Transmitter frequency: 136-173.5 MHz
RF power: 1 W min
Frequency: 5-2,400 Hz
Sensitivity (directional): 122 ±3 dB rel 1 µPa @ 100 Hz = 40 kHz pk dev
Sensitivity (omnidirectional): 122 ±3 dB rel 1 µPa @ 100 Hz = 25 kHz pk dev
Operating depth: 30, 120, 300 m (pre-selectable)
Operating life: 0.5, 1, 4, or 6 h (pre-selectable)
Launch altitude (max): 9, 144 m
Launch speed (max): 370 k @ 564 m

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.

UPDATED

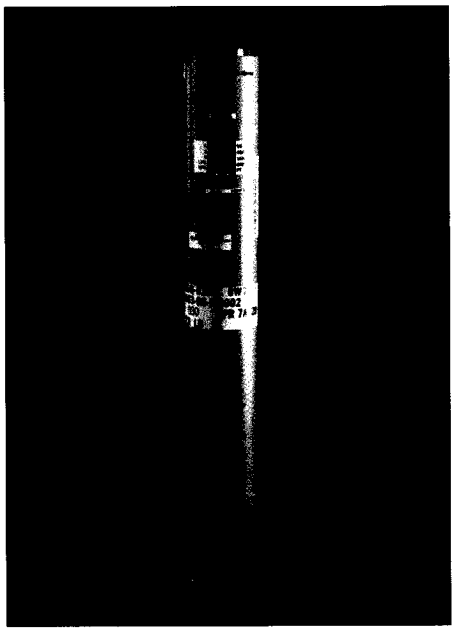
International

AN/SSQ-53D(2)

Type
Passive directional sonobuoy.

Description
The AN/SSQ-53D(2) DIFAR (DIrectional Frequency Analysis and Recording) low noise 'A' size sonobuoy is a derivative of the US Navy's primary sonobuoy sensor. Compared with earlier omnidirectional buoys, the SSQ-53D(2) provides target bearing as well as improved acoustical sensitivity, particularly in the low-frequency ranges. Its directional capability allows ASW forces to detect and track a contact with a single DIFAR and to fix its position with as few as two DIFARs.

The SSQ-53D(2) is the result of a Canadian Forces-sponsored development programme to improve the operational capabilities of the SSQ-53. Changes include extension of the lower limit by one octave to 5 Hz. In addition, omni-acoustic performance has been improved by 10 dB across the frequency range, and the directional hydrophones have been improved by 16 dB at the 10 Hz point.



AN/SSQ-53D directional sonobuoy

The sonobuoy may be dropped from an aircraft at indicated airspeeds of 30 to 370 kt, and from altitudes of 30 to 9,144 m. Descent of the buoy is stabilised and slowed by a parachute assembly. After presetting the desired life, depth and RF channel, operation of the buoy is fully automatic.

Immediately after water entry, the saltwater battery is activated. A lithium battery provides power for the EFS display and memory. Buoy separation occurs, jettisoning the parachute assembly and erecting the VHF transmitting antenna. This allows the surface assembly to rise and separate from the sonobuoy housing. The housing serves as a descent vehicle and separates from the subsurface assembly at the operating depth. Before launch the buoy is programmed, via the EFS (Electronic Function Select) using push buttons, to one of 99 channels, five operating periods and three selectable hydrophone depths. Programmed settings are shown on an LED display located on the side of the buoy. After 8 hours in the water the buoy automatically scuttles itself.

Operational status
In production for the Canadian Forces since 1994 with more than 100,000 delivered. The buoy is also in service with the US Navy and throughout NATO navies.

Specifications
Dimensions: 'A' size (91.44 × 12.4 cm diameter)
Weight: 7.5 kg
Acoustic frequency: 5 Hz-2.4 kHz
Transmitter frequency: 136-173.5 MHz
Sensitivity-directional: 122 ± 3 dB rel to 1 µPa @ 100 Hz (40 kHz pk dev)
Sensitivity-ominidirectional: 122 ± 3 dB rel to 1 µPa @ 100 Hz (25 kHz pk dev)
Directivity, directional: Horizontal cosine ± 1 dB
Vertical cosine ± 3 dB
Directivity, omnidirectional: ± 1 dB horizontal
± 3 dB vertical
RF channels: 99 VHF
RF power: 1 W (min)
Operating depth: 30, 120 or 300 m (preselectable)
Operating life: 0.5, 1, 2, 4, 8 h (preselectable)

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada.

UPDATED

AN/SSQ-53D(3)

Type
Passive directional sonobuoy.

Description
The AN/SSQ-53D(3) DIFAR low noise 'A' size sonobuoy is an enhanced version of the AN/SSQ-53D(2) buoy and is optimised for low frequency detection. Using its 'ambient noise limited' directional hydrophone and complementary suspension system, the buoy is qualified for operation in Sea State 6. To provide improved performance in the littoral environment, a fourth operating depth has been added allowing operator selection of sensor deployment at 60 m as well as 30, 120 or 300 m.

The sonobuoy may be dropped from an aircraft at indicated airspeeds of 30 to 370 kt, and from altitudes of 30 to 9,144 m. Descent of the buoy is stabilised and slowed by a parachute assembly. After pre-setting the desired life, depth and RF channel, operation of the buoy is fully automatic.

Immediately after water entry, the saltwater battery is activated. A lithium battery provides power for the EFS display and memory. Buoy separation occurs, jettisoning the parachute assembly and erecting the VHF transmitting antenna. This allows the surface assembly to rise and separate from the sonobuoy housing. The housing serves as a descent vehicle and separates from the subsurface assembly at the operating depth. Before launch the buoy is programmed, via the EFS (Electronic Function Select) using push buttons, to one of 99 VHF-FM channels, five operating periods and one of four selectable hydrophone depths. Programmed settings are shown on an LED display located on the side of the buoy. After 8 hours in the water the buoy automatically scuttles itself.

Specifications
Size: 'A' size
Length: 91.44 cm
Diameter: 12.4 cm
Weight: 7.5 kg
Acoustic frequency: 5 Hz-2.4 kHz
Transmitter frequency: 136-173.5 MHz
Sensitivity-directional: 122 ±3 dB rel to 1 µPa @ 100 Hz (40 kHz pk dev)
Sensitivity-omnidirectional: 122 ±3 dB rel to 1 µPa @ 100 Hz (25 kHz pk dev)
RF channels: 99 VHF (pre-selectable with EFS)
RF power: 1 W (min)
Operating depth: 30, 60, 120 or 300 m (preselectable)
Operating life: 0.5, 1, 2, 4, 8 h (preselectable)

Contractors
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada.
UnderSea Sensor Systems Inc, Columbia City, Indiana, USA.

UPDATED

AN/SSQ-53E

Type
Passive directional sonobuoy.

Description
The AN/SSQ-53E DIFAR (DIrectional Frequency Analysis and Recording) low noise sonobuoy is an all-digital, improved performance 5th generation passive acoustic sensor. The buoy incorporates two sensors – a constant shallow omni or CSO unit permanently set at 14 m and an advanced DIFAR unit designed to operate at tactically significant depths.

The electronics in the buoy digitally condition and amplify the underwater acoustics and provide directional data essential for establishing the azimuth bearing of the source of the sounds.

The buoy features both EFS (Electronic Function Select) which is used to preset sensor mode, operating life, depth and RF channel prior to launch, and Command Function Select (CFS), which allows selection of operating life, RF channel, sensor Automatic Gain Control (AGC) and RF-off when the buoy is in the water. Access to the CFS command function requires the use of a command signal generator and a UHF transmitter onboard the aircraft.

After launch, with the exception of the DIFAR sensor operating depth, all of the buoy's characteristics (RF transmitter channel, in-water life, DIFAR AGC on/off, sensor mode and command scuttle) can be modified using the CFS function. The hydrophone is a multichannel directional unit of piezoelectric ceramic material.

The AN/SSQ-53F currently in production, supersedes the AN/SSQ-53E and combines the functionality of a calibrated omni-sensor with that of the ASN/SSQ-53E DIFAR. Through the Command Function System (CFS) the ASW operator is able to select data from either the DIFAR or calibrated omni-sensor.

Operational status
1993-1999 – In production for the US Navy.

Specifications
Size: 'A' size
Length: 91.44
Diameter: 12.4 cm diameter
Weight: 9.1 kg
Transmitter frequency: 136-173.5 MHz
RF channels: 96 selectable
RF power: 1 W (min)
Acoustic frequency: 5-2,400 Hz (DIFAR), 30-5,000 Hz CSO
Operating depth: 30, 60, 120, 300 m (selectable)
Operating life: 0.5, 1, 2, 4, 8, h (selectable)

Contractor
Sparton Electronics, DeLeon Springs, Florida
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.
UnderSea Sensor Systems Inc (an Ultra Electronics Company), Columbia City, Indiana.

UPDATED

AN/SSQ-53F

Type
Combination (Passive Directional And Calibrated Wideband Omni Directional) sonobuoy.

Description
The AN/SSQ-53F 'A' size combination sonobuoy is a fully digital hybrid device that combines the functionality of both the AN/SSQ-53D DIFAR and AN/SSQ-57A/B ASPL sonobuoy into a single multifunction sonobuoy. The SSQ-53F incorporates three sensors – a Constant Shallow Omni or (CSO) permanently set at 14 m, together with an advanced DIFAR sensor and a calibrated wideband omni, both designed to operate at tactically significant depths.

The buoy digitally conditions and amplifies the acoustics and provides directional data necessary to establish azimuthal bearing to the source of the acoustic energy.

The combination sonobuoy features both Electronic Function Select (EFS) for use prior to loading and launching, and Command Function Select (CFS) for use when the buoy is deployed in the water. These functions allow the operator to select operating mode, life, depth settings and RF channel. The CFS allows the operator to switch between the combined sonobuoy types.

Following deployment, with the exception of operating depth, all of the buoy's operating characteristics (RF transmitter channel, in water life, DIFAR AGC on/off, sensor mode, and command scuttle) can be modified using the CFS function.

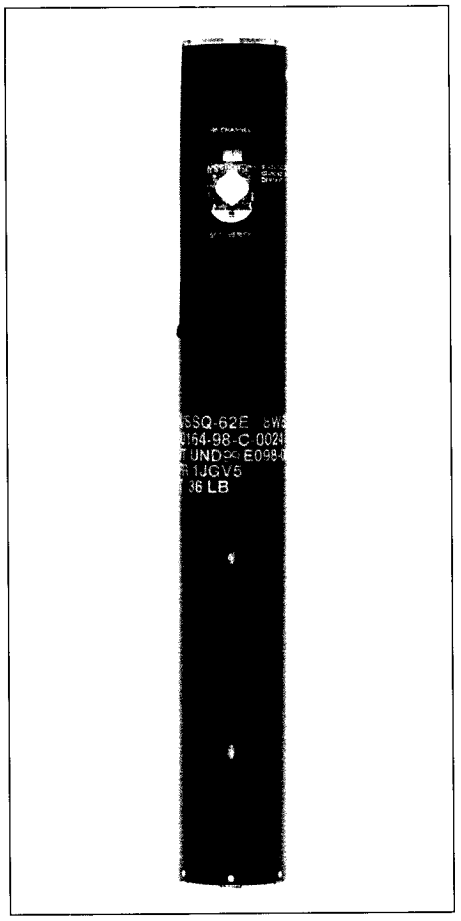
The DIFAR hydrophone is a multichannel directional piezoelectric ceramic transducer.

Operational status
In service. UnderSea Sensor Systems was awarded a contract for 32,645 buoys and Sparton for 25,024 buoys in 2002 with delivery due to be completed by February 2004 or before. This has been followed by a further contract for 30,636 buoys from Sparton Defense Electronics and 10,398 buoys from UnderSea Sensor Systems Inc with delivery to be completed by February 2005. A further order was placed in early 2004 for 11,107 buoys from Sparton Defense Electronics and for 53,332 buoys from Undersea Sensor Systems, both for completion in February 2006.

Specifications
Size: 'A' size
Length: 91.44 cm
Diameter: 12.4 cm
Weight: 8.2 kg
Transmitter frequency: 136 MHz to 173.5 MHz
RF power: 1 W (min)
Transmission channels: 96 (selectable)
Acoustic frequency: 5 Hz to 25 kHz (calibrated omni)
30 Hz to 5 kHz (constant shallow omni)
5 Hz to 2.4 kHz (DIFAR omni)
Operating depth: 30, 60, 120, or 300 m (selectable)
Operating life: 0.5, 1, 2, 4 or 8 h (selectable)

Contractors
Sparton Defense Electronics, DeLeon Springs, Florida, US.
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada.
UnderSea Sensor Systems Inc, Columbia City, Indiana, US.

UPDATED



The AN/SSQ-62E DICASS sonobuoy (Ultra Electronics)
0089216

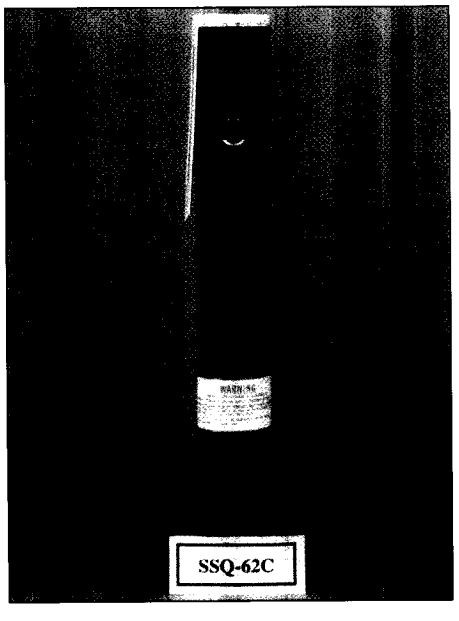
AN/SSQ-62 series DICASS

Type
Active directional sonobuoy.

Description
These monostatic active buoys are the acoustic sensors for the Directional Command-Activated Sonobuoy System (DICASS). A high-performance fully digital sonobuoy, it detects the presence of submarines using sonar techniques under direct command from ASW aircraft. The AN/SSQ-62C can also determine the range and bearing of the target relative to the sonobuoy's position. The SSQ-62C operates on pulsed CW or linear FM. The latest variant is the 62E which operates on one of four sonar frequencies at source levels exceeding 200 dB. The D variant has replaced the obsolete AN/SSQ-47B in operational service.

The DICASS sonobuoy comprises three main sections: a parachute, a surface unit and a subsurface unit. The parachute slows down descent immediately after launch. The surface unit receives commands from the controlling aircraft, via a UHF receiver and sends target information to the aircraft, via a VHF transmitter. The subsurface unit transmits sonar pulses in the ocean upon command from the aircraft and receives sonar target echoes for transmission to the aircraft.

Command signals are received by the sonobuoy and are accepted if the correct address code is identified by a decoder. The command capability includes depth selection, acoustic channel (four selectable frequencies in the 62E) and RF channel. The echoes from the selected activating signal are multiplexed in the subsurface unit before being transmitted to the receiving station or aircraft. There are two deep depth settings in the AN/SSQ-62C (460 and 760 m) one of which may be chosen via Electronic Function Select (EFS) selection before launch. The RF channel can also be selected by EFS prior to launch.



The AN/SSQ-62C DICASS sonobuoy

The buoys can be launched from fixed- or rotary-wing aircraft within the parameters specified in the launch envelope.

Upon impact with the water, the omnidirectional piezoelectric ceramic transducer is released for descent to its shallow operating depth. Immediately after entry, the float is inflated and the VHF-transmitter/UHF-receiver antenna is erected. When the float surfaces, the VHF transmitter begins emitting a continuous FM carrier signal. The sonobuoy is now operating in the passive mode and is ready to receive commands.

The latest generation of the AN/SSQ-62 series is the AN/SSQ-62E. Unlike previous versions, the AN/SSQ-62E is capable of supporting any of the four acoustic frequencies as selected via the EFS. The buoy also incorporates a CFS (Command Function Select) which allows the operator to modify the buoy's mode of operation even after it has been deployed. The buoy is available with either a standard lithium sulphur dioxide battery pack or a thermal battery pack for enhanced safety.

Operational status
The older AN/SSQ-62B with three immersion depths and single channel 0.25 W VHF transmitter is still available in limited production. The SSQ-62E is now in full production. A total of 8,092 SSQ-62E buoys was ordered from Sparton in 2002 and delivery was due to be completed by February 2004.

Specifications
AN/SSQ-62B
Dimensions: 'A' size (91.4 × 12.4 cm diameter)
Weight: 15.9 kg
Sonar channels: 4 (preset acoustic channel (1 of 4))
RF channels: 31 EFS selectable or fixed
RF power: 1 W
Operating depth: commandable, 27, 120, 460 m
Operating life: 1 h
Launch altitude: up to 3,048 m
Launch speed: up to 300 kt

AN/SSQ-62C
Dimensions: 'A' size (91.4 × 12.4 cm diameter)
Weight: 15.5 kg
Sonar channels: 4 (preset acoustic channel (1 of 4))
RF channels: 87 EFS selectable
RF power: 1 W
Operating depth: commandable, 27, 120, 460/760 m
Operating life: 1 h
Launch altitude: up to 3,048 m
Launch speed: up to 300 kt

AN/SSQ-62D
Dimensions: 'A' size (91.4 × 12.4 cm diameter)
Weight: 16.4 kg
Sonar channels: 4 (preset acoustic channel (1 of 4))
RF channels: 92 EFS selectable
RF power: 1 W
Operating depth: 15, 46, 92 m (shallow)
27, 120, 460 m (deep)
Operating life: 1 h
Launch altitude: up to 3,048 m
Launch speed: up to 300 kt

AN/SSQ-62E
Dimensions: 'A' size (91.4 × 12.4 cm diameter)
Weight: 16.4 kg
Sonar channels: selectable (one of four)
Sonar frequencies: 6.5 kHz, 7.5 kHz, 8.5 kHz, 9.5 kHz
RF channels: 92 EFS selectable
RF power: 1 W (min)
RF frequency: 136 to173.5 MHz
Operating Depth: 15, 46, 92 m (shallow)
27, 120, 460 m (deep)
Commandable to 46 and 92 m or 120 and 460 m
Operating life: 1 h (min)

Contractors
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.
Sparton Corporation, Electronics Division, DeLeon Springs, Florida.
UnderSea Systems Inc (an Ultra Electronics company), Columbia City, Indiana.

UPDATED

AN/SSQ-62RO

Type
Range only active sonobuoy.

Description
The AN/SSQ-62RO 'A' size sonobuoy has been developed to replace the obsolete AN/SSQ-47B range only active sonobuoy. The buoy is based on the AN/SSQ-62E digital DICASS, but reprogrammed to activate upon water entry and to function in range only mode.

Compared to the AN/SSQ-47B buoy, the AN/SSQ-62RO features more depth selections, improved reliability, is more powerful and is cheaper. Future enhancements will allow the AN/SSQ-62RO to be reconfigured via the EFS to operate as a standard AN/SSQ-62E DICASS, offering users greater operational flexibility and addressing the inventory management issues as countries upgrade to the AN/SSQ-62E DICASS.

Other features of the AN/SSQ-62RO are: longer life, greater source levels than the AN/SSQ-47B, and lower operating frequency for increased detection ranges.

Specifications
Size: 'A' size
Length: 91.44 cm
Diameter: 12.4 cm
Weight: 16.4 kg
Acoustic frequency: 6.5, 7.5, 8.5, 9.5 kHz
Source level: >199 dB
Internal pulse: 10 s
Pulse length: 0.1 s CW
RF power: 1 W
Operating life: 1 h
Operating depth: 20, 92 or 244 m

Contractors
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada.
UnderSea Sensor Systems Inc, Columbia City, Indiana, US.

UPDATED

AN/SSQ-77C

Type
Passive directional search and surveillance sonobuoy.

Description
The SSQ-77B Vertical Line Array DIFAR (VLAD) is a passive, tactical search and surveillance sonobuoy designed to improve detection and tracking capability for the DIFAR system in a noisy, high-traffic environment. The VLAD concept utilises a vertical line array of eight omnidirectional piezoelectric ceramic hydrophones together with a DIFAR hydrophone to achieve the performance improvements. A directional hydrophone, similar to the DIFAR, is mounted at the array phase centre to provide target bearing data. The buoy is optimisedd for horizontally ariving signals.

The electronic configuration for the hydrophone outputs is the same as that of the AN/SQQ-53D DIFAR series of sonobuoy and no modifications are required to the airborne acoustic processor. All beam-forming functions are accomplished by the sonobuoy, with provision for sea noise equalisation and omnidirectional phase tracking. The buoy features two beam-forming modes (convergence zone or bottom bounce), three operating depths and five operating periods.

The buoy includes Electronic Function Select (EFS), Command Function Select (CFS) and a frequency synthesised FM RF transmitter selectable over the entire range of 96 standard VHF sonobuoy channels. Selection of transmitter RF channel, sensor depth setting, and in water life is accomplished using the EFS push-button mounted on the side of the buoy prio to launch and CFS can change RF channel or life once in the water.

The buoy is deployed as other buoys and automatically scuttles after eight hours.

Operational status
Sparton was awarded an engineering development contract for the AN/SSQ-77C in 2001 to replace the AN/SSQ-77B in service. A contract for 7,418 AN/SSQ-77C buoys was awarded to Sparton in Spring 2004 with delivery to be completed by March 2006.

Specifications
Dimensions: 'A' size (91.44 × 12.4 cm diameter)
Weight: 11.8 kg
Acoustic frequency: 10 - 2,400 Hz (DIFAR and omni)
Transmitter frequency: 136 - 173.5 MHz
RF channels: 96 selectable (136 to 173.5 MHz)
RF power: 1 W (minimum)
Transmitter frequency stability: ±25 kHz
Frequency modulation: 0 - 105 kHz deviation
Operating depth: 60, 150 or 300 m
Operating life: 0.5, 1, 2, 4 or 8 h (selectable)
Launch altitude: up to 9,144 m
Launch speed: up to 370 kt

Contractors
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada
Sparton Corporation, Electronics Division,, DeLeon Springs, Florida, US.

UPDATED

AN/SSQ-110B

Type
Active sonobuoy.

Description
Similar to the Signal Underwater Sound (SUS) device, the AN/SSQ-110B is an aircraft launched, expendable impulsive acoustic source device for extended echo ranging multistatic active area search operations and initial localisation in shallow water.

The buoy consists of an upper control buoy similar to the upper unit of the AN/SSQ-62 buoy, and a lower section comprising two multipoint initiation explosive payloads. Each payload can be remotely activated at one of three depth settings (shallow, medium or deep), as commanded by the deploying platform using EFS. The arming and firing of each payload is electronically controlled.

The buoy is used in conjunction with appropriate passive receiver sonobuoys.

Operational status
Fully developed.

Specifications
Weight: 16.4 kg
Transmitter frequency: 136-173.5 MHz
RF power: 0.5 W (min)
Transmission channels: 99 (selectable)
RF Command receiver: 291.4 MHz UHF signal channel
Operating life: 6 h

Contractors
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada.
UnderSea Sensor Systems Inc
Columbia City, Indiana, USA.

VERIFIED

Russian Federation

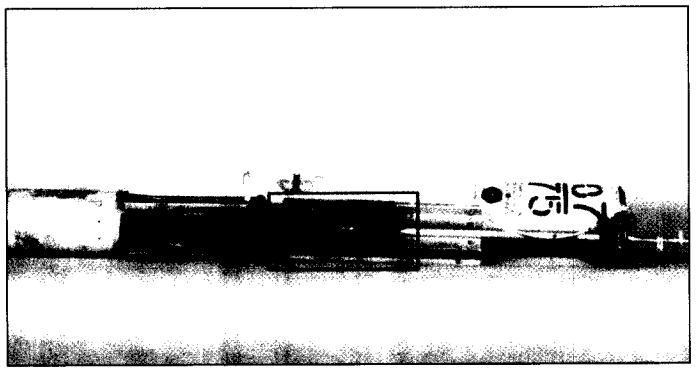
Sonobuoys

Description
Virtually no information on former Soviet sonobuoys had ever been made public until the US Department of Defense released the photograph shown here and published it in *Soviet Military Power*. Early sonobuoys were the RGB-56/64, the latter being a smaller version of the former. In the late 1960s, a passive omnidirectional buoy, the BM-1, was produced. It apparently has a 29 channel FM datalink at about 171 MHz.

The buoy shown here is the Type 75 which is similar to the US AN/SSQ-41B Lofar sonobuoy, although somewhat larger.

Other types of buoy known to exist are designated RGB-1 omnidirectional passive and RGB-2 passive directional sonobuoys which are deployed from Il 38 May and Tu 95/142 Bear aircraft, the RGB-3 a large active/passive buoy, the RGB-16 deployed from the Il 38 May, and the RGB-N and RGB-NM deployed from the Mi 14 Haze and Ka 27/28 Helix.

UPDATED



Type 75 Lofar sonobuoy (Soviet Military Power)

United Kingdom

SSQ-906G Lofar

Type
Omni-directional passive sonobuoy.

Description
This high performance buoy is designed for multistatic surveillance operations in the littoral in a high noise environment and for deep water operation. It combines a new high-performance omni-directional sensor with the proven in-buoy digital electronics of the SSQ 955 HIDAR buoy. This combination takes maximum advantage of digital signal processing to offer a buoy that outputs distortion free acoustic data across a high dynamic range with high linearity across an extended acoustic spectrum.

The 'G' size wideband sonobuoy is designed to be launched from aircraft or helicopters at airspeeds up to 375 kt and at altitudes between 46 and 9,200 m. It can also be hand launched or fired from automatic launchers on ships and boats. Once deployed, the buoy detects and amplifies underwater sounds to modulate the self-contained FM transmitter. The buoy is capable of operating with a range of airborne signal processors.

The buoy features an exceptionally low-frequency acoustic performance (10 Hz to 20 kHz), which results in a significant improvement in operational performance over previous Lofar sonobuoys. The AFS feature provides a fully synthesised and programmable RF channel and life and depth settings, with all selections being carried out simply and manually prior to release. A digital RF link and GPS is available as an option, while a Coastal Surveillance buoy with low salinity and shallow hydrophone depth settings of ice edge or estuarine operations is also available as an option. This variant is able to operate in all salinity conditions ranging from fresh water to 3.6 per cent salinity by weight.

After launch a parachute is deployed to slow down the rate of descent to around 30 m/sec. On impact with the sea the parachute is jettisoned and a surface float is deployed containing the VHF transmitter and antenna for acoustic data telemetry. As the sonobuoy canister descends to the preset depth it streams the lower unit and suspension system; thereafter the canister is discarded.

Omni-directional acoustic sensor signals are transmitted to an airborne or ship-based acoustic processor for passive detection of narrowband, broadband and transient submarine acoustic emissions. The buoy is also able to detect LF active emissions and echoes in a multistatic or active adjunct role.

Operational status
In service with the Royal Navy, Royal Air Force.

Specifications
Length: 419.1 mm
Diameter: 123.8 mm
Weight: 6.8 kg
Acoustic frequency range: 10 Hz to 20 kHz
Operating life: 1 to 7 h in 1 h increments
Operating depth: selectable for either 30, 140 or 300 m
RF channels: 99 (136 to 173.5 MHz at 375 kHz spacing)
RF output: 1 W (min)
Sensitivity: 25 kHz deviation @ 116 dB ± 2 dB re 1μPascal @ 100 Hz

Contractor
Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

UPDATED

SSQ-926 ALFEA

Type
Active Low-Frequency Electro-Acoustic (ALFEA) sonobuoy.

Development
The SSQ-926 ALFEA has been developed by Ultra Electronics under a project definition study to meet the SR (SA) 903 requirement for an Active Search Sonobuoy System (ASSS) for the UK MoD.

The 'A' size buoy was developed to provide an area search capability offering high-probability detection against conventional and nuclear submarines in both deep and littoral waters. The buoy is designed for multistatic active search system integrating data from up to three types of buoy (HIDAR, Barra and ALFEA) and possibly type Sonar 2087 sonar, all data being processed by the AQS-970 processor. All buoys will be fitted with GPS.

Description
ALFEA is a high-power, active low-frequency (1 to 2 kHz) electro-acoustic 'A' size buoy for use in multistatic operations. It incorporates a UHF Command Function Select (CFS) to control its operation after launch. Other features of ALFEA include multiple pings in programmable waveform types, commandable depth capability, autonomous/electronic function select and GPS.

Operational status
Development completed. There is an option to provide an ASSS capability for the Nimrod MRA4 in service date contracted for March 2005.

Specifications
Length: 914.4 mm
Diameter: 123.8 mm
Weight: 17.7 kg
Operating depth: 4 selectable depths
RF Channels: 99
Operating life: 7 h
RF power: 1 or 5 W

Contractor
Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

UPDATED

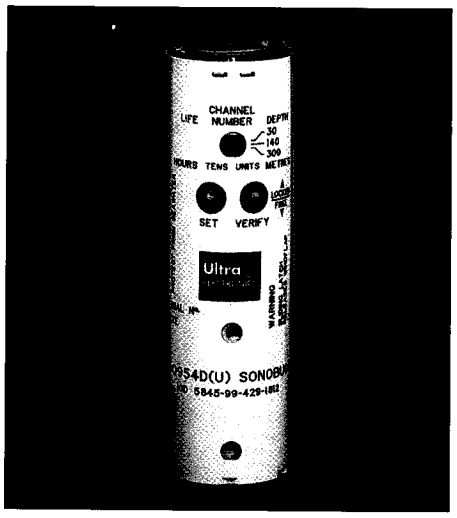
SSQ-954C/E DIFAR

Type
Miniature passive directional sonobuoy.

Description
The SSQ-954C/E DIFAR (Directional Frequency Analysis Recording) 'G' size sonobuoy is a fully automatic directional passive acoustic sensor which has been developed to meet specific ASW operational requirements of the Royal Navy and Royal Air Force.

The SSQ-954C/E can be launched from either rotary- or fixed-wing aircraft, using standard sonobuoy launch systems at speeds of between 40 and 300 kt and altitudes of between 30 and 9,200 m. After launch, a parachute is automatically deployed to slow descent rate to approximately 30 m/s to stabilise the buoy's trajectory. On entering the water the parachute is jettisoned and separation is achieved. The surface unit float is automatically inflated to deploy the RF antenna while the hydrophone assembly descends to its preselected operating depth.

The sonobuoy employs a high-performance DIFAR hydrophone system. Acoustic signals received by the omni and directional hydrophones (sine and cosine signals) are multiplexed, together with azimuth bearing reference data, onto the VHF carrier as a frequency modulated signal for transmission to the aircraft. The sensor is a high sensitivity 88.9 mm hydrophone assembly with inherently low flow noise susceptibility and channel cross-talk. At the end of its selected life, the unit automatically scuttles.



The SSQ-954C/E DIFAR sonobuoy
0006974

The SSQ-954C/E includes a microprocessor-controlled Autonomous Function Selection (AFS) system to select, set and verify electronically the fully synthesised and programmable VHF RF channel and its operating life and depth.

Operational status
No longer in production or being marketed. In service with the Royal Navy, Royal Air Force and the French Navy and is qualified for use by both the US and Canadian services.

Specifications
Length: 419 mm
Diameter: 123.8 mm
Weight: 6.8 kg
Acoustic frequency range: 5 Hz to 2.4 kHz
Operating life: 1, 2, 3, 4, 5 or 6 h (selectable) (375 kHz spacing)
Operating depth: 30, 140 or 300 m (selectable)
RF channels: 99
Sensitivity: Directional: ± 40 kHz peak in 100 Hz field @ 122 dB ± 3 dB/1 µPa/100 Hz
Omnidirectional: ± 25 kHz peak in 100 Hz field @ 122 dB ± 3 dB/1 µPa
RF output: 1 W (min)
Frequency: 136-173.5 MHz (synthesised and programmable)

Contractor
Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

UPDATED

SSQ-955A/C HIDAR

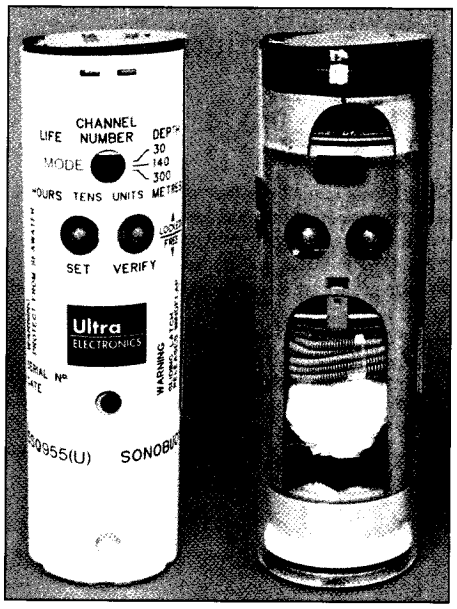
Type
Dual mode directional passive sonobuoy.

Development
In 1996 Ultra Electronics carried out trials with a digital buoy (HIDAR) to test the efficacy of digital telemetry. The object was to develop a buoy that would offer improved dynamic range and linearity performance in littoral waters where there is a high level of ambient noise. The aim was to overcome the problems of targets being masked and intermodulations that could generate false frequencies and bearing errors. This would allow the buoy to operate effectively when deployed close to a task group or near to other shipping in coastal waters. The buoy has been developed for littoral and multistatic use.

Description
The SSQ-955 HIDAR (High Instantaneous Dynamic Range) 'G' size DIFAR buoy is fully compatible with existing VHF FM receivers, DIFAR multiplexer and processors. It combines the highest performance DIFAR acoustic sensor available with an all-digital electronics design.

The VHF telemetry is selectable between digital (coherent GMSK) and standard DIFAR FM analogue formats via Autonomous Function Selection (AFS). Direct digital synthesis of the RF carrier modulation provides distortion-free data transmission to the aircraft in both telemetry modes. The high dynamic range with greatly improved signal/noise ratio and linearity allows operation in high ambient noise, such as areas where there is a high density of shipping or high sea states, and as an LF active receiver. Systematic bearing accuracy and channel matching are improved compared with conventional analogue DIFAR buoys. Sensitivity calibration of the omni and directional channels is independent of RF channel, and automatic depth-sensitive omni calibration is available as an option. The SSQ-955B is fitted with GPS while the SSQ-955A features a calibrated hydrophone.

There is a choice of six operating periods and three hydrophone depths, all selectable via the AFS. The buoy can be deployed at air speeds between 50 and 300 kt at altitudes between 55 and 9,200 m.



Type SSQ-955 HIDAR
(Ultra Electronics)
0064340

Omni and directional acoustic signals are transmitted to an airborne processor for passive detection and localisation of narrowband, broadband and transient submarine acoustic emissions. HIDAR can also be used in a multistatic or active adjunct role for detection and localisation of LF active echoes.

In HIDAR operation mode, digitised sensor signals are transmitted with 14-bit precision using a frame format compatible with the SSQ-981 Barra buoy, providing acoustic data which is mainly free of distortion. RF spectrum shaping allows buoys to be operated on adjacent RF channels. The digitally synthesised standard mode is fully compatible with existing DIFAR processors but offers all the advantages of in-buoy digital processing.

Operational status
The UK MoD has ordered in excess of 100,000 SSQ-955 HIDAR buoys, with production commencing in October/November 1999 and deliveries beginning in 2000 and stretching over five years. The buoy is currently in service aboard UK Nimrod, Merlin and Sea King aircraft and has also been ordered by France and Poland.

Specifications
Length: 419.1 mm
Diameter: 123.8 mm
Weight: 6.8 kg
Acoustic frequency range (HIDAR mode):
5 Hz to 2.074 kHz (directional sonics telemetry)
5 Hz to 1.87 kHz (unaliased directional sonics)
up to 4 kHz (extended omni)
Acoustic frequency range (standard mode):
5 Hz to 3.375 kHz (telemetry)
5 Hz to 2.9 kHz (full specification)
5 Hz to 2.4 kHz (improved bearing accuracy)
Operating life: 1, 2, 3, 4, 5 or 6 h
Operating depth: 30, 140 or 300 m
RF channels: 99
RF output: 1.25 W

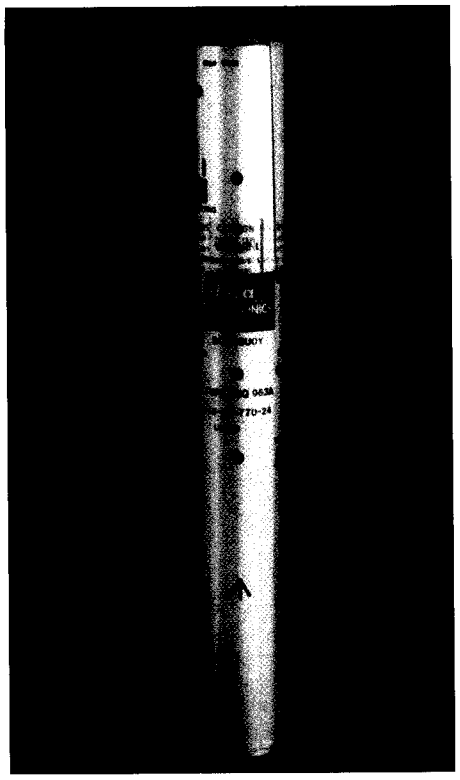
Contractor
Ultra Electronics Sonar and Communication Systems, Greenford. ***UPDATED***

SSQ-963C/D CAMBS

Type
Command active multibeam sonobuoy.

Description
The SSQ-963D Command Activated MultiBeam Sonobuoy (CAMBS) is an 'A' size sonobuoy which was originally developed in 1997 by Ultra Electronics under contract to the UK Ministry of Defence. The SSQ-963D offers further significant operational enhancements over previous variants including a unique stave structured array for greatly improved performance in littoral waters and a higher source level.

CAMBS is an advanced active directional sonobuoy which features a high data rate, and directional information which is obtained by the use of an omnidirectional transmitting acoustic projector combined with a directional receiving hydrophone array. The buoy can be deployed from between 55 to 3,000 m altitude at air speeds between 50 and 300 kt. On deployment from the aircraft, a parachute controls the rate of descent. On impact with the sea, the parachute is automatically jettisoned and a combined float and antenna system is erected. Simultaneously the sub-surface unit descends to one of three preselected depths. Hydrophone depth is adjustable by radio command and there is a 99 channel radio telemetry link



SSQ-963C CAMBS sonobuoy

operating on standard NATO frequencies for communication with the parent aircraft. The antenna is a monopole with ground plane, erected by and integral with the buoy flotation bag. The design incorporates a flux-gate compass with very rapid stabilisation.

While in the passive mode, the buoy relays all signals detected by the receive array hydrophones together with magnetic compass information to the controlling platform via the telemetry link. In the active mode acoustic pulses are emitted from the high-power omnidirectional projectors and the returned echoes are detected by the receive array and, along with compass information, are amplified and fed to a multiplexer. There they are combined to provide a FM multiplexed signal which is transmitted to the airborne platform where it is processed to derive a 'fix' of detected targets.

The power output of the transmitter is 0.5 W and this is fed to the antenna whose radiation pattern is omnidirectional in the horizontal plane with a single lobe typically between 5 and 25° in the vertical plane. The buoy has recently been given a major technology upgrade with the inclusion of new digital and analogue electronics, which have led to improved performance. Included in the improved performance features is an increased rate of descent in water, with an indication to the ASW operator in the airborne platform that the buoy is ready for use at maximum power. ECCM performance has also been improved.

The SSQ-963C includes an Autonomous Function Selection (AFS) system to preset, before launch from the aircraft, the fully synthesised and programmable RF channel and initial depth settings.

Operational status

In production. The SSQ-963C sonobuoy is part of the equipment developed for the Mk II version of the Nimrod ASW aircraft. Ultra was awarded a contract to develop and manufacture the 963D in 2001. The sonobuoys began to enter service with RAF and RN in 2004.

Specifications

SSQ-963C
Length: 914.1 mm
Diameter: 123.8 mm
Weight: 13.2 kg
RF channels: 99
RF output: 0.5 W (min)
Frequency: 136-173.4 MHz (pre-selectable with AFS)
Operating life: 1 h, automatic or command scuttle
Operating depth: 4 selectable depths
Launch altitude: 55-3,000 m
Launch speed: 50-300 kt

Contractor

Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

UPDATED

SSQ-981E Barra

Type

Passive broadband directional sonobuoy.

Description

The SSQ-981E represents a further evolution of the SSQ-981A Barra sonobuoy currently operational with the UK services. The buoy provides broadband passive detection and tracking and narrowband analysis and offers multistatic active reception from <1 kHz to >4 kHz. It features 25 hydrophones mounted on five extending telescopic arms and arranged over a large acoustic horizontal planar array to achieve enhanced detection over conventional buoys. Spectral and broadband energy is digitally telemetered to the ASW aircraft. A Barra-compatible acoustic processor forms 60 beams providing 360° cover to give excellent signal-to-noise discrimination, resulting in good azimuth resolution and extremely accurate contact bearings. Performance is optimised by using a fully digital programmable architecture, from 16-bit sampling of each hydrophone via digital signal processing to digitally synthesised phase-coherent continuous phase FSK or Gaussian Minimum Shift Key (GMSK) telemetry. Adaptive in-buoy processing optimises acoustic signal-to-noise ratio and ensures reliable processor lock under all acoustic conditions. Phase-shading of hydrophone signals optimises DI and bearing accuracy at low frequencies for improved narrowband tracking.

The SSQ-981E is configured as a conventional 'A' size sonobuoy which may be launched from helicopter or fixed-wing aircraft using existing stowage and launching systems. The rate of descent is controlled by parachute to approximately 30 m/sec. This ensures the buoy enters the water nose first, whereupon the parachute is discarded. It operates with an Autonomous Function Selection (AFS) microprocessor system to preset any one of the 50 RF channels and its operating life and depth settings.

Immediately on entering the water the upper unit containing the float, VHF transmitter and antenna system returns to the surface and commences operation. Simultaneously the lower unit descends to one of two preset depths and deploys the acoustic array and begins to operate in the passive directional mode.

All new sonobuoys are manufactured for, but not with, GPS.

Operational status

First production deliveries to the UK MoD commenced in 1998.

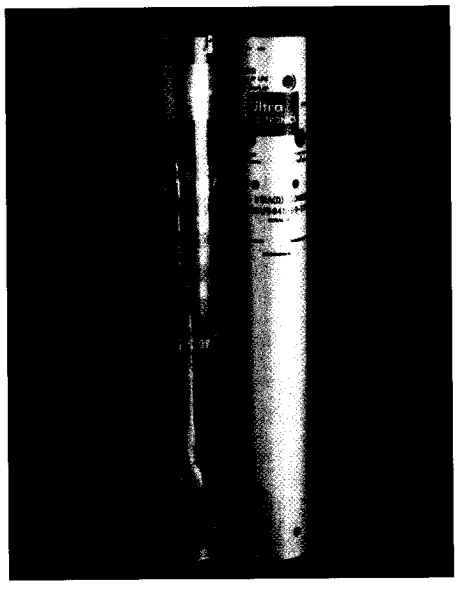
Specifications

Length: 914.1 mm
Diameter: 123.8 mm
Weight: 9.1 kg
Operating life: 1, 2, 3 or 4 h (selectable with AFS)
Operating depth: 22, 60 or 120 m (selectable with AFS)
RF channels: 99 (136 MHz to 173.5 MHz with 375 kHz spacing
RF output: 1 W (min)
Channel separation: 750 kHz
Acoustic frequency range: 10 Hz to 2.0 kHz plus any 400 Hz band within 10 Hz to 4.5 kHz
Transmission: Narrow Band Frequency Shift Keyed (NBFSK) modulation.

Contractor

Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

UPDATED



SSQ-981 Barra sonobuoy

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

United States

AN/SSQ-41B

Type
Passive omni-directional sonobuoy.

Description
The AN/SSQ-41B is an omni-directional, 'A' size passive sonobuoy with a multiple life and depth capability. In volume production since 1963, the series has been the mainstay of US Navy sonobuoy operations but is gradually being replaced by the newer directional AN/SSQ-53B.

The AN/SSQ-41B, extensively redesigned from the earlier AN/SSQ-41, provides an audio bandwidth expanded to 20 kHz and improved dynamic range capabilities. The depth selection is 60 or 1,000 ft and operating life selection is 1, 3 or 8 hours.

The AN/SSQ-41B may be launched from aircraft at airspeeds up to 370 kt and from altitudes up to 9,000 m.

After a controlled and stabilised descent and upon impact with the water, the subsurface unit and the hydrophone are released and descend to a preselected operating depth of either 20 or 300 m. On contact with seawater, the battery is activated and the sonobuoy becomes fully operational within 60 seconds at shallow depth and 100 seconds at deep depth.

Modulation is accomplished in the crystal oscillator stage by a variable capacity diode. Two frequency doubling amplifiers multiply the RF oscillator-doubler frequency to the desired operating frequency of the sonobuoy, which is pre-set at time of manufacture to one of 31 VHF channel frequencies within the 162.25 to 173.50 MHz band. Available in both standard and low noise versions.

Operational status
Although large-scale production was contracted until 1982, the US Navy has discontinued further development. This unit will continue to be available. Over 500,000 units have been manufactured over the last 20 years. Remains in service with maritime air units of Taiwan.

Specifications
Length: 914.4 mm
Diameter: 123.8 mm
Weight: 9 kg
Acoustic frequency: 10 Hz-20 kHz
Transmitter frequency: 162.250-173.5 MHz (31 × VHF channels) or 136-173.5 MHz (91 channels)
RF channels: 31
RF power: 1 W
Operating depth: 20 and 300 m
Operating life: 1, 3 or 8 h
Launch altitude: 0-9,000 m
Launch speed: 30-370 kt

Contractor
Sparton Corporation, Electronics Division, DeLeon Springs, Florida.

UPDATED

AN/SSQ-41N

Type
Passive omnidirectional sonobuoy.

Description
The AN/SSQ-41N sonobuoy is an omnidirectional, passive buoy modified from the AN/SSQ-41B and with a multiple life and dual-depth capability specifically designed for low-frequency, low-noise operation. The buoy differs from the 41B model in various parameters, for example operating depth (just two selectable depths rather than multiple depth selectivity). It has been specifically designed to operate from 5 Hz to 2.4 kHz.

Upon launching, a parachute deploys to slow down descent and provide stability. After entering the water a seawater battery activates the electronics and initiates deployment of the hydrophone system to its preselected operating depth. Buoyancy for the transmitter electronic assembly is provided by a CO_2 gas filled urethane float. The sonobuoy becomes fully operational within 60 seconds of entering the water at the shallow operating depth, and after 100 seconds at the deeper operating depth.

Modulation is accomplished in the crystal oscillator stage by a variable capacity diode. Two frequency doubling amplifiers multiply the RF oscillator-doubler frequency to the desired operating frequency of the sonobuoy, which is preset at time of manufacture to one of 31 VHF channels within the 162.25 to 173.50 MHz band.

The buoy can be supplied with different operating depths and a variety of attenuated source levels for special applications.

Specifications
Dimensions: 'A' size (91.4 × 12.4 cm diameter)
Weight: 9 kg
Acoustic frequency: 5 Hz-2.4 kHz
RF channels: 31
RF power: 1 W
Operating depth: typically 20 or 120 m
Operating life: 1, 3 or 8 h
Launch altitude: 12.2-15.2 m (in hover attitude), 30.5-9,000 m @ 45-370 kt
Launch speed: hover or 45-370 kt

Contractor
Sparton Corporation, Electronics Division, DeLeon Springs, Florida.

VERIFIED

AN/SSQ-57B

Type
Passive intelligence gathering sonobuoy.

Description
The AN/SSQ-57B 'A' size buoy is a passive, calibrated sound reference sonobuoy which features a hydrophone that affords exceptional performance stability under temperature and pressure extremes. The hydrophone is a piezoelectric ceramic segmented cylinder with a smooth frequency response to 40 kHz. The sonobuoy is calibrated to allow determination of underwater acoustic sound pressure levels over this wide frequency range.

The AN/SSQ-57B can be air-launched from altitudes between 100 and 30,000 ft (30 and 9,000 m) into sea conditions of up to Sea State 5 and is effective at ranges up to 10 n miles.

On launching, a parachute deploys to provide descent retardation and stability. Immediately after entering the water the seawater-activated battery system is energised to activate the electronics and initiate deployment of the hydrophone system to its preselected operating depth. CO_2 gas filled cylinders inflate the sonobuoy float, jettisoning the parachute assembly and erecting the VHF transmitting antenna. This permits the surface assembly to rise and separate from the sonobuoy housing. The sonobuoy housing serves as a descent vehicle and separates from the subsurface assembly at the operating depth.

Operating life is 1, 3 or 8 hours, selected before launch. At the end of the operating life, the transmitter is shut off and the buoy scuttles itself using an electronic timing circuit to activate a burn device in the tip of the float.

The buoy can be provided with a 99 RF channel capability with EFS.

The AN/SSQ-57A (XN-5) is a version of the AN/SSQ-57A that has a fixed operating depth of 1,000 ft (305 m) and is available in both standard and low-noise versions.

Operational status
The AN/SSQ-57A is in limited production. The AN/SSQ-57B is in widespread operational use in the US Navy and a number of other navies.

Specifications
Length: 914.4 mm
Diameter: 123.8 mm
Weight: 9 kg
Acoustic frequency: 5 Hz-40 kHz
RF channels: 31
RF power: 1 W
Operating depth: 20 or 90 m
Operating life: 1, 3 or 6 h
Launch altitude: 30-12,200 m
Launch speed: 45-370 kt

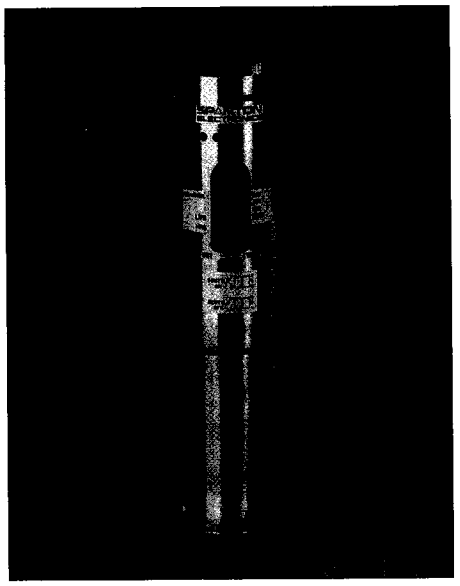
Contractors
Sparton Corporation, Electronics Division, DeLeon Springs, Florida.
Undersea Systems Inc (an Ultra Electronics company), Fort Wayne, Indiana.

UPDATED

AN/SSQ-57M

Type
Shallow water, moored, passive sensor buoy.

Description
The AN/SSQ-57M is a two-thirds 'A' size, air-deployable, low-cost long-life, moored, passive omnidirectional (Jezebel) sensor buoy. The LOFAR expendable omnidirectional passive buoy is designed to detect surface and subsurface targets in shallow water. After launch from aircraft, or ship, the buoy relays, by FM VHF radio transmission, in the audio frequency range, acoustic signals initially received by the ominidirectional hydrophone system.



AN/SSQ-57M sonobuoy

The buoy comprises an omnidirectional hydrophone that descends through the bottom of the sonobuoy canister to a preselected depth. Operating on one of 31 RF channels preset during manufacture the buoy can also be fitted with a 99 RF channel capability.

The AN/SSQ-57M features the same Sparton-designed hydrophones as used in the AN/SSQ-57 buoy and has similar acoustic performance characteristics. It has a mooring capability similar to the AN/SSQ-58 moored buoy.

The buoy can be launched at altitudes between 12 to 15 m from a stationary ship or between 30.5 to 9,144 m altitude at speeds between 45 and 370 kt. Water entry is facilitated by a parachute. The hydrophone and mooring system are released on water entry. Buoyancy is obtained from a CO_2 gas inflation system. The buoy can operate in surface currents up to 2 kt and in up to Sea State 5.

A saltwater battery provides 12 hours of operation. The buoy is capable of being anchored in water depths from 25 to 120 m in salinity down to zero per cent. Hydrophone depths are 15, 30 or 60 m. Operating life is 1, 4 or 12 hours. Scuttle is automatic at the end of the selected life period, or may be overridden, depending on circumstances. An Electronic Function Selector (EFS) provides prelaunch selection for the RF channel, operating life, hydrophone depth, and scuttle on/off.

The frequency range, hydrophone operating depth, attenuated sensitivity level and operating life of the buoy can be modified by Sparton, according to customers requirements. System calibration data to allow measurement of underwater acoustic sound pressure levels for special applications can also be supplied.

Operational status
Available for the US and other navies. Currently being used by the Swedish Navy for shallow water, coastal deployment.

Specifications
Dimensions: ⅔ 'A' size (61 × 12.4 cm diameter)
Weight: 9.3 kg
Acoustic frequency: 4 Hz-20 kHz
Sensitivity: 116 ±3 dB/µPa= ±25 kHz deviation
RF channels: 99 selectable
RF power output: 1 W
Operating depth
Hydrophone: 15, 30 or 60 m
Anchoring: 25-120 m
Operating life: 1, 4 or 12 h
Launch altitude: 12-15 m (in hover altitude), 30.5-9,000 m
Launch speed: 0 kt and 45-370 kt

Contractor
Sparton Corporation, Electronics Division, DeLeon Springs, Florida.

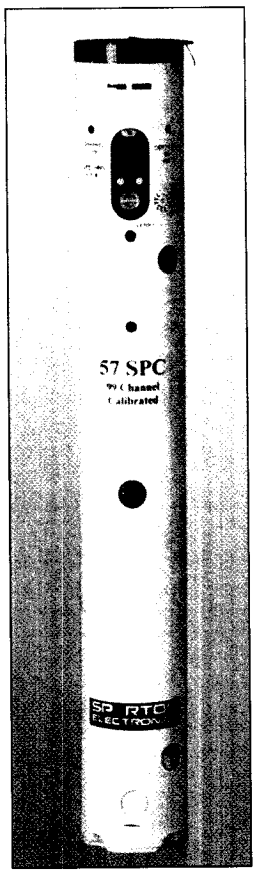
VERIFIED

AN/SSQ-57SPC

Type
Passive, omnidirectional sonobuoy.

Description
The AN/SSQ-57SPC passive directional sonobuoy is the latest version of the SSQ-57 that has been in service for over 25 years. The buoy has been updated to both a 31 and a 99-channel version. Both versions allow channel selection via an electronic function selector. The buoy is factory calibrated to allow operation over its entire frequency range. The unit's VHF transmitter is rated at 1 W.

The buoy can be air launched across the same envelope as the previous SSQ-57 buoys and can also be deployed from the deck of a research vessel.



The AN/SSQ-57SPC sonobuoy
(Sparton Corporation)
0043262

The unit is powered by a seawater battery which is activated when the buoy enters the water. Operating life is selectable at either 1, 3 or 8 hours with an automatic scuttle at the end of 8 hours. Other optional life setting selections are available within the 8-hour period.

Using the electronic function selector the buoy can be set to operate at one of two operating depths (either 60 or 400 ft) selected before launch. Other optional depth suites are available, with up to three depth choices in a suite.

The buoy is also available with an optional command function selector which allows the operator to command the unit to change VHF frequencies, to change to a longer life than originally set, and to toggle the RF on and off to conserve life. Command function selection commands are detected via a 291.4 MHz UHF receiver.

The buoy can also be modified for special application to include fixed calibrated attenuators up to a maximum of 80 dB.

Operational status
In service with Australian armed forces.

Specifications
Dimensions: 'A' size (91.4 × 12.4 cm diameter)
Weight: 10 kg
Acoustic frequency: 5 Hz-20 kHz
RF channels: 31 or 99
RF power: 1 W
Operating depth: 18-122 m
Operating life: 1, 3 or 8 h
Launch altitude: 12-15 m (in hover altitude), 30.5-9,000 m
Launch speed: 45-370 kt

Contractor
Sparton Corporation, Electronics Division, DeLeon Springs, Florida. ***VERIFIED***

AN/SSQ-58B moored sensor

Type
Passive/active sensor buoy.

Description
Sparton Electronics has developed the lightweight moored sensor buoy, a multipurpose building-block system for at sea measurements. Two separate versions of the buoy are available: a passive system for harbour surveillance, and an active system for use in test ranges and so on. Other applications of the buoy include a variety of oceanographic and environmental requirements. The buoy is retrievable and reusable and can also be configured in a free-floating version. Powered by commercially available rechargeable batteries, or extended life alternative power sources, it has a long operational life. It is available with 31 VHF FM transmitter (AN/SSQ-58A model) selectable frequency channels and is compatible with all sonobuoy receivers and processors.

The buoy consists of: a high density foam float, from which is suspended its mooring and hydrophone array; a suspended hydrophone assembly; sonobuoy electronics package integrated with a 31 channel radio transmitter; ruggedised radio antenna; radar reflector; and navigation warning light that can be switched on or off, depending on the tactical situation. It is normally deployed from a small vessel, usually in depths of approximately 12 to 35 m. A deep mooring version is also available. A VHF antenna and a radar reflector are mounted on top of the float.

Operational status
Available for the US and other navies.

Specifications
Acoustic frequency: 50 Hz-10 kHz
Operating life: 100 h (between battery recharging)
Operating depth: 7-180 m
Dimensions of float: 1.07 m (diameter) × 20 cm (deep)
RF channels: 31
RF power: 1 W

Contractor
Sparton Corporation, Electronics Division, DeLeon Springs, Florida. ***VERIFIED***

AN/SSQ-101 ADAR

Type
Passive sonobuoy.

Description
The AN/SSQ-101 ADAR 'A' size sonobuoy has been developed through a joint venture. It is the first sonobuoy to be specifically designed as an active source receiver for multistatic operations in shallow water.

The buoy features a high-gain multibeam horizontal planar array that incorporates in-buoy processing and a digital uplink to achieve optimum performance in the littoral.

Operational status
Fully developed. Erapsco of Columbia City, US, was awarded a contract for the supply of 2,479 AN/SSQ-101 sonobuoys in May 2003.

Contractor
Undersea Sensor Systems Inc, Columbia City, Indiana.

UPDATED

AIRBORNE ACOUSTIC PROCESSING AND RECEIVING SYSTEMS

Canada

AN/UYS-504

Type
Sonobuoy acoustic processing system.

Description
The AN/UYS-504 was developed from the long line of previous AN/UYS-503 acoustic processing systems, including the AQS-970 and the AN/UYS-503. It employs an architecture based on high density COTS hardware that allows for future technology insertions to prevent obsolescence. Using standard commercial and military interfaces, Operator Machine Interfaces (OMI) and operating systems, the AN/UYS-504 provides processing for all types of sonobuoys, both analogue and digital, with growth capability for future sonobuoys.

The system design enables the AN/UYS-504 to remain ahead of the ever-changing threat in order to meet the detection, localisation and attack challenges posed by new-generation nuclear and diesel submarines operating in shallow and littoral waters. It functions as a complete system by providing all of the required input signal conditioning, signal processing and analysis, post-detection processing, control and display processing and includes a removable disk that allows the full mission to be digitally recorded for replay into a ground base Fast Time Analysis System (FTAS).

The system is designed for both the MPA environment, which features concurrent processing of 16, 32 or 64 sonobuoys of any type, and the ASW helicopter environment featuring the processing of 8 or 16 sonobuoys in a more rugged and conduction cooled format. Among the major features and capabilities of this acoustic processing system are:

- Interfaces for data management system, sonobuoy receivers and UHF/HF transmitter
- Colour spectral analysis
- Command function select
- Full suite of multistatics active sources
- Wideband coverage for active intercept
- Passive/active energy maps overlaid on geographic display
- Auto diesel detection aids
- Embedded AQQ-T502 for both passive and active (including multistatics) training

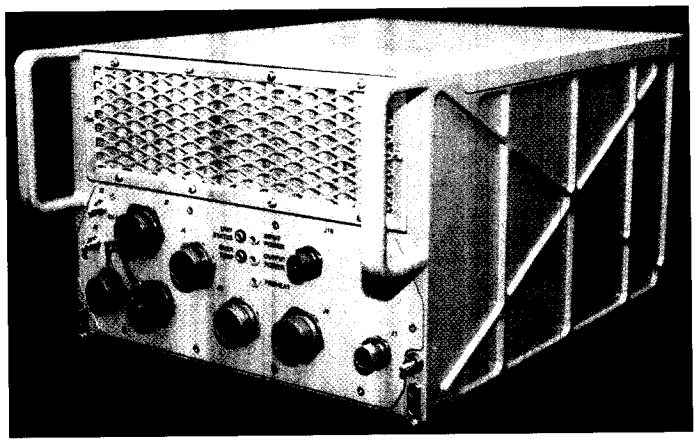
The system incorporates two enclosures - the VME Acoustic Signal Processor (VASP) and the Dual Hard Disk Drive (DHDD).

Operational status

AN/UYS-504	(MVASP) Currently in production for the Canadian CP-140 Aurora fleet.
AQS-971	Operational on the UK Nimrod MR2 fleet.
AQS-970	Delivered to UK for installation on the MRA4 Nimrod replacement.

Contractor
General Dynamics Canada, Maritime Systems, Ottawa, Ontario.

UPDATED



AN/UYS-504 acoustic processor (General Dynamics Canada) ***NEW***/0583220

FTAS

Type
Post mission fast time acoustic analysis system.

Description
General Dynamics Canada's FTAS (Fast Time Analysis System) product allows for fast-time and real-time Post Flight Analysis (PFA) of recorded sonobuoy information from all ASW platforms. FTAS is capable of performing spectral analysis of recorded acoustic data for the purposes of target identification, classification and characterisation, mission reconstruction, mission debriefing, crew training and maintenance of intelligence databases.

Second line analysis is a time-critical function that directly supports acoustic operations through the collection of tactical acoustic intelligence (ACINT) and the rapid turnaround of that information to ASW platforms engaged in current operations.

FTAS can be used to provide confirmation of target detection, assess operator contact time with the target and perform detailed analysis of each acoustic mission. The information can then be used to assist post mission tactical analysis, post flight communications and command level decision-making. Acoustic signatures obtained during the contact analysis can be archived to support ACINT activities on a local or national basis. Hard-copy and soft-copy outputs of the acoustic signatures can be used for the short-term production of ACINT data to support operations.

FTAS allows for acoustic mission reconstruction of large-scale exercises while providing flexibility for in-depth real-time analysis required by higher levels of intelligence gathering. The FTAS also provides the capability for supporting the production, long-term archiving and publishing of hard-copy and soft-copy ACINT data.

FTAS is designed to operate from fixed on-shore sites, deployed sites and onboard ships. Data can be input from either analogue or digitally recorded data of all in-service fleet active and passive sonobuoys. The addition of new sensors is provided by simple software upgrades. FTAS can provide processing for up to 64 sonobuoys concurrently.

Operational Status

FTAS	Currently in production for the Canadian CP-140 Aurora fleet PFA mission support centres. Currently in production for the Canadian Acoustic Data Analysis Center (ADAC).
FTAAS	Operational in support of the Australian AP-3C at RAAF Edinburgh.

Contractor
General Dynamics Canada, Maritime Systems, Ottawa, Ontario.

NEW ENTRY

MVASP

Type
Acoustic processor.

Description
The MVASP (Modular VME Acoustic Signal Processor) is currently being manufactured to replace the OL-5004/AYS processor on the Canadian CP140 Aurora maritime patrol aircraft. The MVASP will provide 16 acoustic channels with the capability of being expanded to 32 channels and even possibly 64.

Operational status
No longer being marketed. There have been 27 MVASP ordered and 16 CP-140 Aurora will be upgraded with MVASP which incorporates the AQQ-T-502 stimulator.

Contractor
General Dynamics Canada, Maritime Systems, Ottawa, Ontario.

UPDATED

France

ASRC

Type
Active sonobuoy remote-control equipment.

Description
ASRC is a ½ ATR processing Line Replacement Unit (LRU) providing active buoy control signals. The unit is controlled through a serial datalink (RS-422) by a PC or a host computer. This datalink continuously provides system configuration and sonar emission triggering messages. Buoys to be controlled are selected through their VHF channel and the system provides remote control of active directional buoys (DICASS SSQ 62 type) for depth and scuttle process; and remote control (DICASS SSQ 62) with single tone pulse emission (short, medium or long pulses) or FM pulse emission (up or down linear modulation). Pulse repetition may be either automatic (8, 16, or 32 seconds) or manual.

The ASRC can independently control eight buoys at the same time. A processor unit manages emitted frequency coherence; emission rhythm and buoy power handling coherence; and correct signal multiplexing to feed a UHF emitter.

The unit is connected to an onboard UHF emitter receiving multiplexed control signals.

Contractor
DCN , Paris.

VERIFIED

INCA

Type
Interactive classification aid.

Description
The INCA interactive classification aid is designed to enhance classification, which is the mandatory function of passive detection and the main task of intelligence gathering. INCA therefore can form a major element in the ASW scenario, as indeed does any classification aid, aboard any type of ASW platform (airborne, surface vessel, or submarines).

INCA (INteractive Classification Aid) gathers classification parameters after spectral and/or audio analysis. Spectral analysis is performed on current or stored signals and is immediately displayed. Spectrum analysis capabilities include Lofar, vernier, Demon, Ali, and spectrogram and features an ×8 speed-up in analysis. INCA performs audio analysis in signals using a pass-band filter, variable speed (X4, 2, 1, ½, ¼, ⅛) and normal/reverse, as well as transient analysis.

INCA selects possible sources for any contact by comparison with classification statistical data stored in the database. INCA then helps in building a confidence level for every classification hypothesis. These confidence levels are then sorted to give the likeliest classification hypothesis.

Operational status
System fully developed.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

SADANG

Type
Sonobuoy signal processing and display system.

Description
The two-operator SADANG system is adaptable to all types of ASW aircraft. It is capable of processing Lofar (up to 64 simultaneously), DIFAR, DICASS and Barra sonobuoys. The basic module, which can be fitted on ASW fixed- or rotary-wing aircraft, handles mission tactics and processes sonobuoy data on one console manned by a single operator. Automated functions relieve operators from repetitive tasks, particularly during the search phase. Operators can choose to display sonobuoy detection or classification images.

As a processing system, the SADANG can be integrated with new-generation data management systems, or can operate in a stand-alone mode, handling complex information, including tactical data and fire control.

The SADANG is designed both to accommodate a large number of configurations and to offer a large potential for evolution, which will enable it to process data from advanced digital sensors such as sonobuoy networks and new active arrays. Additionally, a general purpose beamformer has been developed and tested in co-operation with Australian affiliate Thales Underwater Systems.

Using the latest processing technologies, coupled with current graphics displays and data fusion techniques, the systems are designed for the sanitising and survey of both deep and shallow waters. Up to 16 DICASS can be processed simultaneously enabling a typical coverage of about 200 n miles.



SADANG version 1C during sea trials with the French Navy on board an ATL 2 maritime patrol aircraft

Advanced processing covers the full spectrum of noise including narrowband frequency lines, broadband signals, swaths, transients and Demon signals.

The SADANG 2000 offers an improvement in performance using modern, proven technology. This two-operator system features an impressive range of operator aids, including colour-coded software tools for improved classification and data fusion. It also provides lightweight, optimised operations, designed to meet a wide range of threats and tactical situations.

Operational status
The SADANG 2000 version 1C equips 25 French Navy Dassault Atlantique 2 Maritime Patrol Aircraft. SADANG 2000 1C is also operational aboard the three Pakistani Atlantic 1 MPA. The system has also been acquired by the UAE Navy for the CN235 MPA where it operates in conjunction with the HS 312 dipping sonar.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

TMS 2000

Type
Sonobuoy processing system.

Description
The TMS 2000 family of acoustic processors uses sophisticated graphic displays and data fusion techniques to efficiently survey deep, as well as shallow waters. The system is built around COTS hardware and uses proven algorithms developed as part of the SADANG and AQS 900 series of processors. These have been rehosted and enhanced with new colour broadband, data fusion and multistatic processing techniques.

The passive functions of the high-capacity model, performed on up to 64 channels, rely on a number of processors devoted to wideband, swaths and narrowband frequency lines, transients and DEMON signals. Double DEMON processing ensures full coverage of both the carrier noise bandwidth and modulating spectrum to achieve permanent detection of transient cavitation phenomena. The active functions of TMS 2000 can process up to 16 DICASS in monostatic/multistatic mode, as well as new-generation LF projectors like LFAS and LODICASS. Typical coverage provided by the processor is 200 nm². The MMI makes extensive use of the Geographic Energy Plot (GEP) to provide a plot which results from data fusion. This GEP can be superimposed on an acoustic localisation plot (sonobuoy position, coastlines and sea bottoms) enabling the operator to easily fulfil the mission.

Operational status
SADANG and AQS 900 series are in service with various navies. The TMS 2000 is currently available. A 16-channel version has been selected for the French Navy NH 90. TMS 2000 is being proposed for the MPA-R and French Navy Atlantique 2 mid-life upgrade in a 64-channel version. The processor has been ordered by the Spanish Air Force and the UAE Navy.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

United Kingdom

AA34030 sonobuoy command transmitter

Type
Sonobuoy command transmitter.

Description
The AA34030 (a variant of the AD 3400 VHF/UHF transmitter/receiver) is a UHF transmitter developed specifically to function as the sonobuoy command transmitter for the RF downlink of a sonics data processing system, allowing selection of the sonobuoy mode, uplink channel, ping and so on. It has been developed in conjunction with the AQS-903 processing system. The transmitter provides AM or FM analogue or digital communications over the frequency range 282 to 292 MHz with 50 kHz channel spacing throughout the band. This can be reduced to 25 kHz increments if desired.

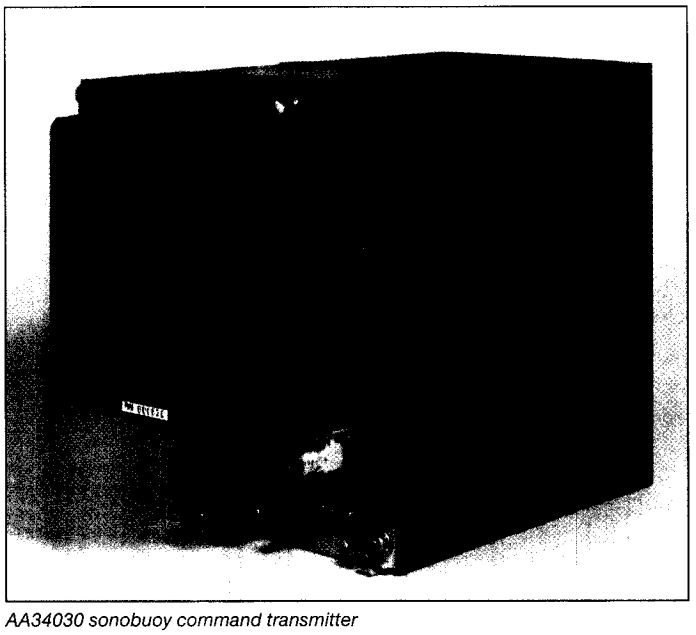
The design of the transmitter is related to the AD3400 multimode VHF/UHF airborne communications transmitter/receiver in using the same 'sliced' modular construction, with five of seven modules making up the transmitter being common to both units. An additional Transmitter Control Interface Module (TCIM) unique to the sonobuoy provides an interface between the AQS 903 acoustic Radio Control Module (RCM) and the sonobuoy.

Operational status
The AA34030 is being installed in the Royal Navy's Merlin helicopter.

Specifications
Frequency range: 282-292 MHz
Channel spacing: 50 kHz
No of channels: 200
Frequency accuracy: 2 ppm
Transmitter power: 50 W FM, 15 W AM
Weight: 6.5 kg

Contractor
BAE Systems Avionics, Basildon, Essex.

VERIFIED



AA34030 sonobuoy command transmitter

AN/ARR-970-AN/ARR-502 series

Type
A family of sonobuoy telemetry receivers.

Description
These sonobuoy receiver systems have been designed to meet the requirements of all current ASW aircraft, being capable of operating with all known sonobuoys and with the capability to meet future requirements.

Designed specifically for the Nimrod MRA4 and Orion P3 maritime patrol aircraft and Sea King helicopters, the receivers incorporate an acoustic test signal generator function that supports the BITE function to provide for complete end-to-end system test and fault isolation to the module level.

The ARR-502 receiver which provides for 16 or 20 acoustic channels, is used with a number of acoustic processors to provide the reception and demodulation of sonobuoy signals in the 136 to 174 MHz frequency range. Varying configurations are possible using standardised cards that support each available function. For example, additional acoustic channels use a common receiver module configuration supported by additional backplane circuitry and/or enclosure. Current installations use an external preamplifier to account for transmission losses between the antenna and receiver. However, the units are capable of being configured with an internal preamp and antenna filter.

The receivers can operate with an omni-directional antenna or a directional antenna array that also provides sonobuoy position information. The sonobuoy position system provides real-time geo-location of up to 99 deployed buoys using interferometer techniques with the supply of aircraft navigation and metrics. The sonobuoy position system is also capable of providing on top positioning, RF scanning and RF levels and can also locate SAR distress signals. This system supports various current antenna configurations from three antennas on the NH-90 and up to 10 antennas on the Aurora CP-140.

Since the standard receiver modules are both FM and AM capable, the on-top position indicator function can be obtained through the addition of a standard receiver module connected to a DF antenna system, or is available with the sonobuoy positioning system through software.

The usual 99 RF channels are provided with tuneable resolution from 5 to 375 kHz between each channel. For the Nimrod configuration with two R624 receivers, up to 64 RF simultaneous acoustic channel reception is available with any mix of analogue or digital signals.

The system features extremely low acoustic receiver baseband noise and incorporates active mixer technology for third order intermodulation and spurious response performance. A threshold extending FM detector with programmable time characteristics for sonobuoy type optimisation is fitted, together with the latest generation surface acoustic wave IF filtering for improved phase and delay response. This provides good bearing accuracy for multiplexed sonobuoys and good data error rate for digital sonobuoys.

High-resolution local oscillator tuning can be used to optimise performance with off-tuned sonobuoys and for operating in a countermeasure environment.

Operational status
On order for Canadian CP-140 Aurora and P-3B Orion modernisation programme of the Spanish Air Force MPA. Delivery was in 2002.

Specifications
Frequency range: 136.0 to 174 MHz
No of RF channels: 99
No of acoustic channels: 16/20 and 32 simultaneous
Noise figure: 5 dB
Dynamic range: 80 dB
FM sensitivity: 12 dB @ 0.5 µV input
20 dB @ 1.0 µV input
25 dB @ 1.5 µV input
Interference rejection: >140 dB out of band, >80 dB in band

Contractor
Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

VERIFIED

AQS-901

Type
Sonobuoy processing and display system.

Description
The 99-channel AQS-901, which first entered service in 1979, processes data from all NATO inventory sonobuoys including advanced buoys such as Barra, CAMBS and DIFAR.



AQS-901 sonobuoy processing and display system

The aircraft contains two systems, each with two CRT displays, (one being colour) and two hard-copy displays. A fifth CRT, which is able to show data from either system, is provided for system management and shows processed and tabular data from either system. Information is displayed via both hard-copy and CRT display media, and is controlled and interrogated by the operator using a keyboard, trackerball, on-screen menus and cursor.

Operational status
No longer in production but still in service. The AQS-901 is fitted to over 30 RAF Nimrod MR Mk 2s, 18 RAAF P-3W Orions and six Portuguese Orion P-3P aircraft. Deliveries were completed in Autumn 1986.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

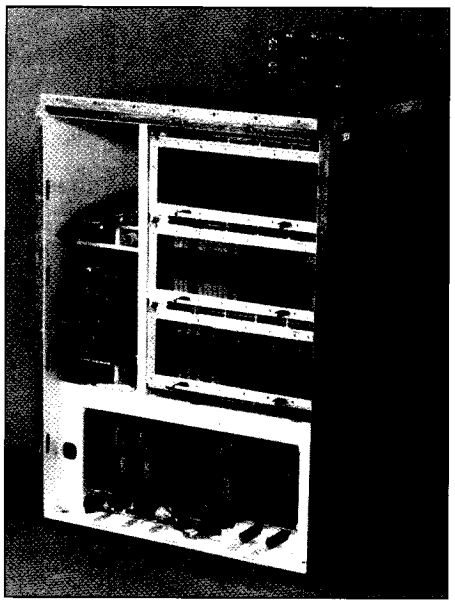
AQS-903/AQS-903A

Type
Sonar processing and display systems.

Description
The AQS-903 and AQS-903A are powerful lightweight acoustic processors for helicopter and fixed-wing applications. These systems can process data from eight to 32 sonobuoys in any combination. This flexibility is derived from the design based around a number of processing 'pipelines', each able to handle a certain quantity of passive and/or active sonobuoys. Four of these pipelines provide a processing power eight times that of the earlier generation AQS-901, at a fraction of the size and weight.

AQS-903/903A series make extensive use of distributed processing, with the systems incorporating the latest component technology to provide the operator with a wealth of information. The system provides a wide range of processing options to enable the operator to smoothly progress from initial contact detection to classification, localisation and tracking to achieve an effective mission. Analysis and display cues are in plain language, requiring a minimum of operator training.

The system can process data from LOFAR, DIFAR, HIDAR, Barra, DICASS and CAMBS buoys.



AQS-903 acoustic processing rack



RN Merlin ASW helicopter

Operational status
There have been 44 AQS 903 systems delivered for the Royal Navy Merlin helicopter and the 903A upgrade will be completed and accepted in 2004. The basic configuration will process data from the complete range of NATO inventory sonobuoys.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

AQS 970

Type
Multisonobuoy acoustic processing system.

Description
The AQS 970 airborne acoustic processor is being developed through collaboration between Ultra Electronics in the UK and Computing Devices of Canada. The system is derived from Computing Devices Canada UYS-503 system that is already in operational service (see UYS-503 entry).

The AQS 970/971 uses standard interfaces to the Tactical Command System (TCS) and the Sonobuoy Receiving System (SRS), providing signal conditioning, signal and data processing, display generation and control functions.

The system is designed to meet the detection, localisation and attack requirements posed by the latest-generation nuclear and diesel submarines operating in open ocean and littoral water environments. The modular architecture of the AQS 970 and its ample processing power and memory capacity enable it to readily accommodate new buoy types and processing techniques including multistatic, active search systems, without hardware modification. The system comprises four main elements: acoustic processor; sonobuoy receivers; RF distribution box and sonobuoy positioning system. The sonobuoy positioning system can locate buoys accurately in range and bearing without having to overfly the buoys. It uses four blade antennas as processing electronics fitted in the sonobuoy receiver.

The system employs a scalable hardware and software architecture configurable as 16, 32 or 64 identical processing channels (the AQS 971 is a 32-channel system), providing full 64-buoy simultaneous processing capability (subject to buoy RF channel limitations) for all NATO variants of the following exisiting or planned sonobuoy types:

Passive search and localisation
- DIFAR
- LOFAR
- VLAD
- CODAR (DIFAR/omni pairs)
- HIDAR
- BARRA

Active search and localisation
- CAMBS
- DICASS
- RO
- SSQ-110
- ALFEA

Special purpose
- Ambient Noise Monitoring (ANM)
- BATHY

The system also features a built-in acoustic test signal generator and tactical acoustic trainer.

Processing and display (20 in high resolution flat screen monitor) capabilities include: bearing coherent processing and effective colour-coded displays; energy map (to display submarine energy sources) and acoustic situation displays; narrowband, broadband/swath, diesel, Demon, and transient detection processes; variable band CODAR (using DIFAR buoys); adaptive interference rejection/anti-jam processing (HIDAR, DIFAR, BARRA, CAMBS).

Operator display analysis aids include: gram markers and harmonic dividers, CPA analysis, Lloyd's mirror analysis, display magnify/freeze/zoom/pan, cross-hair and hook, adjustable thresholds and integration times, concurrent multiresolution processing, rapidly selectable operator-defined display formats and combinations. General aids provided include frequency/bearing/range trackers, synchronised audio, range prediction, data fusion and contact tracking, auto alerts. The operator can switch and select between displays in real time, tracking up to eight independent targets.

Operational status
The AQS 970 airborne acoustic processor has been selected for the Nimrod MRA4 programme and deliveries have commenced.

Contractor
Ultra Electronics, Sonar and Communication Systems, Greenford, Middlesex.

UPDATED

ARR 970

Type
Sonobuoy telemetry receiver.

Description
The ARR 970 sonobuoy receiver system has been designed to meet the requirements of current ASW aircraft, while providing additional facilities to meet future requirements. It amplifies and demodulates FM sonobuoy transmissions and provides the output to an acoustic processor for analysis and display.

Two models are available. A multichannel version offers 16-, 20 and 32-channel options, while a single-channel version provides only the 32-channel capability. Both models include options for an On-Top Position Indicator (OTPI) function, channel scanning and a sonobuoy positioning system.

Power requirements for both units are 115 V, 3-phase, 400 Hz.

Specifications
16-channel system
Weight: 33 kg
RF channels: 99+ test (375 kHz spacing, standard); 505 (75 kHz spacing, optional)
Audio interfaces: balanced, 2 Vrms for 75 kHz peak deviation
IF bandwidth: 240 kHz standard

32-channel system
Weight: 39 kg
RF channels: 99+ test (375 kHz spacing, standard); 505 (75 kHz spacing, optional)
Audio interfaces: balanced, 2 Vrms for 75 kHz peak deviation
IF bandwidth: 240 kHz, standard
Control interfaces: MIL-STD-1553B, RS-422

Operational status
Selected for use on UK Nimrod MRA4.

Contractor
Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

VERIFIED

CRISP

Type
Portable mission support acoustic analyser.

Description
The CRISP (Compact, Reconfigurable Interactive Signal Processor) equipment has been developed using the Thomson Marconi Sonar Series 5 technology to provide a compact portable mission support system. The current version of CRISP is now available to support the airborne processing community.

A high-resolution (1,024 × 1,024 pixels) colour graphics display with pop-up menus and mouse roll-and-click selection allows interactive and user-friendly operation. The system uses a Windows-style environment.

Using modular boards already in operational naval service CRISP offers the following capabilities:

- simultaneous broadband and narrowband analysis;
- digital DIFAR processing (16 channels – real time in omni and steered cardiod with bearing extraction);
- frequency range from infrasonic to intercept;
- very fast time replay (×8 of standard);
- short-term event capture and analysis;
- rapid software reconfigurability.

Spectral processing analysis bands cover 2,400, 1,200, 800, 400, 200, 100, 80, 40, 20 and 10 Hz. Demon processing covers input bands of 300, 600 and 1,200 Hz with analysis bands of 40, 80 and 200 Hz. In LOFAR the CRISP system processes eight channels from 0 to 19 kHz.

The CRISP architecture allows it to be an onboard data gatherer or a mission support, faster than real-time analyser. This flexibility has allowed it to be successfully operated by NATO navies and air forces.

Operational status
In service with UK RN, RAF and Canadian Air Forces.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

SPIRE III

Type
Sonobuoy data telemetry and real-time analysis system.

Description
The SPIRE III telemetry system provides a calibrated RF datalink from a group of omnidirectional passive sonobuoys for analysis and recording in a surface warship or shore-based unit via a small helicopter. As such the system provides an extended communication range.

The aircraft unit receives VHF data from the buoys and retransmits, on UHF link to ship or shore, the digital multiplexed acoustic data together with the helicopter GPS and sonobuoy positions. The helicopter element comprises a single ATR ARINC enclosure and an external aerial and data input device.

The ship receives the retransmitted data either directly via the VHF link or via the UHF SPIRE receiver.

The system is controlled by a PC with a touchscreen intuitive MMI giving the operator total control over all signal selections and recordings within the system.

The signal selector provides 32 selectable output channels of data. The system contains an oscilloscope and Lofar processor to analyse and calibrate the acoustic signals. The processor provides 16 selectable input channels for display in a Lofar format.

The system uses a time code reader/generator to synchronise the system time to ship's time, allowing recorded data to be referred to other recordings taken on board the ship. An RF calibration source is used to calibrate received acoustic data.

An additional functionality allows real-time helicopter position and track and 'own ship' and sonobuoy positions to be displayed on an electronic chart display located on the parent vessel or ashore.

Operational status
In service with the Royal Navy aboard Lynx ASW helicopters and under consideration by the manufacturer for installation in Nimrod, Merlin and Sea King aircraft.

Contractor
Drumgrange, Chertsey, Surrey.

VERIFIED

Type R605 receiver

Type
Sonobuoy data receiver.

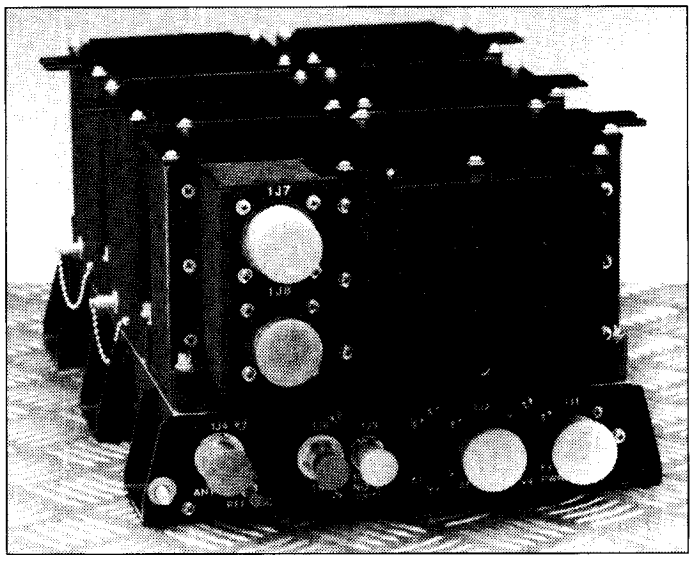
Description
The R605 receives, demodulates and amplifies FM sonobuoy signals in the frequency range from 136 to 173.5 MHz over 99 channels. Simultaneous operation can be carried out on four channels and a demodulated output for analysis and display is provided. The R605 receiver features a large RF dynamic range and high sensitivity over a broad base bandwidth and also provides a wide linear phase, audio output with close uniformity between each of the four audio channels. Digital sonobuoy data undergoes matched filter detection and clock regeneration in the receiver. Differentially driven clock and data signals are available for each of the four receiver outputs at any of the data rates and code functions. The equipment is DIFAR and DICASS compatible.

The R605 is a much improved version of the AN/ARR-75 and uses many of its mechanical and electrical design features to simplify retrofit applications and can thus provide a direct replacement for the AN/ARR-75 set.

Control options include MIL-STD-1553, RS-422, ARINC 429 or a manual control unit. MTBF is quoted as better than 2,000 hours, and the life of the system is better than 20,000 hours of continuous operation.

Extensive BITE is provided. An optional remote preamplifier allows receiving sets to be mounted at a distance from the system antenna.

Operational status
In production since 1996 and currently being manufactured for the Royal Navy's Merlin EH 101 helicopter and in service on RAF Nimrod MR2 and RAAF P-3C Orion aircraft.



R605 sonobuoy receiving set

Specifications
Dimensions: 159 × 351 × 232 mm
Weight: 10 kg
RF Frequency range: 136-173.5 MHz
Channels: 99 RF, 4 acoustic
Noise figure: 5 dB at 50 Ω
Stability: ± 3 PPM

Contractor
Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

VERIFIED

Type R612 receiver

Type
On-top position indicator sonobuoy receiver.

Description
The Type R612 is a modular 99-channel, on-top position indicator which covers the frequency range 136 to 173.5 MHz. It is suitable for use on both fixed-wing aircraft and helicopters. The equipment is fully compatible with all known sonobuoys and a variety of antenna systems. When used in conjunction with an ADF system it enables the operator to home on and locate sonobuoys on any of the 99 channels. The R612 is interchangeable with the R-1651/ARA without changes to existing wiring. Control options include RS-422, MIL-STD-1553B (via R605), or a manual control box.

The R612 functions as an amplitude demodulator for the direction-finding system, and produces an indication that an adequate signal exists when the RF signal input is sufficient for reliable direction-finder operation. The presence of the adequate signal is indicated in three ways; a 400 Hz tone to the operator's headset, a light on either side of the control box, or as a discrete signal to the R605 sonobuoy receiver.

Operational status
In production and in operational service since 2002.

Specifications
Sensitivity: 10 dB S/N ratio @ 2.5 µV input
Dimensions: 126 × 135 × 78 mm
Weight: 2.16 kg
MTBF: 3,000 h

Contractor
Ultra Electronics Sonar and Communication Systems, Greenford, Middlesex.

UPDATED

United States

AN/ARN-146

Type
On-top position indicator for sonobuoys.

Description
The AN/ARN-146 radio receiving set is a 99 RF channel on-top position indicator used on board ASW rotary- and fixed-wing aircraft to provide bearing and on-top position indication of deployed sonobuoys. When used in conjunction with a suitable DF system, the equipment enables the operator to locate and verify the position of deployed sonobuoys operating on any of 99 channels.

The AN/ARN-146 has a modular, solid-state design and it is designed to be used with computer control, either via RS-422 directly, or when connected with the AN/ARN-84 sonobuoy receiver. The AN/ARN-146 is form and fit interchangeable with the R-1651/ARA and R-1047 A/A OTPI receivers. It is compatible with ARA-25, ARA-50 and OA-8697/ARD (DF-301E) DF antenna systems.

The AN/ARN-146 set consists of the R-2330/ARN-146 radio receiver and the C-11699/ARN-146 radio set control. The R-2330/ARN-146 is a VHF, AM receiver, which receives signals from sonobuoys operating on any of 99 RF channels, in the frequency range from 136 to 174 MHz. This receiver houses all the electronics, including internal transfer circuits for the switching of RF, baseband, power and phase compensation circuits for sharing the DF system between the OTPI and an associated UHF receiver system for the DF. The R-2330/ARN-146 also contains a PLL synthesised local oscillator, digital address decoder, voltage-tuned BP filters, AGC and BIT circuitry.

The C-11699/ARN-146 radio set control is an optional manual control box which is used in place of the RS-422 bus or the MIL-STD-1553B dual bus of the AN/ARN-84. This control box provides the capability to apply power to the AN/ARN-146 system, to select any one of 99 RF channels, to activate the BIT circuitry and to display adequate signal strength and results of the BIT via the adequate signal strength indicator.

The equipment is compatible with all known or planned sonobuoys, including DIFAR, LOFAR, Ranger, BT, CASS, DICASS, VLAD, CAMBS, BARRA, HLA, ATAC and SAR.

Operational status
In production for the US Navy. In service aboard SH-60B helicopters.

Contractor
Ultra Electronics, Flightline Systems, Victor, New York.

UPDATED

AN/ARR-75

Type
Sonobuoy receiving system.

Description
The AN/ARR-75 sonobuoy receiving set is a 31 RF channel FM receiver designed for use on ASW fixed-wing aircraft, as well as shipboard applications. Independent receiver modules provide four simultaneous demodulated audio outputs each capable of selecting one of 31 RF input channels. The AN/ARR-75 is used on the LAMPS Mk III, LAMPS Mk I and SH-3H, as well as various other surface combatant platforms.

The AN/ARR-75 receiving set is composed of two units. The first is the OR-69/ARR-75 receiver group assembly, which in turn consists of a power supply (PP-6551/ARR-75), four receiver modules (R-1717/ARR-75) and the chassis (CH-670/ARR-75). The receiver group assembly contains the majority of the system's electronics.

The second unit is the radio set control (control box), C-8658/ARR-75 or C-10429/ARR-75. This control unit provides independent RF channel selection and signal strength, monitoring of any of 31 RF channels for each of the four receiver modules.

Flightline Electronics also manufactures a maintenance kit for the AN/ARR-75. This optional equipment is designated MK-1634/ARM maintenance kit (also known as the suitcase tester) and is designed to facilitate interim maintenance of the AN/ARR-75 at the intermediate level. The MK-1634 contains module extenders, adaptors, cables and a test bench panel for interconnecting with and testing the AN/ARR-75.

Operational status
In service with US Navy SH-2, SH-3H and SH-60 and Japanese SH-60S helicopters.

Contractor
Ultra Electronics, Flightline Systems, Victor, New York.

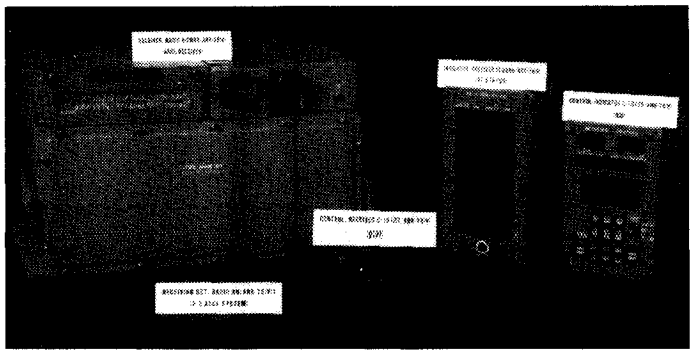
UPDATED

AN/ARR-78(V)

Type
Sonobuoy Communication Link.

Description
The AN/ARR-78(V) radio receiving set, also known as ASCL (Advanced Sonobuoy Communication Link), is for the operation and management of anti-submarine sonobuoys by the crew of ASW aircraft, such as the P-3C Orion (Update III) maritime patrol aircraft and S-3B Viking. The equipment comprises five main items (described below) and is employed with an associated onboard ASW signal processor. The main units of the AN/ARR-78(V) are:

- the AM-6875 RF preamplifier, an optimised high-performance, low noise VHF preamplifier which provides amplification and prefiltering of received RF signals
- the R-2033 radio receiver, which contains 20 fully synthesised high-performance receiver modules (16 acoustic and 4 auxiliary), and one each of the following modules: RF/ADF amplifier multicoupler, reference oscillator, Proteus digital channel, I/O processor, clock generator, BITE, and DC power supply module. Each single conversion receiver module includes mixer conversion, frequency synthesised LO, demodulator and output interface circuits. Each of the acoustic receiver modules processes FM/analogue or FSK digital signals at any of the 99 channels in the extended VHF band. Each of the four auxiliary receiver modules processes signals at any of the 99 channels and provides: one channel for selection and processing of the On-Top Position Indicator (OTPI) signals; two channels for the operator to monitor acoustic information; and one channel to monitor the RF signal level in any of the RF channels. Common receiver modules are interchangeable
- BITE circuits provide comprehensive end-to-end evaluation of each receiver from the VHF preamplifier to the receiver output interface circuits. BITE is initiated automatically by the computer (such as Proteus) and/or by the operator through the Indicator Control Unit (ICU). Performance status is displayed on the ICU and routed to the computer



AN/ARR-78(V) advanced sonobuoy communications link equipment (P-3C configuration)

- the C-10126 Indicator Control Unit (ICU), provides the operator with manual control over the assignment of each receiver channel frequency, receiving mode and self-test. It also displays status of the receiving set and operator entry information
- the ID-2086 receiver status indicator, which continuously displays the control mode setting, the RF channel number and the received signal level for each receiver
- the C-10127 receiver control unit, which provides the operator with control over the OTPI channel frequency.

Surface Acoustic Wave (SAW) IF filters are incorporated to provide high selectivity, coupled with good linear phase characteristics, which yield low levels of distortion. Microprocessors are used in the ICU and I/O module to process the commands to, and display status data from, the receivers. Versatile programs accommodate changes without requiring aircraft modification.

The auxiliary receivers permit the operator to aurally monitor signals in any of the 99 RF channels without interrupting data processing in that channel.

The ASCL PLUS incorporates enhancements which doubles the receiver complement by incorporating two digital receivers in the current AN/ARR-78 (V) receiver module to provide up to 40 acoustic channels for processing. Each digital receiver is easily commanded to any frequency in the 99 channel receiver band. The demodulised output of each receiver is fully compatible with existing ASW signal processors.

Operational status
By the end of 1994, over 500 systems had been delivered for P-3C Update III and S-3B aircraft. An additional 91 receivers are on order. The receiver is used by the Norwegian, Japanese and South Korean defence forces.

Specifications
Frequency: extended VHF
Receivers: 20 (16 acoustic/4 auxiliary)
Channels: 99 per receiver
Audio output
Analogue: 2 V or 4% V RMS (balanced)
Power input: 115 V AC ±10%, 380-440 Hz, 3-phase 450 W; 18-32 V DC, 7 W; 26.5 V AC, ±10%, 400 Hz, 50 W

Dimensions
AM-6875: 7.6 × 14.6 × 10.8 cm; 0.95 kg (weight)
R-2033: 30.9 × 54.1 × 38.9 cm; 45.9 kg (weight)
C-10126: 22.9 × 14.6 × 16.5 cm; 3 kg (weight)
ID-2086: 26.7 × 14.6 × 12.7 cm; 1.9 kg (weight)
C-10127: 5.7 × 14.6 × 8.3 cm; 0.6 kg (weight)

Contractor
BAE Systems North America, Advanced Systems, Greenlawn, New York.

VERIFIED

AN/ARR-84

Type
Airborne and surface vessel sonobuoy receiver.

Description
This receiver features four acoustic channels capable of receiving signals from up to four deployed sonobuoys simultaneously on any of 99 RF channels. It is suitable for installation on a variety of rotary- and fixed-wing aircraft, as well as large surface vessels and fast patrol craft. It is a form and fit replacement for its predecessor, the AN/ARR-75 (see AN/ARR-75 entry).

Additional features of the AN/ARR-84 include dual selectable IF bandwidths for optimum performance, with a wide variety of sonobuoy types. It provides high AM rejection and mechanical vibration immunity, which severely reduces interference from propeller/rotor multipath and platform vibration. The receiver has a very low susceptibility to conducted and radiated energy, allowing the set to be used near strong onboard emitters and shipboard search radars.

An optional radio set control, intended for use when online computer control is not available, provides power control and BIT operation for the receiver group. RF channel selection, sonobuoy type selection and RF level readout is provided independently for each of the four receivers in the group. Operator input is through a multifunction keypad with signal strength provided as a histogram display and, entry readback/failure data provided by a 16 character message display.

Operational status
In production and in use on board US Navy SH-60B, SH-60F, LAMPS Mk III, Royal Australian Navy S-70B and Taiwanese S-2T tracker fixed-wing aircraft.

Contractor
Ultra Electronics, Flightline Systems, Victor, New York.

UPDATED

AN/ARR-502

Type
Sonobuoy receiver.

Description
The AN/ARR-502 is a 495 channel RF radio receiver that provides simultaneous reception and demodulation of 16 NATO standard sonobuoys in the 136 to 173.5 MHz frequency band on any of 99 RF channels (505 sub-frequencies and tuneable resolution from 5 to 375 kHz between each channel). The standard configuration system provides for 17 acoustic receiver channels, digital output, end-to-end test, On-Top Position Indicator, and optionally, the sonobuoy referencing/positioning system, which provides remotely the range and bearing of up to 16 sonobuoys simultaneously.

It is capable of receiving and simulating all types of sonobuoys, including Lofar, DIFAR, BT, VLAD, ambient noise, range only, and DICASS. Additionally, capability is provided to operate with CAMBS, BARRA and ATAC buoys, as well as future developmental sonobuoys such as ADAR and EEC. Capability is also provided for receipt and demultiplexing of GPS signals from all types of existing sonobuoys being modified to incorporate GPS.

The AN/ARR-502 can be controlled either by a MIL-STD-1553B or RS-422. Multiple bandwidths and channels are provided for improved performance and compatibility with existing and future sonobuoys.

The receiver features extremely low acoustic receiver baseband noise floor, active mixer technology for third order intermodulation and spurious response performance, threshold extending FM detector with programmable characteristics for sonobuoy type optimisation, progressive AGC with programmable time constants to improve multipath, propeller artifact and countermeasures rejection. It also has surface acoustic wave IF filtering for improved error rate for digital buoys, signal strength indication and high resolution local oscillator tuning.

Operational status
The AN/ARR-502 is in production for the Canadian Air Force and is currently installed on Sea King, CP-140 Aurora and RAF Nimrod aircraft. The ARR-502 has also been ordered by Poland for integration into the Bryza maritime patrol aircraft. Other versions have been ordered for the European NH90 ASW helicopter and Spanish P-3 Orion MPA.

Specifications
Channels: 99 RF
Dynamic range: 80 dB
Noise: 5 dB
Signal:Noise ratio: 12 dB at 0.5 µV and 20 dB at 1.0 µV
Out of band interference rejection: >140 dB
In band interference rejection: >80 dB
Audio distortion: ≤1 per cent from 2 Hz to 5 kHz, and ≤3 per cent from 5 kHz to 50 kHz for input levels of 10 to 100,000µV

Contractor
Ultra Electronics, Flightline Systems, Victor, New York.

UPDATED

R-624(V)

Type
Sonobuoy receiver.

Description
The R-624(V) sonobuoy receiver is a variant of the AN/ARR-502 receiver, intended for Maritime Patrol Aircraft (MPA) applications. The receiver is capable of simultaneously tuning and demodulating 32 NATO standard sonobuoy transmissions. Two receivers may be used in an acoustic suite to allow for processing of 64 simultaneous sonobuoy transmissions. The standard 99 RF frequencies for sonobuoys (505 sub-frequencies for special sonobuoys) are supported.

The R-624(V) is controlled via a dual-redundant MIL-STD-1553B databus. If a two-receiver configuration is employed, intra-receiver communication is achieved via a RS-422 link. The receiver can be commanded to determine the signal strength of all or selected channels and execute built-in test for end-to-end determination of system health, control receiver module parameters for particular buoy-type optimisation, and perform calibration functions of the Sonobuoy Position System (SPS) (if so equipped). With SPS, the receiver is capable of directional location of sonobuoys and SAR emergency beacons using interferometer techniques. In this configuration OTPI information is also available.

In common with other Flightline sonobuoy receivers, the R-624(V) provides an extremely low acoustic receiver baseband noise floor, exceptional third-order intermodulation and spurious response performance, threshold-extending FM detector facilitating sonobuoy-type optimisation, progressive automatic gain control (AGC) with programmable time constants to improve multipath, propeller artifact and countermeasure rejection. Also provided are surface acoustic wave IF filtering (for improved error rate for digital buoys), signal strength indication and high-resolution local oscillator tuning.

The R-624(V) receiver is fully solid-state system with no mechanical relays. Comprehensive BIT capability provides initial system Go/No Go status, as well as fault isolation to increase maintainability. No special test equipment is required.

Other features of the system include:

- 99 RF channels (505 sub-channels) supported
- Simultaneous reception of up to 64 acoustic channels with any mix of analogue or digital signals (using two 32-channel sonobuoy receivers)
- 5 dB noise figure
- 80 dB dynamic range
- 12 dB signal to noise ratio at 0.5 µV input and 20dB signal to noise ratio at 1.0 µV input
- AM immunity: progressive AGC with programmable time constants for improved multipath immunity
- >140 dB out-of-band interference rejection
- >80 dB in-band interference rejection
  Excellent third-order intermodulation characteristics with 'active' mixer technology
- Accommodates RF signals over the range of 0.5 µV to 100,000 µV (-113 dBm to -7 dBm)
- Extended acoustic base band frequency response: 0.1 Hz to 125 kHz
- Audio Distortion ≤1% from 2 Hz to 5 kHz, and ≤3% from 5 kHz to 50 kHz for input levels of 10 to 100,000 µV
- Voltage Standing Wave Ratio (VSWR) does not exceed 2.0 to 1 over the 136 to 174 MHz range
- Acoustic RF signal strength reporting ability.

Specifications

Dimensions: 604.5 × 308.9 × 374.6 mm (including rear connectors and vibration isolators)
Weight: <120 kg
Reliability: >1,200 hrs MTBF predicted
Power: 115 V AC, 400 Hz, 3-phase Wye
Frequency: 136-173.5 MHz
Sonobuoy compatibility: All standard NATO types

Operational status

The R-624(V) receiver is in service on the Nimrod MRA-4 MPA.

Contractor

Ultra Electronics, Flightline Systems, Victor, New York.

NEW ENTRY

R-1651/ARA

Type

On-top position indicator for sonobuoys.

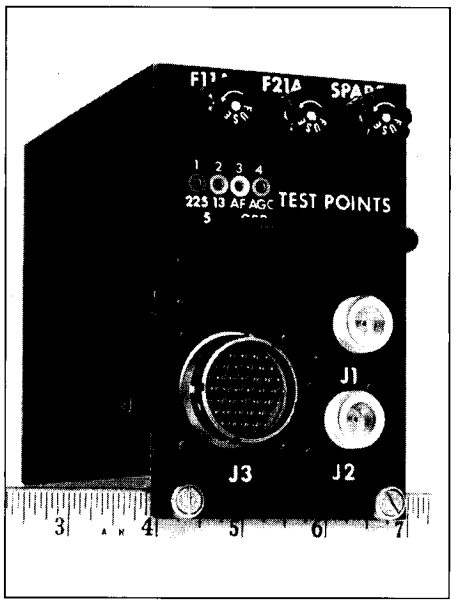
Description

The R-1651/ARA radio receiving set is a 31 RF channel On-Top Position Indicator (OTPI) used aboard ASW rotary- or fixed-wing aircraft to provide bearing and on-top position indication of deployed sonobuoys. When used in conjunction with a suitable DF system, it enables the operator to locate and verify the position of deployed sonobuoys operating on any of 31 VHF RF channels.

The R-1651/ARA is form and fit interchangeable with the R-1047 A/A OTPI. This radio receiving set is compatible with ARA-25 and ARA-50 antennas and it is also available in a modified configuration, which is compatible with the DF-301E antenna system. The R-1651/ARA is controlled by the optional C-3840/A control box.

The R-1651/ARA is a single-conversion, 31 channel, superheterodyne VHF receiver which is designed to receive signals from deployed sonobuoys over the frequency range of 162.25 to 173.50 MHz.

The antenna input is switched by a relay to the receiver or the UHF receiver, on external command. The RF signals (R-1651/ARA) pass through bandpass filters, are amplified, and converted to an IF of 25 MHz. After IF amplification and detection, the resultant audio signal is amplified to the level required by the ADF system. The AGC level is developed at the detector, amplified and used for gain control of the IF and RF stages and to operate the adequate signal strength circuits.



R-1651/ARA sonobuoy OTPI radio receiver

The local oscillator provides one of 31 possible LO signals. Thirty-one crystals are appropriately selected using external controlled code lines containing a 6-bit binary code. Line receivers, decoding gates and matrix drivers connect one of 31 crystals to the local oscillator circuits.

The optional C-3840/A radio receiver control is used to switch the antenna system, by energising an external coaxial relay, from the UHF/ADF mode of operation to the sonobuoy OTPI mode of operation. This enables the selection of any one of the 31 RF channels and indicates adequate signal strength when the R-1651/ARA receives an RF signal of –86 dBm or greater.

Operational status

In service aboard P-3C Updates II and III and SH-60 LAMPS Mk III aircraft of the US Navy.

Contractor

Ultra Electronics, Flightline Systems, Victor, New York.

UPDATED

VHF sonobuoy receiver

Type

Lightweight 16-channel sonobuoy VHF receiver.

Description

The lightweight 16-channel sonobuoy VHF receiver is intended for a wide variety of maritime patrol aircraft (MPA) and ASW helicopters. The basic configuration provides for the simultaneous reception of 16 separate acoustic channels. With the addition of sonobuoy location system (SLS) modules, the receiver is capable of providing bearing data for deployed sonobuoys. The receiver is compatible with all standard NATO types of sonobuoy.

The VHF receiver consists of specialised plug-in modules which afford quick and reliable maintenance. The receiver module contains advanced circuitry and software-selectable tuning, allowing for the reception of the standard 99 RF channel frequencies (505 sub-channels). The receiver is controlled via RS-422 bus and includes a self-contained pre-amplifier. The receiver is cooled using a self-contained, forced air fan assembly.

The system offers an extremely low acoustic receiver baseband noise floor, exceptional third-order intermodulation and spurious response performance, threshold-extending FM detector facilitating sonobuoy-type optimisation, progressive AGC with programmable time constants to improve multipath, propeller artifact and countermeasure rejection. The VHF receiver also incorporates surface acoustic wave IF filtering for improved error rate for digital buoys, and signal strength indication and high-resolution local oscillator tuning, which can be used to optimise performance with off-tuned sonobuoys and for operating in a countermeasures environment.

The VHF receiver is fully solid-state with no mechanical relays. Comprehensive built-in test (BIT) capability provides initial system Go/No Go status, as well as fault isolation to increase maintainability. No special test equipment is required.

Other features of the system include:

- 99 RF Channels supported
- Simultaneous reception of up to 16 acoustic channels with any mix of analogue or digital signals
  5dB noise figure
- 80dB dynamic range
- 12dB SNR at 0.5 µV input and 20dB SNR at 1.0 µV input

- AM immunity: progressive AGC with programmable time constants for improved multipath immunity
- >80dB in-band interference rejection
- MTTR <16 minutes for module replacement
- stics with 'active' mixer technology
- Highly immune to out-of-band interference (125 dB minimum rejection)
- Accommodates RF signals over the range of 0.5 µV to 100,000 µV (-113 dBm to -7 dBm)
- Extended acoustic base band frequency response: 0.1 Hz to 125 kHz
- Audio Distortion <=1% from 2 Hz to 5 kHz, <=3% from 5 kHz to 50 kHz for input levels of 10 to 100,000 µV
- Voltage Standing Wave Ratio (VSWR) does not exceed 2.0 to 1 over the 136 to 174 MHz range
- Acoustic RF signal strength reporting ability.

Specifications

Dimensions: 485.8 × 247.9 × 383.5 mm (including rear connectors and vibration isolators)
Weight: <25 kg
Reliability: >1,500 hrs MTBF predicted
Power: 115 V AC, 400 Hz, 3-phase Wye
Frequency: 136-173.5 MHz

Operational status

The lightweight 16-channel sonobuoy VHF receiver has been qualified on the NH 90 helicopter.

Contractor

Ultra Eectronics, Flightline Systems, Victor, New York. ***NEW ENTRY***

STATIC DETECTION SYSTEMS

Canada

CSAS-80 sonar

Type
Active seabed or platform-mounted sonar system.

Description
The CSAS-80 surveillance sonar is a high-performance omnidirectional sonar designed for the detection of underwater intruders such as divers using open or closed breathing apparatus, swimmers, Swimmer Delivery Vehicles (SDVs), mini-submarines and so on.

Surveillance over a large area (2,000 m radius) is provided, and the sonar can either be used as a single unit or combined in a series of underwater units to provide coverage over a much larger area. The system may be integrated with other sensors such as radar, IR camera, motion sensors, and so on, to provide a complete security system.

The system can be used in a number of applications including: harbour surveillance; perimeter surveillance for naval bases or other coastal facilities; protection of offshore platforms or other high value assets; and to deny access to strategic waterways.

The sonar comprises an underwater unit (with transducer and transmitter/receiver subassemblies), sea cable (2,000 or 3,000 m optional), and a shore-based control/display formatter unit, operator unit and power control unit. It provides surveillance coverage of 360° with sector operation for restricted channel or cluttered archipelago areas using an array of 256 rapidly scanned, preformed receiving beams. Horizontal beamwidth is 3° with an adjustable vertical width of 6, 12 or 24°. Electronic tilt (±24° from the horizontal) provides surveillance coverage of the entire water column in deep water. The system provides automatic detection and tracking of new and moving targets at varying depths. Target history track is provided for all targets on the display. A constant update of target range, bearing, depth, speed and course is also provided as a digital readout on the screen. To aid classification the sonar incorporates an operator-activated zoom capability. The system uses adaptive processing techniques to suppress noise and provide a clear image of targets in the operating area. Stable static background targets within the sonar's area of coverage are suppressed allowing changing target echoes to be easily identified. The non-fading display presentation is in 16 colours, each colour representing a certain echo strength. An alphanumeric display presents key sonar operating parameters, as well as time and date. Five range scales (250 m, 500 m, 1,000 m, 1,500 m and 2,000 m) are provided. The system can be optimised to suit the specific conditions of any particular site.

Operational status
In service with the Swedish and other navies. This model has been upgraded to Model CSDS-85 (see separate entry).

Specifications
Frequency: 80 kHz
Source level: 218 dB/µPa/m
Power output: 10 kW
No of beams: 256
Beamwidth: 3° (horizontal); 6, 12, 24° (vertical)
Electronic tilt: ±24°

Contractor
C-Tech Ltd, Cornwall, Ontario.

UPDATED

CSDS-85

Type
Active seabed or platform-mounted sonar system.

Description
The Model CSDS-85 is C-Tech Ltd's new generation bottom mounted active sonar designed to detect divers and mini submarines. The system provides high resolution combined with improved range performance. Following on from the successful CSAS-80 system, the new Model CSDS-85 builds on the same features and user friendly design of its predecessor; but includes a smaller underwater unit and new flat panel LCD display.

The CSDS-85 surveillance sonar is a high-performance omnidirectional sonar designed for the detection of underwater intruders such as divers using open or closed breathing apparatus, swimmers, Swimmer Delivery Vehicles (SDVs), mini-submarines and so on.

Surveillance over a large area (2,000 m radius) is provided, and the sonar can either be used as a single unit or combined in a series of underwater units to provide coverage over a much larger area. The system may be integrated with other sensors such as radar, IR camera, motion sensors, and so on, to provide a complete security system.

The system can be used in a number of applications including: harbour surveillance; perimeter surveillance for naval bases or other coastal facilities; protection of offshore platforms or other high value assets; and to deny access to strategic waterways.

The sonar comprises an underwater unit (with transducer and transmitter/receiver subassemblies), sea cable (2,000 or 3,000 m optional), and a shore-based control/display formatter unit, operator unit and power control unit. It provides surveillance coverage of 360° with sector operation for restricted channel or cluttered archipelago areas using an array of 256 rapidly scanned, preformed receiving beams. Horizontal beamwidth is 3° with an adjustable vertical width of 6, 12 or 24°. Electronic tilt (±24° from the horizontal) provides surveillance coverage of the entire water column in deep water. The system provides automatic detection and tracking of new and moving targets at varying depths. Target history track is provided for all targets on the display. A constant update of target range, bearing, depth, speed and course is also provided as a digital readout on the screen. To aid classification the sonar incorporates an operator-activated zoom capability. The system uses adaptive processing techniques to suppress noise and provide a clear image of targets in the operating area. Stable static background targets within the sonar's area of coverage are suppressed allowing changing target echoes to be easily identified. The non-fading display presentation is in 16 colours, each colour representing a certain echo strength. An alphanumeric display presents key sonar operating parameters, as well as time and date. Five range scales (250 m, 500 m, 1,000 m, 1,500 m and 2,000 m) are provided. The system can be optimised to suit the specific conditions of any particular site.

Operational status
Awaiting production order contract.

Specifications
Frequency: 80 kHz
Source level: 218 dB/µPa/m
Power output: 10 kW
No of beams: 256
Beamwidth: 3° (horizontal); 6, 12, 24° (vertical)
Electronic tilt: ±24°

Contractor
C-Tech Ltd, Cornwall, Ontario.

NEW ENTRY

Finland

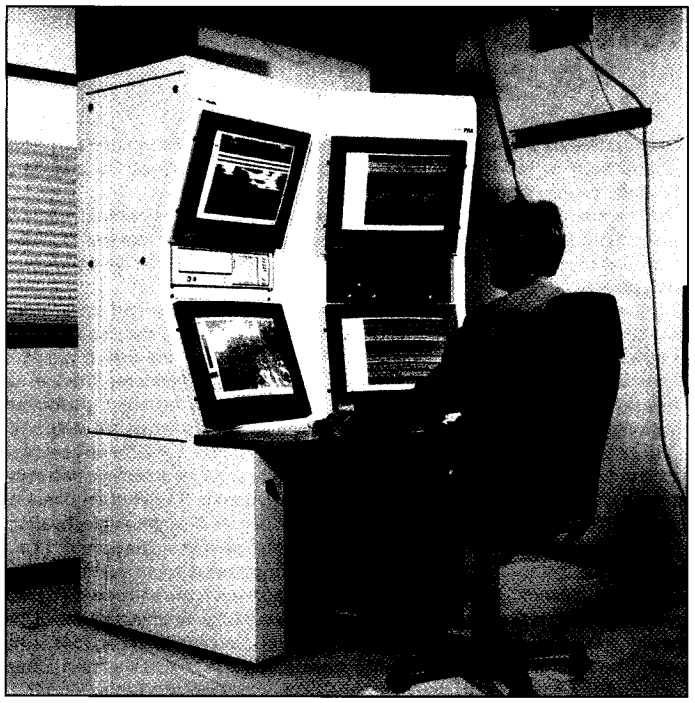
Sonac PFA

Type
Passive static fixed-sonar array.

Description
Moored on the seabed, the redeployable passive Sonac PFA can detect surface vessels as well as underwater targets in restricted waterways, such as straits, estuaries, harbours and so on. The system can also be used for surveillance in a large water area. The requirement to identify and locate the target can be fulfilled by using two or more arrays according to the scenario with optional magnetic and UEP sensors providing additional non-acoustic boundary surveillance. All the arrays are connected by an underwater fibre optic cable to one operating unit on the shore.

The received signals are digitised in the array and transmitted to the processing system via the fibre optic cable in digital form, which allows the arrays to be installed far away from the shore, often in excess of 30 km. The shore-based equipment incorporates a display unit in one cabinet and a signal conditioning unit housed in another cabinet. The processing system, which is organised in a parallel multiplexed configuration, provides high computing capacity in order to utilise adaptive algorithms. The results are presented on four independent colour video monitors by means of clear waterfall displays. Typically these display: surveillance (two monitors — one for each array); presenting both broad- and narrowband information from the beam-formed signals; target acoustic signatures; and bathymetric map with Sonac detected targets and targets detected by other sources linked to the network. Sonac PFA provides the operator with easy access to all essential information. The six main functions are:

- broadband surveillance information; signals from all directions are presented showing both source direction and signal power
- narrowband surveillance information; spectral estimates of signals from different directions are presented
- more detailed information on targets being tracked is analysed and displayed



Operator's console of the Sonac PFA system (Patria Finavitec) 0097844

- tactical display monitoring, target movement and surface traffic situation on the map
- audio information from a selected direction is generated for headphone and/or for classification purposes
- alarm and replay of unexpected events, transients, and so on is performed.

Several different audio modes are available. The operator can select whether audio of a beam-formed signal from one array is monitored in mono or from two arrays in stereo. In addition there are three different ways to select the audio channel beam bearing. This can be on a fixed beam bearing, continuous scanning of a selected sector or the channel beam can be set to automatically follow the movements of a selected target.

Narrowband and DEMON signatures of tracked targets are presented on a special display. Target signatures can be compared with previously recorded signatures for classification purposes. Ray tracing software is integrated into the system.

The wide acoustic bandwidth of the array allows acoustic signatures ranging from propeller tonals to mine avoidance sonars to be covered. The hydrophones are arranged in nested octave band subarrays. With a typical distance between 2 to 5 n miles enables cross bearing calculation and unambiguous target location to be achieved over an extensive sea area.

Sonac PFA uses COTS components, Linux operating system and CORBA architecture.

Operational status
In service with the Finnish Navy for several years.

Specifications
Total length of each array: 45-90 m (depending on configuration)
Array deployment depth: 20-200 m
Length of optical cable: 40 km (max)

Contractor
Patria Finavitec Oy, Tampere.

VERIFIED

Germany

Hydroacoustic Coastal Range

Type
System for detection, collection and analysis of underwater sounds and signals by means of fixed arrays in defined coastal or sea areas connected to relevant shore stations, surveillance of coastal and sea areas as well as choke points.

Description
The Hydroacoustic Coastal Range has been developed and manufactured to enable naval forces not only to control the surface and airspace of a certain shore or sea area but also to detect and classify/identify subsurface targets to provide continuous underwater surveillance.

For this task the subsurface system performs:

1. continuous control of the entire hydroacoustic frequency spectrum, in order to detect acoustic phenomena and characteristic sounds and signals of passing vessels and objects
2. recording, displaying, classification/identification of the received sounds and signals; analysis and storage of data in order to steadily improve the capabilities of the system; correlation of data with information gained from other sources
3. transmission of received and evaluated data to:
   a) intelligence centres for further evaluation and as input for establishment of databases
   b) operational authorities for tactical assessment and early warning.

The results gained by the Hydroacoustic Coastal Range improve with increasing significance the vital support of surveillance and control of specific sea and coastal areas in any aspect and application; data collection for ASW and mine warfare (target information); training of sonar operators; and early warning.

Passive sensors are placed at suitable distances in the area to be surveyed. The arrays have directional sensitivity to allow directional resolution, range-finding and tracking of individual targets.

If active sensors are integrated they can guarantee independence from the noise of the target in extreme situations.

Manning of the system is kept to lowest requirements.

Operational status
In operational service.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

International

CSDS (Coastal Surveillance Display System)

Type
Real-time, multisensor correlation and graphical display system.

Description
The CSDS was developed to allow operators to monitor surface and subsurface contacts in shallow coastal waters. The system displays large quantities of sensor data from a variety of sensors including radar, sonar, visual and thermal imaging sensor systems using easily recognised symbols and formats overlaid on maps of the operational area. The operator also has the capability to control and calibrate multiple sensor systems in the configuration. In addition, the system provides automatic sensor input recording, replay and permanent archive capabilities, as well as a video camera image capture feature. The CSDS can track as many as 500 active targets simultaneously. Potential applications for the CSDS include coastal area surveillance, use as a vessel tracking management system, near shore shallow water surveillance, port and harbour security, and offshore environmental monitoring. The software and hardware can be customised to meet specific requirements.

The system typically comprises a number of COTS elements including Hewlett-Packard J210 workstation; 20 in high-resolution colour monitor; CD-ROM and digital audio tape drive; radar track processor; and control/video processor; interface units (radar, video and thermal imaging, underwater acoustic sensor systems). A Windows NT version with a flat screen is also available.



Basic CSDS screen 0077278

Operational status
A customised system is on order for a foreign navy for harbour surveillance applications. US and foreign government agencies have shown interest in both the coastal water and land-based surveillance configurations of the system. The US Navy's Mobile Inshore Undersea Warfare (MIUW) units incorporate a Graphical Data Fusion System (GDFS) (a forerunner of the CSDS) developed jointly by SAIC and CEA Pty Ltd.

Operational with the US Navy under the description GDFS.

Contractors
CEA Pty Ltd, Canberra, Australia.

Science Applications International Corporation (SAIC), Ocean and Remote Systems Division, San Diego, California.

VERIFIED

Italy

Underwater Surveillance System

Type
Lightweight sonar system for harbour and coastline surveillance.

Description
The Underwater Surveillance System has been designed for the automatic detection, acquisition, localisation, tracking and classification of small underwater targets in high reverberation environments like harbours and coastal areas.

The system provides surveillance capabilities against threats with either low signature and/or small target strength, such as divers, midget submarines, AUVs and mini-submarines.

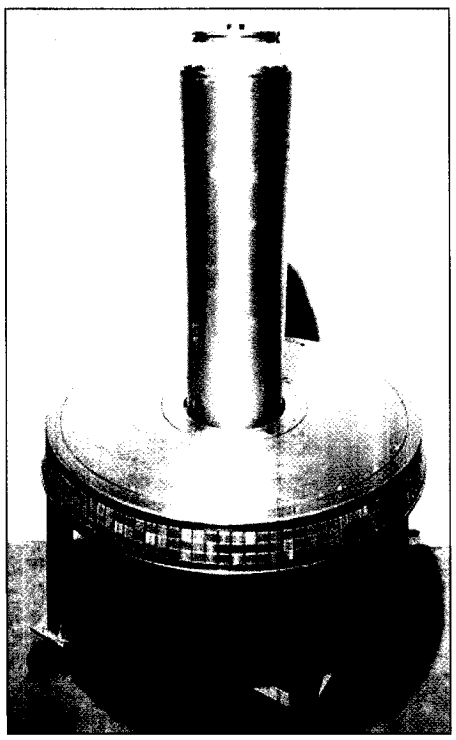
The surveillance capability is based on a passive and active sonar module. This module consists of:

- Surveillance antenna comprising transmitting antenna and receiving antenna
- Power supply unit
- Processing unit
- Console

Depending on the operational requirements and geographical situation, more than one sonar module can be used to ensure that the protected area is fully covered. In the minimum configuration the Underwater Surveillance System consists of one sonar module and the processing unit which is integrated into the console. Transmit and receive modes available include: pulsed stepped FM, pulsed CW, continuous transmission in FM and continuous transmission in CW. Both omni-direction and sectorial (30°) transmission is available. The system incorporates a static object echo rejection capability.

The seabed installation is linked to the shore station by an underwater fibre optic link.

Other features include automatic detection and tracking and an underwater fibre optic link.



Acoustic module of underwater surveillance system
(Whitehead Alenia Sistemi Subacquei)
1022769

Specifications
(Passive and active operating modes)
Horizontal coverage: 360°
Vertical coverage: 35°
Source level: >210dB/1μPa/m (max)
Receive channels: 120
Operating depth: 80 m (max)

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

Russian Federation

Fixed sonar systems

Type
Static sonar surveillance systems.

Description
The RFAS has developed an extensive number of fixed and moored sound surveillance systems which have been deployed at a number of locations around the world. Very little information is available on this sphere of operations.

It is known that the former USSR has deployed Cluster Lance planar acoustic arrays in Pacific waters near the Russian landmass where broad area surveillance is required.

Barrier arrays have been deployed at points of egress and ingress from SSBN operating areas, such as in the Barents, Greenland and Kara Seas. These are placed in or near trenches at 'choke points' which would serve as 'tripwires' more than long-range surveillance systems. These arrays use the Reliable Acoustic Path (RAP) form of propagation, which offers satisfactory detection in relatively shallow water regions.

One system developed by the former Soviet Union and now available on the open market is Searchlight. This is a bistatic passive/active system with a range of 130 n miles.

The system is deployed to operate at a depth of 300 m, the transmitter being capable of being moored in depths of up to 1,300 m with the unit floating at 300 m. The hydrophone receiver array, however, is mounted directly on the seabed. The transmitter system is probably LF operating at a frequency below 1 kHz.

The USA considers that acoustic sensors have considerably increased their detection ranges and will include improved hydrophone arrays and acoustic processing capability. There is even a suggestion that long-range, low-frequency arrays could be mounted on the permanent Arctic ice pack.

The former Soviet Union is also believed to have been developing non-acoustic surface signature detection systems which sense the disturbance on the surface caused by a passing submarine. Wake detection systems that sense turbulent wake, internal wave wake or contaminant (chemical or radioactive) wake have also been under development.

Volkhov
Type: MF static passive/active surveillance sonar
Development: Volkhov was designed in 1952-55 and tested in the Black Sea between 1955-56. It entered service in 1957. A number of Volkhov systems were produced and sited in the Barents Sea and Sea of Japan.
Description: The array consisted of a cylinder 1.8 m in diameter and 1.5 m high with 32 piezoelectric transducers built from crystals of Rochelle salt. The array, which used vacuum tube electronic equipment, was mounted in a hermetically sealed dome filled with castor oil. The single beam was manually rotated. The array could be mounted in depths up to 200 m.
Operational status: No longer in production or service.
Contractors: Morfizpribor, St Petersburg (design)
Vodtranspribor, St Petersburg (serial production)

Amur (MG-517)
Type: Static passive surveillance sonar for detection and tracking of submarines
Development: Amur was designed in 1959-65 for long range search and detection. It was tested in the Pacific Ocean close to the Kamchatka peninsula in 1967.
Description: The array is mounted in a cylindrical metal container 20 m in diameter and 5 m high. It contains more than 2,000 transducer modules mounted with Rubin-type rings of piezoelectric ceramic prisms. The array could be mounted in depths up to 250 m using a special anchoring system. Beam forming, processing and display vacuum tube equipment are housed in 70 cabinets mounted in the array and in the shore station at the coast, which could be sited up to 40 miles from the array.
Operational status: No longer in production. Two systems are sited in the Sea of Japan.
Contractors: Morfizpribor, St Petersburg (design and production of prototype)
Akhtuba, Volgograd (serial production)

VERIFIED

United Kingdom

Sea Guardian

Type
Static or mobile surveillance and swimmer detection sonar system.

Description
The Sea Guardian is designed to counter the threat of terrorism and sabotage, offering comprehensive protection to naval bases, commercial ports and other economically vital assets such as offshore oil platforms, oil refineries and nuclear power stations. It can be supplied either as a fixed system mounted on the pierside or in a mobile form for shipboard installation on moored or anchored vessels.

The system will continuously and automatically detect, classify and track intruders (subsurface swimmers or swimmer delivery vehicles) at ranges that allow successful interception. When a target is detected a series of detection, classification and tracking algorithms are initiated before an alarm is activated. This level of interaction with the possible intruder provides very low false alarm rates. The auto-detection process is programmable to meet the requirements of target threat versus environmental conditions. The special characteristics, or signatures, of swimmers and small vehicles ensure that they can be accurately tracked while similar sized harmless debris is eliminated electronically.

Having confirmed the presence of an intruder, the system will predict its track and estimate the time of interception. Using the sonar beam, a police launch or similar craft fitted with a transponder can be directed to a position immediately above the intruder.

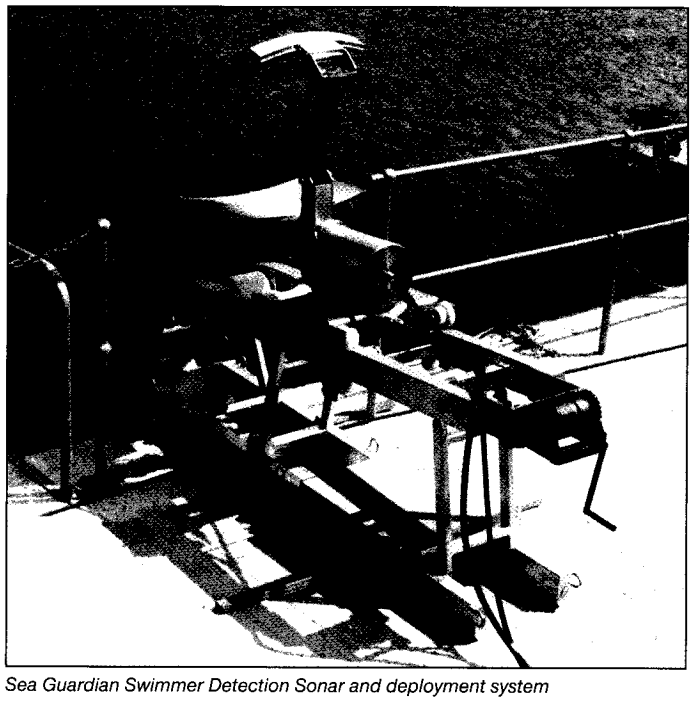
Due to the high degree of automation, it is possible for an unskilled person to interrogate the system. There is no display of raw sonar data but a synthetic tactical picture, which highlights the position of the threat (showing track history and speed) allowing rapid identification of the type of intrusion, its range, speed and bearing. This allows the operator to trigger an immediate response.

Sea Guardian uses a HF mirror array as the sensor. The array provides near perfect beam-forming with a minimal number of components, in a robust, low-cost configuration. The fixed installation consists of a 120° sonar unit, giving an azimuth resolution of 0.6° over the total field of view. The trainable mobile installation has a 40° azimuthal field of view. The electronically scanned sonar heads have no moving parts, thus ensuring high reliability and ease of maintenance. The 250 kHz system has a range of about 300 m. The acoustic mirror is unaffected by interference from acoustic jamming and passing sea traffic, which results in a very low false alarm rate.

Sea Guardian can be provided as a stand alone system with single or multiple sonar head feeding a synthetic tactical map display. Alternatively it can be integrated via a LAN in a network-centric configuration multisensor surveillance system comprising radar, IR sensors, thermal sensors, vibration sensors, acoustic fences and physical barriers. Used in combination, these systems offer protection against intruders from up to 30 miles away right up to the inner harbour zone. For a total area defence system an external communication capability is available.

A flexible communications system with facilities for point-to-point, broadcast and group communications is available at all displays. Interfaced external communications provide up-to-date data for naval forces and harbour authorities. Full command and control facilities allow optimum co-ordination and prevent any possibility of undetected escape or reinforcement.

Operational status
Sea Guardian has successfully undergone extensive proving trials in a variety of demanding environmental conditions worldwide. Orders for 15 Sea Guardian systems were placed by the US Navy in 2002, and the first system was delivered in 2003.



Sea Guardian Swimmer Detection Sonar and deployment system

Contractor
Thales Underwater Systems, Cheadle Heath, Stockport.

UPDATED

United States

ADS (Advanced Deployable System)

Type
Undersea surveillance system.

Description
The portable and expendable passive acoustic undersea surveillance ADS is designed to meet a broad range of short- and long-term littoral requirements. The system provides detection, localisation and tracking capabilities designed to deal with both nuclear and diesel-electric submarine threats in potentially hostile, littoral waters in adverse conditions of shallow water and strong currents.

The ADS consists of a series of wet end hardware acoustic arrays and dry end hardware/software subsystems that process, evaluate, report and integrate data with mission appropriate naval C⁴I systems. The battery powered hydrophone array can be deployed by a UUV that is controlled from a surface vessel. The ADS is controlled from a shore station that monitors the data gathered by the ADS. Alternatively, the system might be deployed, controlled and monitored from an ASDS. The ASDS would be used to deploy the thin hydrophone arrays in deep water that could be terminated with suitable connections in a submerged buoy at an intermediate depth. Divers could then be used to link up the ADS control and display suite in the ASDS with the submerged buoy.

Operational status
Under contract for engineering and manufacturing development to complete by December 2005.

Contractor
Lockheed Martin Naval Electronic and Surveillance Systems, Undersea Systems, Manassas, Virginia.

VERIFIED

AN/WQX-2

Type
Swimmer detection sonar.

Development
Transitioned directly from R & D to operational use, following the terrorist attack in Dharan, Saudi Arabia in June 1996.

Description
The system is integrated into the US Waterwide Security System (WSS) which is designed to detect and track surface and subsurface targets in the vicinity of piers.

The sonar head can be mounted on the seabed, moored or suspended from an anchored buoy.

The AN-WQX-2 has had its processing hardware and software upgraded to advanced capability standard, integrating commercial sound heads with the ADCAP signal processor. In the longer term SSC-San Diego is working with companies in the UK to develop a new sonar for the WSS.

Operational status
Derivatives of the AN/WQX-2 are planned to form part of the US Navy's shipboard protection system. The WSS protects USN assets in Bahrain, and the missile submarine bases at Kings Bay, Georgia and Bangor, Washington.

Contractor
Texas University, Applied Research Laboratories, Austin, Texas

NEW ENTRY

MIUW

Type
Surface and subsurface surveillance system.

Description
The Mobile Inshore Undersea Warfare (MIUW) system is designed to provide surface and subsurface surveillance in littoral areas around the world. The system has been upgraded to the MIUW-SU variant, which includes enhancements to the transportable AN/TSQ-108A Radar Sonar Surveillance Centre (RSSC). This

element of the system incorporates an upgraded AN/SQR-17A(V)3 acoustic processor and ESM, together with improved communications. The RSSC operates in conjunction with a portable sensor platform, mobile sensor platform and lightweight underwater sensor string than can be deployed from small boats.

The MSP is mounted in a HMMWV utility vehicle to permit rapid deployment. The vehicle is fitted with a thermal imaging sensor and a visual imaging sensor collocated on a computer-controlled pan and tilt mechanism and a Furuno X-band surface search radar with a radar track processor. A microwave link transmits radar and data imagery back to the RSSC over distances of up to 10 km.

Operational status

There are 22 systems operated by US Naval Reserve Units now operational around the world.

NEW ENTRY

Sea Sentinel

Type

Surface and undersea coastal detection and tracking system.

Description

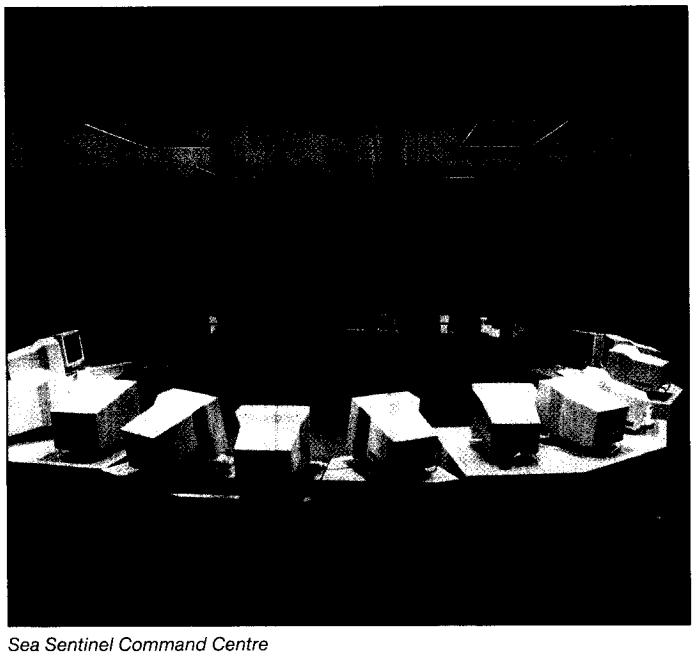
The Undersea Surveillance System (USS) Sea Sentinel is an undersea detection tracking system which uses ruggedised acoustic sensors on ocean floors to perform continuous surveillance and detection of surface or submerged intruders. Potential targets for the system include: surface and subsurface vessels; patrol boats; mining activity; illegal fishing; illegal immigration; terrorists (frogmen); or pirates.

Sea Sentinel quickly and accurately identifies and locates threats, without the need for repeated aircraft or surface vessel patrols or traditional aircraft, surface vessel, or sonobuoy methods. The seabed acoustic sensor comprises a series of air backed (for shallow water) or oil backed (for deep water) ceramic cylindrical hydrophones. These are combined into arrays for installation on the seabed and connected to the shore command centre via a fibre optic cable. The configuration of the arrays is determined from the modelling of environmental data relating to the area in which the system will operate. If required non-acoustic sensors such as magnetic and electric field sensors can be integrated into the system.

The surveillance system's shore-based command centre operates on a modular, open architecture system, incorporating a single or multiring workstation configuration interconnected by industry standard fibre optic LAN that can be tailored to meet specific surveillance requirements. The command centre includes acoustic, geographic, and system control and maintenance displays. Acoustic displays present visual images of sound energy detected by underwater sensors. Geographic displays show contacts on built-in world and national maps. The USS system control and maintenance display enables operational commanders to configure the system displays and workstations for specific tactical situations and continually monitor performance of the system. Monitoring is carried out via individual displays or on large screen format. The system is built entirely from COTS hardware. Software is based on modern object oriented programming techniques. Virtually all operator interface programming is done in C++. Each object is individually configurable.

Advanced spectrum analysis converts signals into frequency components making detection and classification more precise. Adaptive beam-forming reduces interfering sources of noise. Workstations use the same hardware as the signal processing computer. Logistics support and spares are compatible for low cost and ease of maintenance, while COTS hardware and open system architecture reduce installation and maintenance costs.

Sea Sentinel provides more efficient use of existing tactical systems, including ships and aircraft, by timely alert and accurate localisation of threats. The system can be implemented for a small fraction of the cost of traditional aircraft, surface vessels or sonobuoy methods. The underwater components sensors by Raytheon Naval and Maritime Systems comprise hydrophones with internal electronics telemetry components mounted in watertight housings. Sensors are connected to the shore station via fibre optic cable. General Dynamics Advanced Technology Systems provides for long haul telemetry multiplexing and power distribution.



Sea Sentinel Command Centre

Operational status

A demonstrator system has undergone a three-year test period in Puget Sound. The demonstrator comprised a split aperture array some 238 m long incorporating LF, MF and HF nested sub-arrays. These were linked to the shore base housed in a specially fitted out ISO container via a 10 mm diameter electro-optical telecommunications trunk cable some 5 km in length.

Contractors

Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island (underwater sensors and components).

Lockheed Martin Naval Electronics & Surveillance Systems, Undersea Systems, Manassas, Virginia (shore processing and systems integration).

General Dynamics Advanced Technology Systems, Greensboro, North Carolina (long haul telemetry and power).

Global Marine Systems, Southampton, UK (installation and maintenance of underwater cables and arrays).

UPDATED

Sea Sentry

Type

Coastal and harbour surveillance system.

Description

The Sea Sentry system is designed to provide surveillance and protection against intrusion by ships, small boats, submarines and swimmer delivery vehicles operating offshore. It will cover the inshore region including coastlines, straits, harbour, approaches and choke points. The relocatable system can be deployed on short notice for defence, law enforcement or intelligence gathering missions.

Sea Sentry can be deployed in vans for relocation, or in fixed-site installations using radar, acoustic and optical sensors for detection. All sensors are hand deployable in the field and acoustic units can be fully deployed from a small 22 ft boat.

The system uses commercially available components which allow for easy upgrading and expansion to provide systems customised to meet specific requirements. The radar, video and modular acoustic units offer optimum performance by allowing site-specific system configurations.

The sonar subsystem consists of commercially available processors and displays integrated in a modular open architecture that makes use of industry standard interfaces such as VME, SCSI, Ethernet, RS-232, RS-343, RGB and commercially available software. The system is Linux OS with POSIX compliant C and C++ coded applications. The underwater unit uses passive acoustic sensors such as sonobuoys, arrays and omnidirectional string barriers to acoustically detect and track surface and subsurface targets. Sonar contacts are correlated with sonar data and overlaid on site-specific geographic maps to simplify the surveillance assessment. The modular string sensor design allows the customer to site the passive sensors in the optimum configuration dependent on the geographic requirements of the area. The passive string sensors are powered from the van and use fibre optic telemetry for data transmission from sensor to shore.

The radar subsystem comprises one or more commercially available surface search radars modified to improve detection and tracking performance. This subsystem detects and tracks a large number of surface contacts, which it overlays on site-specific geographic maps. This allows the operator to monitor surface vessel positions and movements with geographically referenced real-time tracking data. A radar warning receiver is also provided to gather additional information on surface and airborne emitters.

Command and control is achieved using a combination of voice and record datalinks. HF/VHF/UHF and SATCOM voice links are available in a variety of configurations to meet customer specific requirements.

An embedded training system provides multisensor team training, while acoustic sensor positional training is available as an option. Tactical situation data is readily available in a standard US format for evaluation by the appropriate national authorities.

In addition to the sensor specific displays a single tactical console is used to provide the operator with multisensor contact information.

Contractor

DRS Electronic Systems, Inc, a unit of DRS Technologies, Inc, Gaithersburg, Maryland.

UPDATED

SOSUS

Type
Fixed sound surveillance system.

Development
The current US philosophy regarding defence against the principle ASW threat (hostile submarines) can be summarised by relying on engaging these submarines in forward areas and at barriers before they can get within attacking range of US forces. To do this, reliance rests primarily on American SSNs, SWATH platforms deploying extremely long towed arrays and long-range P3 patrol aircraft supported by underwater surveillance systems.

The ability to locate enemy submarines within broad ocean areas is essential to the task of containing a large hostile submarine force. The Sound Surveillance System (SOSUS) which is now part of the Integrated Undersea Surveillance System (IUSS) has played a major role in this effort for several years. This 40 year old programme has been recognised as nationally important by the Joint Chiefs of Staff.

The first detection of a Soviet submarine was made on 26 June 1962.

Description
SOSUS consists of fixed undersea acoustic networks of passive hydrophone arrays deployed in the Atlantic and Pacific oceans to provide significant detection capabilities. SOSUS functions as an operational network of shore sites that collect, analyse, display and report acoustic data. Strings of hydrophones, preferably laid at the depths of the deep sound channel are located at intervals along a linking cable connected to the shore stations. Submarines are detected using narrowband frequency analysis, using the same LF acquisition and ranging processors common to modern sonobuoys. Over the years the network has evolved as increments were added to expand coverage. In 1992, the US Navy embarked on a SOSUS Consolidation Programme to address the evolving threat, and take advantage of advances in technology. The specific details of this programme remain classified; however, it is known that the improvements include workstation display and communication elements and complementary improvements to the signal and data processing elements, thereby facilitating greater operational use of the data obtained by the undersea array sensors.

With the collapse of Soviet Russia and declining budgets, the SOSUS Consolidation Programme also focused on reducing manning requirements by consolidating processing facilities through the evolution of technology and using the SOSUS system assets for Dual Uses programmes that included whale monitoring and detection. The whale detection system, called the Marine Mammal Acoustic Tracking System (MMATS) centres around a hydrophone monitoring system that automatically identifies calls from several whale species, correlates signals between hydrophones and produces positions and tracks. The Dual Uses programme also makes the considerable assets of SOSUS available to the scientific community for other purposes, to include: acoustic thermometry of ocean climate to study global warming; seismic monitoring; and acoustic tomography for mapping the ocean floor.

To reduce operational costs, more processing and analysis are being accomplished by fewer personnel and with greater use of COTS-based computer systems. In addition, the number of shore facilities and personnel required to support those facilities have been significantly reduced by remoting the signal processing function to distant facilities. As a result, the station forces have reduced staffing to approximately one half the 1992 level. The use of COTS equipment has evolved from about 1 per cent before the SOSUS Consolidation Programme to 60 per cent after its implementation.

Operational status
No longer in production. Remaining arrays maintained by the US Navy. The SOSUS network is in a standby status under which data is available but not continuously monitored and continues to play a key role in Integrated Undersea Surveillance.

Since the ending of the Cold War a number of arrays and shore stations have been closed down.

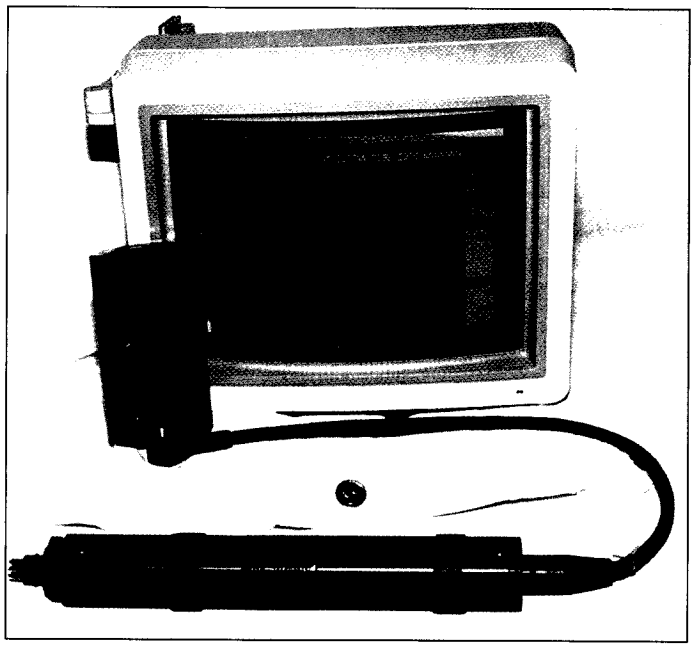
Contractors
General Dynamics Advanced Technology Systems, Greensboro, North Carolina (research, engineering and integration).
TRW, McLean, Virginia (engineering and technical assistance).

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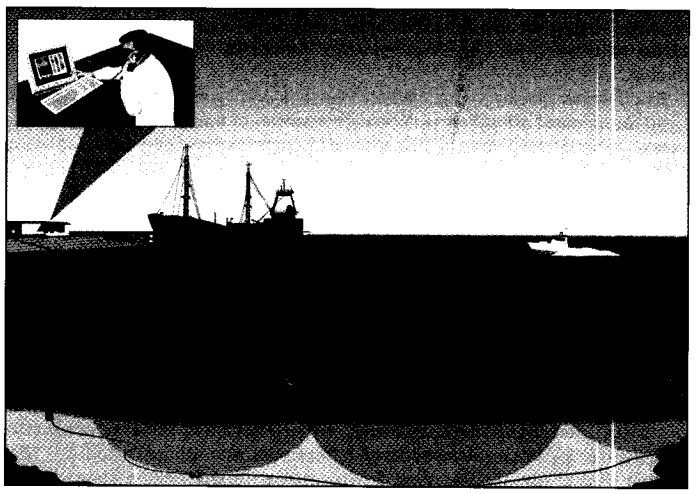
Swimmer detection system

Type
Rapidly deployable active acoustic sonar barrier.

Development
The SAIC active acoustic sonar barrier was specifically designed for the protection of valuable commercial and military assets in shallow water and port areas. This barrier is ideal for harbour security and is intended for use against a variety of target types and sizes including scuba divers, free swimmers, Swimmer Delivery Vehicles (SDVs) and mini-submarines. Lightweight active acoustic elements attached to a cable are arranged along the ocean bottom to form a 'tripwire' zone. The upward-looking active elements form a 'fence' resulting in the display of a target in real time as it moves through the barrier. This simply designed PC-based system is made up of readily available commercial-off-the-shelf (COTS) components which make maintenance and parts replacement quick and easy. Overall system cost is well below that of a fixed conventional system. In addition, the ability to deploy and retrieve this system in a matter of minutes is ideal for the unpredictable and ever changing operational scenario of modern limited warfare and counter-terrorist situations.



Swimmer detection system (rapidly deployable active acoustic sonar barrier) 0077280



Swimmer detection system 0077281

Originally conceived as an internal research and development project in 1990, the active acoustic barrier was first demonstrated in the waters off San Diego in July 1991. In this instance, the system showed excellent detection capability by picking up divers crossing the barrier in 30 ft of water. After another successful demonstration in January 1992, the system was modified to handle greater water depths. During the subsequent July 1993 test, the system successfully detected divers in 60 ft of water with an increased detection range. Maximum water depths of 100 m are practicable.

Operational status
The demonstration system consists of three upward-looking active transducer nodes, 1,000 ft of underwater cable, and a shore-based PC-based signal processing and display system. An operator monitoring the colour waterfall display can clearly see divers or other targets passing through the barrier as brightly coloured swaths against a blue background. Enhancements to the system's target detection and classification algorithms and efforts to add more active nodes to increase the barrier's length (up to 2 km) are continuing. The enhanced design has been considered by the US Navy, US Customs Service, and the Defense Special Weapons Agency.

Contractor
Science Applications International Corporation (SAIC), Ocean and Remote Systems Division, San Diego, California.

VERIFIED

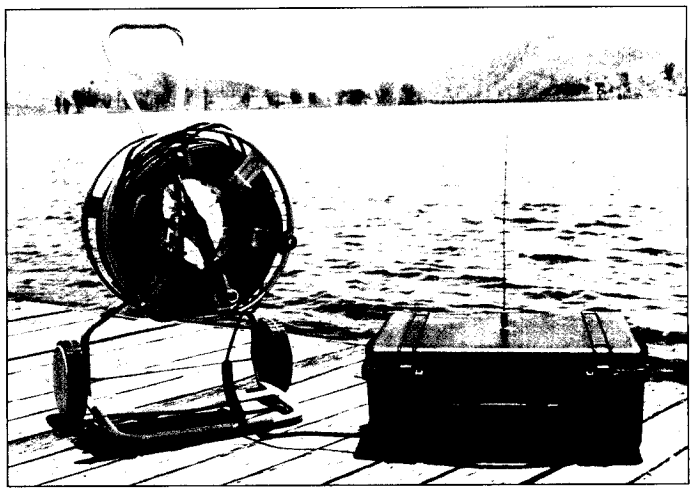
Underwater Sentry

Type
Rapidly deployable passive acoustic boat detector.

Development
The Underwater Sentry is designed to detect and track small vessels entering a restricted area or heading in a suspicious direction on lakes, rivers or coastal waterways. The area under surveillance, the boundary line, and system hours of operation are first preset by the user. Once the system is set up, it will automatically provide an RF-transmitted alert or visual/audio indications when a boat is detected crossing into the restricted area. This covert, rapidly deployable underwater system is designed to operate autonomously in the field for several weeks at a time. An additional option is the provision of a bearing versus time track that can be displayed on a PC or laptop computer, providing the user with a real-time observation tool or monitoring capability. The key features of this system are autonomous operation – no operator required; auto alert; position tracking capability on a 2-dimensional (2-D) geoplot (using two systems); special digital processor-based signal processing to eliminate false alarms; and rapid deployment capability (within 30 minutes).

Operational status
The current demonstration system consists of two passive hydrophones, 400 m of underwater cable, a shore-based signal processing module and a battery pack. The cable and hydrophones are wound onto a portable cable reel for easy, rapid deployment and recovery. The signal processing modules and battery pack are housed in an all-weather environmentally sealed container that can be buried or concealed for covert operation. This basic demonstration system can be adapted or configured to specific customer needs. US and foreign law enforcement agencies have shown interest in the application of this system to detect small boats engaged in illegal smuggling or poaching activities along international border waterways and in marine sanctuaries.

The system has been demonstrated operationally with the US Border Patrol.



Underwater Sentry small boat detection system 0077279

Contractor
Science Applications International Corporation (SAIC), Ocean and Remote Systems Division, San Diego, California.

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juws.janes.com

COUNTERMEASURES

Introduction

The threats facing both submarines and surface ships are many and varied, but one that neither can afford to ignore at their peril is the modern, sophisticated homing torpedo. For surface ships in particular, the torpedo threat is very real. However, most navies have tended to ignore it and pay closer attention to the anti-ship missile. But while attack from the torpedo has not produced such spectacular results as the anti-ship missile during recent conflicts (apart from the sinking of the Argentine cruiser *Belgrano* in the South Atlantic War of 1982), the threat is, nevertheless, very real. It is in fact possibly more dangerous than the anti-ship missile in that, unlike the latter, there is little available in the way of countermeasures to counter the latest generation of torpedoes.

For both submarines and surface ships there has, until recently, been little real progress in the development of anti-torpedo measures since the Second World War. For both, the current primary method of defence remains a towed or expendable noisemaker, with the bubble generator, which uses a chemical reaction to produce a large cloud of bubbles to act as a false target, remaining a primary countermeasure for submarines. Not until the late 1980s was any real progress made in the field of acoustic countermeasures.

Modern torpedo defence systems comprise three main elements:

- intercept sonar
- automated torpedo attack warning processor
- countermeasures

On board submarines a dedicated sonar provides the intercept capability. On surface ships, torpedo warning is provided by a specific array, which forms an adjunct to an existing sonar (these systems are covered in the section on sonars).

The torpedo warning processor is designed to carry out detection, classification, localisation and threat evaluation. In addition it provides tactical advice to the command team on the most effective evasive manoeuvre to perform, linked with the tactical deployment of countermeasures.

There are three main types of acoustic homing torpedo:

- Weapons which passively home onto radiated noise sources such as engines and propellers
- Weapons that actively transmit sonar pulses and home on to the echo from the target, and
- Hybrid passive/active homing weapons.

In addition many of these weapons are now wire guided.

Current developments in acoustic softkill countermeasures to counter acoustic homing torpedoes can be considered to be analogous to the ESM and ASM softkill countermeasures employed in above water warfare. The countermeasure stores themselves currently fall into two categories - decoys and jammers. Both are noisemakers, but the decoy is designed either to confuse the hostile torpedo's homing sensor as it seeks to find its target, or the parent platform's sonar if it is 'locked-on' to the submarine preparatory to firing a torpedo. To achieve this it transmits a radiated noise pattern to emulate the target's signature, but at a higher source level so as to present the passive homer with a more attractive target than the ship it is attacking.

The jammer is used when the torpedo's on-board sensor has homed on to its target and the weapon is commencing its terminal homing phase. Three types of jammer can be employed:

- The broadband jammer that saturates the head of passive and active homers with a high power source
- The complex signal jammer which is customised to increase effectiveness against known threats (both passive and active) and may be optimised to operate at the threat torpedo frequencies
- The echo repeater which re-transmits pulses received from active homing torpedoes, suitably modified to simulate the acoustic properties of the target.

Exact sequence of deployment of the decoy or the jammer may obviously vary according to the tactical situation.

In addition, both types of decoy may be of the static or mobile type, and can be deployed in a mix - again the method of deployment depending on the tactical situation. The main difficulty in deploying a mix of countermeasures is that of ensuring that the various types are correctly co-located in order to present a realistic target scenario to the incoming torpedo.

The latest development currently the subject of study in the USA features expendable countermeasures that can communicate with similar devices and the launch platform. This will enable countermeasures to further confuse and counter incoming torpedoes. Communication between countermeasures and launch platform will allow devices to respond to a changing tactical situation, while the ability to be re-programmed once launched will allow them to operate effectively against an incoming threat in co-operation with the deployment of friendly 'hard kill' measures such as mini torpedoes. By using single-crystal transducer technology a 76 mm diameter mobile device can now produce the same source level as a 152 mm diameter device.

The primary method of launching expendable stores from a submarine is by the Submerged Signal Ejector (SSE) which is fitted inside the pressure hull, allowing the system to be replenished from the boat's internal stores. The latest developments involve mounting a number of launchers between the submarine's outer casing and the pressure hull. This allows several countermeasures to be launched in quick succession to maximise effectiveness, thus overcoming the constraints of reload times with the SSE. The countermeasure/launcher combination is optimised to allow for various combinations of payloads to be launched at various speed, depth and manoeuvring combinations to provide the command with a varied tactical response, and offering the boat unlimited manoeuvring flexibility according to the form of attack.

It is essential that, whatever method of deployment is used, the store is launched noiselessly and positioned correctly at all operating depths and through the full range of manoeuvres in which the submarine is likely to engage, while trying to evade torpedo attack. Launching a decoy from a moving platform poses enormous problems operationally, both for the store and for the platform. The primary concern with the store is that it is not damaged on launch. The store can easily be damaged as it leaves the launch tube, particularly if the submarine is carrying out a violent evasive manoeuvre at high speed. Hydrodynamic forces can also damage the store. Inert stores are particularly susceptible to such damage when they leave the boat under their own power. As they are ejected, they may be damaged by collision with the boat as it manoeuvres. The most delicate part of the store is the tail fin assembly that ensures that the store is maintained at the correct attitude and depth once launched. It is essential that this vital part is not damaged. Equally important is the need to protect the internal electronic assemblies of the store from damage that can be caused through mechanical or hydrodynamic forces as the store is launched.

Developments are currently under way to develop an effective hard kill system to counter the torpedo. Various concepts are under investigation such as electromagnetic guns and high-speed projectiles powered by chemical propellants, as well as mini-torpedoes (see also section on torpedoes).

Other countermeasures used to disguise a target's signature are covered in the section on signature management.

But what is really required for the future, for both submarines and surface vessels, is a torpedo defence system that is fully integrated into the platform's combat system and which, like the surface ship's anti-missile soft/hard kill countermeasures, can be almost entirely automatic in response. The difficulty in developing such a system, however, is that it must be highly sophisticated in order to be 100 per cent effective. If it is not, then the submarine is 'dead' and with it, its highly trained crew. Few navies seem willing, even in collaborative ventures, to devote the necessary funds to developing such a system.

However, the entry into service of the latest generation of torpedoes, using highly sophisticated homing systems and embodying counter-countermeasures, is giving rise to increased efforts to enhance torpedo defence, and both soft and hard kill systems are currently being developed, albeit at a very slow pace. The latest technology now under development relates to expendable sonar countermeasures. These are designed to operate at platform sonar frequencies and would be deployed to prevent an enemy from establishing a fire-control solution, or if already under attack, would jam the sonar of a submarine controlling a wire-guided torpedo.

The other main countermeasure fitted in the submarine is the radar ESM system. Its primary role is to detect radar emissions from surface and airborne platforms, identify them, and warn the boat if it is under threat from a hostile platform or weapon as it comes to the surface. Using this data, together with other sensor data, enables the boat to rapidly draw up a tactical picture of the above water scenario.

The sensor detects emissions, measures their amplitude and analyses the parameters so that the transmission can be identified against a stored library of emitter characteristics. This is combined with an indication to the command that to raise a radar or other sensor mast above the surface would expose the submarine to detection.

Additionally identification of the potentially hostile emitter through signal analysis of its characteristics and comparison with the stored emitter library also provides alert for the initiation of self-protection measures.

In some submarines the ESM can also be used to provide passive targeting information for long-range weapons such as anti-ship torpedoes or missiles. For this function a highly selective antenna is required (for example a high gain reflector). Because this antenna is necessarily much larger than the standard ESM antenna (which is usually mounted on the search periscope) it has to be mounted on a separate mast which is only used for the short duration required to gather data for weapon deployment.

Finally the ESM can be used in the ELINT role providing high intercept capability, limited onboard display, analysis and recording functions so that gathered data can undergo detailed analysis and evaluation ashore.

This function has now greatly increased in importance as the role of the submarine has expanded and the platform has become an integral element of the task force embodying the network centric warfare concept. The credence placed on the submarine's ISR role means that electronic warfare will play a much greater role in the submarine's capacity to conduct littoral warfare operations than previously.

In the past most ESM systems have been configured for open ocean warfare. Now, however, the littoral threat presents a much more demanding scenario for which many ESM systems were not conceived. Signal density is very high and covers a much wider range of targets including naval platforms, commercial shipping, shore-based emitters as well as airborne emitters, both commercial and military. In addition, electromagnetic interference from TV and cellular radio, as well as military emissions from datalinks all add to the confusion of signals. Furthermore all these potential emitters are in much closer proximity to the submarine than they might have been in the open ocean.

To cater for this complex scenario, ESM systems require channelised receivers to provide for the intercept and measurement of several simultaneous signals while narrowband receivers are needed to search for individual low power radars that would be hidden in the dense environment. In addition the measurement of

unintentional modulation within transmitted radar pulses, together with the use of more capable signal sorting algorithms, are necessary to provide greater confidence in signal analysis and identification.

Finally, all this data must be analysed and processed to provide the command with a real time situation report to allow appropriate measures to be undertaken for successful operation.

Allied to the radar warning ESM system is the communications ESM element. In view of the developments in communications between submarines and the outer world and the need for communications contact to be maintained – at least to the submarine if not in the reverse direction – it is now essential for submarines to carry some form of communications ESM capability. Communications ESM systems fall primarily into three main categories – warning, surveillance and over the horizon targeting. In the warning role the communications ESM rapidly scans the frequency spectrum to detect HF/VHF/UHF transmissions originating from a platform (surface or submerged) in the operating area of the submarine. Automatic warning (visual and audio) is given of any detected transmissions. In the surveillance role the full frequency spectrum is monitored to detect any transmissions. These are then recorded and analysed to identify transmission patterns and level of activity. Submarines, because of their covert mode of operation, are ideal platforms with which to carry out this SIGINT operation.

Finally communications ESM can be used for over the horizon targeting. In this role the communications ESM provides bearings on hostile transmissions at much greater ranges than radar ESM, the data from which can be used to assist in providing five control solutions for torpedoes and submarine launched anti-ship missiles.

Requirements for communications ESM systems require that the antenna be mounted on an existing mast to reduce unwanted mast exposure. The most suitable mast will be one used for some of the electro-optic sensors.

Other areas requiring attention are the full integration of communications ESM processed data with the command system, extensive signature libraries and, of course, security. System demands include an ability to carry out fast acquisition, perform narrowband search and monitoring with the need to employ scanning receivers and wideband open receiver.

To cater for future developments array communications ESM systems will need to be configured with open architecture, together with the ability to make use of COTS technology.

UPDATED

ACOUSTIC DECOYS

France

LAT

Type
Anti-torpedo jammer.

Description
Etienne Lacroix Defense has developed the LAT anti-torpedo jammer for deployment from surface vessels using the New Generation Dagaie System (NGDS). The jammer generates a high intensity acoustic signal in the low frequency band from several hundred Hz to >20/30 kHz. The rugged effector can be deployed in the close vicinity of the ship as well as at long range and has an effective duration of up to 10 minutes. It is available in two operating modes: in a straight jam mode close in; or deployed by rocket out to a range of 2,000 m from the ship in a decoy mode. In the NGDS system it uses the EADS launcher and data processing together with the anti-missile elements.

Operational status
Fully developed. The NGDS will equip the French Forbin class Horizon frigates.

Contractor
Etienne Lacroix Defense, France.

VERIFIED

Sea Defender/TMS 4550

Type
Integrated anti-torpedo countermeasure system.

Description
The fully integrated Sea Defender system (TMS 4550) combines technology from the existing Satar (TMS 4520) and Albatros (TMS 4530) torpedo alert systems, a threat assessment and reaction system developed jointly with Frequency Engineering Laboratories in the USA and provision to use a range of jammer/decoy effectors. The detection, classification and localisation subsystem is based on a towed array sonar with automatic left/right ambiguity resolution and signal and data processing. A threat assessment and reaction subsystem uses the track data generated by the alert system to determine and recommend optimum ship manoeuvre patterns and countermeasure response. The countermeasure system is based on the SLQ-25A Nixie and an optional launched effector system using existing countermeasures.

Sea Defender provides omnidirectional coverage maintaining continuous contact with the target through the use of the short array. It features a low false alarm rate resulting from an optimised receive bandwidth and the use of a 2-stage neural net classification scheme.

Operational status
A variant of Sea Defender will be installed on the Australian Navy's six Adelaide class frigates under an upgrade programme.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Germany

TCM 2000

Type
Torpedo countermeasure system for submarines.

Description
Developed in 1995, the TCM 2000 is a rapid reaction, multi-effector, soft kill concept developed to meet the requirement for a torpedo countermeasures system for the new Type 212 submarines for the German and Italian navies. It is designed to counter modern and advanced lightweight torpedoes and also wire-guided and non wire-guided, acoustic homing heavyweight torpedoes, by effectively decoying them using threat-matched jam and decoy functions.

TCM 2000 is designed to operate in a similar way to missile decoys, seducing the torpedo and causing it to break contact with its intended target, deceiving the weapon's sonar by one or more decoys, and exhausting its energy in carrying out ineffective re-attack procedures to regain contact with the target, which meanwhile carries out evasive manoeuvres. The essential functions will be carried out by autonomously deploying effectors that work in jam or decoy mode. The deployment of a number of effectors creates a multitarget scenario which confuses the weapon's intelligence and its re-attack capabilities. To build up a multitarget scenario the mobile effectors are fitted with powerful acoustic functions for jamming and decoying the torpedo.

For jamming, the transmitted signal from an effector must be significantly higher than the incoming echo signal from the submarine, so that the latter is hidden by the decoy signal and torpedo contact with it is broken. For decoying the deceptive signal generated by the effector is as similar as possible to the signal which would be created by the real target. It is, however, transmitted from a different location and therefore attracts the torpedo away from the submarine.

To counter passive homing torpedoes or torpedoes operating in active plus passive mode, the jammers can assume the characteristic of a passive target.

In order to carry out its designed functions the system incorporates an acoustic transducer array which provides omnidirectional transmitting and receiving characteristics in an appropriate broad frequency range.

Torpedo threat detection and alarm are generated by the submarine sonar providing bearing details which are continuously fed to the TCM 2000 which is maintained in a constant standby condition ready to respond to any alert. After launch the first effector operates in jamming mode to confuse the torpedo and cause it to break contact, after which the second effector operates in decoy mode to simulate a realistic alternative target. The movement and false target signatures presented by the effectors follow precisely the speed profile and noise signature of the intended target, causing the torpedo to re-attack various decoys and so be drawn away from the real target.

Short reaction time is one of the design features, and the system is flexible enough to launch effectors having various performance parameters and meeting the customer's specific requirements. About 10 discharge units with 127 mm effectors are placed in one launch container that is integrated to form a flush surface with the surrounding structure. One or two containers can be provided on each side of the boat.

Main features of the system are:

- Short time of preparation for discharge
- Discharge of several effectors in a short time
- Discharge without bubbles and swell
- High degree of functionality and safety
- No adverse effect on hull signatures
- Compatibility with submarine systems
- Automative or interactive operation
- Easy loading and unloading of launch containers
- Possibility of retrofit
- Design according to rules and regulations for submarine.

Operational status
Under development.

Contractors
HDW, Kiel, Germany.

VERIFIED

India

Toted

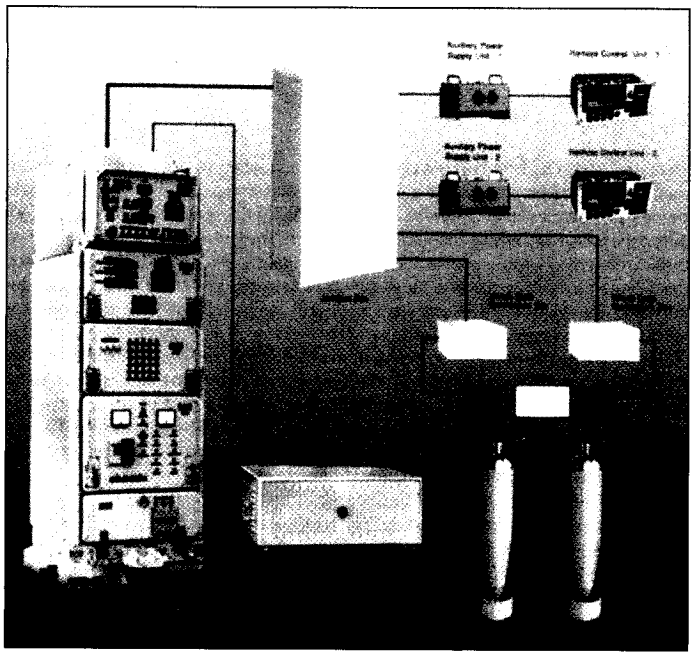
Type
Towed torpedo decoy.

Description
Toted is an acoustic countermeasure system derived and developed from the British Type 182 for deployment from surface ships. Its primary role is to decoy attacking active and passive homing torpedoes away from the ship towards its remotely controlled decoying signal.

The decoy signal is electronically generated in the main electronics unit. The signal is amplified by a high-gain wideband amplifier and fed to the piezoelectric transducer housed inside the towfish via an electromechanical cable wound on a cable drum on the winch deck. Horizontal beamwidth is 140°, vertical beamwidth 50°. The minimum transmission source level is 85 dB. The towfish is deployed approximately 400 m away from the ship. The high-intensity acoustic signal produced is designed to divert passive homing torpedoes astern and confuse or jam the steering mechanisms of active homing torpedoes.

Provision is made to eliminate interference with 'own ship's' sonar or with sonars of other ships nearby through front panel selectable filters.

Facilities are available to monitor the depth and roll of the towed fish.



The Toted system (Bharat Electronics Ltd) 1027399

Operational status
In service with the Indian Navy aboard Godavari class frigates. It is believed that up to six systems have been delivered and more are on order for the Brahmaputra class frigates.

Specifications
Operating modes: noise – passive homing torpedoes; CW – active homing torpedoes; noise/CW – both passive and active homing torpedoes
Beam pattern: horizontal >140°; vertical >50°
Transmission source level: 85 dB (min – ref 1 micro bar) in noise mode

Contractor
Bharat Electronics Ltd,Bangalore.

UPDATED

International

CIRCE

Type
Integrated anti-torpedo countermeasures system.

Description
HDW in Germany and WASS of Italy have jointly developed the Circe rapid reaction multi-effector soft kill torpedo countermeasures system. Circe is designed to counter modern lightweight and wire and non wire-guided acoustic homing heavyweight torpedoes.

The system operates using threat-matched stationary jammers and mobile decoys. The decoys are able to produce echoes for any type of torpedo acoustic transmission by means of wide band signal processing and separate acoustic receiver and transmitter.

The system comprises:
- a launching system mounted externally on the pressure hull of the submarine
- a control computer, fitted with a MMI and connected with the submarine's torpedo detection system, which controls the launch of the countermeasures

The jammer features a highly efficient transducer covering the whole torpedo bandwidth, with a switching power amplifier and high-energy density thermal battery. The jammer generates a very high amount of energy spread over the entire reception band of the acoustic head of the torpedo. By emitting a high intensity broadband noise, the jammer masks the target echo as well as target radiated noise, preventing target acquisition by the torpedo.

The mobile decoys must draw the torpedo away from its real target. To achieve the deception effect, the mobile decoy uses a sophisticated transponder to simulate a real target, generating in real-time acoustic echoes to any multifrequency-coded pulse emitted by the torpedo. The echo structure is equal to the one of a real target (acoustic length, highlights). During its underwater run the mobile decoy radiates noise in order to be representative of a moving target. The noise radiation occurs independently from the transponder function. Decoys feature, over a wide band, a constant target strength, and are compatible with the jammer's presence, also a short distance from these. A high energy density thermal propulsion battery powers the mobile decoy. The underwater trajectory of the mobile decoys is pre-set immediately before launch. The vectors of the mobile target emulator are derived from the A200 mini-torpedo developed by WASS within the frame of the LCAW.

The modular design and commonality with existing devices, combined with simple functional architecture, enables the effectors to be easily interfaced with the majority of existing platforms.

The countermeasures are deployed from a dedicated launching system, one for each side of the submarine, comprising a multibarrelled module fitted externally to the pressure hull. The number of barrels per module and the number of modules can be tailored to meet customer requirements.

The system is controlled from a control computer in the operations room. The panel of the control computer displays the status of the launchers and countermeasures. The system operates automatically via a link with the torpedo alert system. The submarine's sonar provides threat detection and alarm signals that are continuously fed to the Circe system, which remains in constant standby ready to respond to any alert. Manual control of the system is also possible.

Operational status
Ordered for the Type 212A programme for Germany and Italy and for the Greek Type 214 Programme.

Contractors
HDW, Kiel.
Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy.

UPDATED

LESCUT

Type
Surface ship deployed, reactive, expendable torpedo decoy.

Description
The LESCUT (Launched Expendable Scutter) is a joint product between Rafael of Israel and BAE Systems, USA. It is a rocket or mortar launched, expendable torpedo decoy based on the BAE Systems Lead ballistic module and acoustic module and on Rafael's Scutter electronics, software and logic.

The LESCUT uses the body of a standard chaff round into which is fitted a flotation bag and the acoustic payload, which is Scutter (or SUBSCUT) equivalent. LESCUT can be rocket or mortar launched from a long list of standard chaff launchers that can be found throughout the world, such as SBROC Mk 36, Super Barracuda, as well as Rafael's IDS. LESCUT can also be launched pneumatically over the side in a short-range version. The decoy is launched on a timing signal from the ATDS system to take responsibility for an incoming torpedo from a towed decoy or to form a decoy barrier in other torpedo defence systems. The pattern is defined by the relative angle of the launcher, and the range is selected through settings to a rocket or selection, or a mortar round. The range of LESCUT is up to 2,000 m with the rocket round, and 200 m in the mortar round.

After entering into the water the acoustic logic and characteristics are the same as in Scutter or SUBSCUT (see separate entries on Scutter and SUBSCUT).

Operational status
Under contract.

Specifications
Diameter: 130 mm (for Mk 36 launcher)
Length: 1,224 mm rocket round, 1,226 mortar round
Weight: 25.9 kg
Frequency range: 17 – 85 kHz
Transmission source level: >180 dB/µPa/m
Duration: 8 minutes

Contractors
Rafael Armament Development Authority Ltd, Ordnance Systems Division, Haifa, Israel.
BAE Systems, Ocean Systems, Braintree, Massachusetts, USA.

VERIFIED

SLAT

Type
Integrated anti-torpedo warfare system.

Description
The Franco-Italian SLAT (Système de Lutte Anti-Torpille) Project, initiated in 1993 with the development phase beginning in 2000 and final qualification in 2003, is a fully integrated system incorporating the ALERTO acoustic sensor, RATO reaction and CMAT countermeasure subsystems. The system is fully automatic and reactive and incorporates a countermeasure-effectiveness assessment capability from which it determines the reaction (in terms of countermeasure deployment and counter manoeuvre advice) and whether further reactions will be required in the face of repeated attacks.

SLAT uses a linear towed array sonar with bearing ambiguity resolution capability using up to 100 beams, with automatic and operator assisted target

classification using a tracking and spectral analysis process with broadband and narrowband signature analysis to track the course of the engagement and initiate further responses if required. These are further aided by combining data fusion techniques featuring data from the hull-mounted and towed array sonars and the towed and intercept arrays. The 42-element linear towed array provides detection, classification and warning over 360° in azimuth. The receiver is mounted in the main towed array antenna and is supplemented by an optional complementary antenna incorporated in the ship's bow sonar system.

The anti-torpedo reaction is initiated by a torpedo alarm, which can be generated by the dedicated sensor (ALERTO), by an external system or by the operator. It is calculated by the RATO sub-system on the basis of the threat's characteristics. The reaction comprises the deployment of a salvo of soft-kill countermeasures (a sequence of deployment is calculated) and suggested evasive manoeuvres by the ship.

The CMAT sub-system assures the countermeasure deployment and the functions of the countermeasures.

SLAT uses two types of soft-kill countermeasure:

- A jammer effector, Spartacus, which is fired from a Sagaie launcher and descends to the sea surface by parachute where it is then suspended from a float, transmitting a signal which masks the acoustic signatures of the ship, allowing it to manoeuvre out of danger.
- The mobile target emulator countermeasure dedicated to deceiving the incoming torpedo by simulating its intended target. The mobile target emulator is pre-set at launch in order to perform an optimum pattern for the characteristics of the threat.

The acoustic decoys/jammers operate over an extensive broadband with high emission levels. Control is exercised from a console with two displays or from two single consoles. The deployment of the countermeasures is performed by two dedicated trainable launchers with 12 tubes each (Sagaie).

Operational status

A prototype SLAT carried out sea trials aboard the French carrier *Foch* at the end of 1994 and on the Italian trials vessel *Alpino* during 2002-03. The system now equips the Italian carrier *Giuseppe Garibaldi* and will also be fitted in the new carrier *Andrea Doria* which will have two launchers. In 2006, the system is scheduled to be fitted to the French nuclear carrier *Charles de Gaulle*. It will also be installed on the new French and Italian 'Horizon' type frigates (each country has two units currently under construction). It also equips the three new Saudi Arabian 'Al Riyadh' class frigates.

Contractors

DCN, Paris, France.
Thales Underwater Systems, Sophia Antipolis, France.
Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy.

UPDATED

SUBSCUT

Type

Submarine deployed, reactive, expendable torpedo decoy.

Description

SUBSCUT is a joint product between Rafael of Israel and Ultra Electronics Ocean Systems of the USA. It is a self-propelled, 3 in reactive, expendable torpedo decoy based on the Ultra Electronics hardware and Rafael's Scutter electronics, software and logic. SUBSCUT is designed to respond to two different types of torpedo simultaneously, whether they are active passive or passive/active homing.

SUBSCUT is a reactive decoy. On receipt of a torpedo alert on board, SUBSCUT is launched from any SSE (including 76 mm) or from an external launcher. The decoy is automatically initiated after launch, the decoy propelling itself to a preset depth between 10 and 300 m where it hovers and listens for the torpedo transmissions.

Active acoustic transmissions are detected and analysed and the decoy selects and generates the appropriate deception signal for transmission, including Doppler effect simulations and simulation of the noise generated by the submarine. This allows the submarine to perform evasive manoeuvres. If no torpedo transmissions are detected, SUBSCUT incorporates generic responses that are transmitted to counter passive homing torpedoes.

The decoy computer library contains threat correlations and threat identifications. The program provides tailored responses to defeat various logics incorporated in modern torpedoes, such as range gates, Doppler shifts and target discrimination. The decoy can be programmed for specific known threat characteristics.

The decoy can operate for between 5 and 10 minutes at depths down to 300 m providing 360° coverage. The decoy sinks on completion of its mission, thus preventing its retrieval by hostile forces.

SUBSCUT retains all Scutter capabilities in a 76 mm device similar to that used by the US Navy.

Operational status

Development of the product has been completed and it became operational in the 2nd quarter of 2003.

Specifications

Length: 1,020 mm
Diameter: 101 mm
Weight: 4 kg
Frequency range: 17 – 85 kHz
Transmission source level: >180 dB/µPa/m
Duration: 10 minutes
Operational depth: 10-300 m

Contractors

Rafael, Armament Development Authority Ltd, Ordnance Systems Division, Haifa, Israel.
Ultra Electronics Ocean Systems, Braintree, Massachusetts, USA.

UPDATED

Israel

ATC-1

Type

Acoustic torpedo decoy.

Description

ATC-1 (Acoustic Torpedo Countermeasures-1) is a towed decoy, developed to counter modern, high-speed acoustic-homing active/passive torpedoes. It generates and transmits strong acoustic signals which are accepted as a legitimate target by attacking torpedoes which home in on the decoy and attack and reattack until its power source is exhausted and it sinks.

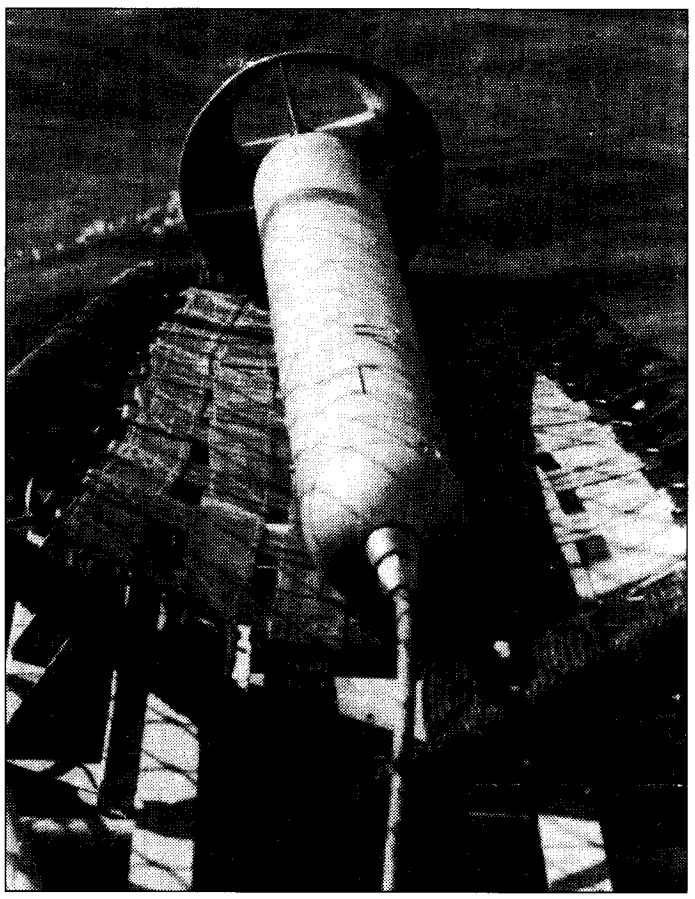
The ATC-1 does not restrict the speed or manoeuvrability of the towing ship. Lightweight, compact and reliable, it is simple to install and requires a minimum of deck and below deck space.

Compatible with a wide range of both naval and merchant vessels, from fast missile boats, corvettes, frigates and destroyers to cargo ships and tankers, the ATC-1 has been designed, built and tested to MIL-E-16400. The decoy does not interfere with other systems on board, and is not affected by them. Optimal vessel protection is ensured by a frequency range that covers all existing homing heads.

The ATC-1 features a towed body, together with winch, launch and recovery units weighing a total of 1,325 kg. Also on board the ship is an electronics cabinet weighing 190 kg and a remote-control unit weighing 10 kg, neither of which requires much space. The manufacturer claims that a single operator is required for the system.

The towed body consists of three sections:

- the nose assembly incorporating the towpoint containing a watertight member which absorbs the mechanical load of the tow cable



Rafael ATC-1 towed body

- the transducer assembly
- the tail assembly incorporating stabilising fins and a shroud ring which regulates the movement of the towed body through the water

The towing cable is a double armour, electro-mechanical cable with electrical conductors feeding the transducers running within the cable.

The ATC-1 is a multithreat countermeasure with the capability of handling up to 12 simultaneously attacking torpedoes of various types.

Specifications
Length: 1,200 mm
Diameter: 300 mm
Weight: 25 kg (in air)

Operational status
In service. Operational aboard the Israeli Eilat class corvettes. The system will be replaced by ATDS.

Contractor
Rafael, Armament Development Authority Ltd, Ordnance Systems Division, Defense Directorate, Acoustic Systems, Haifa.

VERIFIED

ATC-2

Type
Acoustic torpedo decoy.

Description
ATC-2 is an upgraded ATC-1 decoy that can synthesise a signal with a coverage of all known torpedo frequencies from 17 to 85 kHz with a variety of profiles and with a very high source level of 187 dB/µPa/m. The decoy simultaneously transmits and listens for the radiated signature of a torpedo as it passes at close range.

It offers unique short-range torpedo detection capabilities to pinpoint incoming torpedoes.

Operational status
ATC-2 is designed to form part of the ATDS torpedo defence system in concept stage.

Contractor
Rafael, Armament Development Authority Ltd, Ordnance Systems Division, Defense Directorate, Acoustic Systems, Haifa.

VERIFIED

ATDS

Type
Advanced Torpedo Defence System.

Description
This concept has been developed to provide surface ships with a defence system to counter modern torpedoes fitted with advanced counter-countermeasures subsystems by using a layered defence concept.

The system comprises a Torpedo Detection Towed Array (TDTA) for long-range sonar detection of torpedoes, the ATC-2 (an upgraded ATC-1) towed decoy which simultaneously transmits acoustic signals and provides close-range localisation of the torpedo and Scutter – an expendable, intelligent decoy which is deployed from the ship to finally divert and decoy the torpedo using tailored or generic responses until its fuel is exhausted.

The TDTA and ATC-2 are towed in tandem by a cable carrying the electronics signals between the surface ship and the sensors. Typically the TDTA and ATC-2 are towed at a distance of about 500 m behind the ship, being deployed as soon as the vessel leaves harbour.

The first phase of the operation involves the TDTA providing a 360° coverage alert and bearing data of the launch of a torpedo and noise signals radiated by the weapon at detection ranges of several kilometres. Onboard electronics process the signal data from the TDTA, received from the torpedo's propulsion system to provide classification and identification of the attacking weapon. This intelligence provides the defending vessel with sufficient time to engage the second layer of defence to effectively counter the threat.

The second layer of defence requires the processed data from the TDTA to be fed to the ATC-2 which responds by transmitting a signal tailored to decoy the torpedo. The torpedo then attacks the towed ATC-2 and even modern torpedoes will make their initial attack on the first target of preference, the ATC-2. Simultaneously, while transmitting, the ATC-2 also listens for the radiated signature of the torpedo as it passes at close range. Detection of the torpedo enables it to be localised in time and space, thus providing the ship with time to manoeuvre while initiating deployment of the Scutter decoy.

Originally designed for submarine defence against homing torpedoes, Scutter is able to receive, classify and identify active acoustic transmissions from homing torpedoes and to respond accordingly with its own decoy transmission. A passive homing torpedo will correspondingly receive transmissions from Scutter which are acceptable on board computers. The torpedo then attacks the Scutter. Depending on the type of threat, a sequence of Scutter decoys can be deployed while the torpedo attacks each one in turn until its fuel supply is exhausted.

The ATDS comprises a 'wet end' integrated towed array equipment and on board hardware and software. An operator's console contains two 19 in colour monitors and human machine interface tools.

The 'wet end' features a 500 m towcable, a towed body housing the TDTA front end electronics, depth, vibration and direction sensors and the ATC-2 transducers, the TDTA mini line towed array and a tail stabilising module as well as vibration isolation module.

Onboard hardware and software features the electronic console containing: TDTA analogue front end, amplifiers, filters, digital/analogue and analogue/digital circuitry, beam-forming algorithms, trackers and signal processors; ATC-2 close-range detection circuitry, low power unit and synthesiser and power amplifiers.

Target detection is affected in two modes: broadband and narrowband. Tracking and classification is based on broadband, narrowband and Demon data. The principle features include: broadband detection with automatic normalisation and jammer rejection; narrowband detection with 4 Hz resolution; eight trackers using broadband, narrowband and Demon data; and long-range torpedo detection and alert.

The broadband detection process provides the operator with all frequency bands and a sector coverage of nearly 360°. The broadband detector features true linear beam-forming with a full dynamic range. It reduces the masking effects of low level sources by high-level sources and beam-forming of patterns with very low sidelobes. Other features include automatic narrowband jammer rejection and true bearing stabilisation to allow long time integration. Spatial normalisation provides a clear and legible picture on the display by suppressing sea noise on each beam and compressing sea noise variance over the 360° coverage. In addition, integration time is selectable from 1 to 128 seconds.

The narrowband detector features true linear beam-forming and panoramic filtering with a fine spectral analysis performed on each beam. Frequency resolution is matched to expected tonal widths and offers a preclassification capability right from the time of detection. Frequency normalisation improves detection and enhances the display presentation. Integration time is selectable to optimise the detection range with contact dynamics and signal-to-noise ratios. A complementary integration gain is attained through visual integration provided by the display which presents a picture of the frequency lines.

Eight targets can be tracked simultaneously and automatically following operator initiation. Additional targets can be tracked manually using a cursor. The automatic tracker uses up to seven data sources to obtain each target's bearing. The sources include broadband information, three narrowband trackers and three Demon trackers. Data sources are integrated to form one common bearing. The tracking module can handle a large dynamic range, high bearing rates, crossing targets and end-fire crossings.

An alert is sounded immediately a torpedo is detected. Simultaneously, torpedo bearing and identification data are provided to facilitate activation of anti-torpedo self-defence countermeasures.

Contractor
Rafael, Armament Development Authority Ltd, Ordnance Systems Division, Defense Directorate, Acoustic Systems, Haifa.

VERIFIED

Scutter

Type
Submarine and surface ship-deployed expendable torpedo decoy.

Description
Scutter is a self-propelled expendable torpedo decoy designed to respond to two different types of torpedo simultaneously and against the threat from acoustic homing active and/or passive torpedo threats. On receipt of a torpedo alert, Scutter is launched from any standard submarine internal signal ejector or external hull-mounted launcher. System operation is automatically initiated after launch, the decoy listens for torpedo transmissions. It then propels itself automatically to a depth between 10 and 300 m.

Active acoustic torpedo transmissions detected are analysed and the decoy selects and generates the appropriate deception signals for transmission, including Doppler effect simulations and simulation of noise radiated by the launch platform. This allows the launch platform to perform evasive manoeuvres. If no torpedo transmissions are detected, Scutter incorporates generic responses which are transmitted to counter passive homing weapons. The decoy's computer 'library' contains threat correlations and threat identification and its programs provide tailored responses to defeat various logics incorporated in a modern torpedo such as range gates, Doppler shifts, target discrimination and so on. The decoy can be programmed for specific known threat characteristics.

The decoy can operate for up to 8 minutes at depths down to 300 m providing 360° coverage. The decoy self-destructs and sinks on completion of the mission thus preventing retrieval by hostile forces.

Scutter can be deployed by all types of submarine and has no special installation requirements and no presets. Due to its light weight and compact size it takes up very little space.

The decoy's hydrodynamically shaped body is manufactured from composite materials which house the acoustic transducer, electronic boards, thermal batteries, electric motor, propeller and an external waterproof test connector.

Operational status
The system is in service aboard the Dolphin and Gal class submarines and has also been exported.

Specifications
Length: 1,020 mm
Diameter: 101 mm
Weight: 7.8 kg
Frequency range: 17-85 kHz
Transmission source level: >180 dB/µPa/m
Receive threshold: >130 dB/µPa
Operating life: 8 min
Operating depth: 10-300 m

Contractor
Rafael, Armament Development Authority Ltd, Ordnance Systems Division, Defense Directorate, Acoustic Systems, Haifa.

VERIFIED

Italy

C303

Type
Submarine anti-torpedo countermeasures system.

Description
This is an anti-torpedo countermeasures system designed to counter attacks by acoustic homing, active/passive, lightweight and heavyweight, wire and non wire-guided torpedoes, using expendable stationary jammers and decoys. The decoys are able to produce echoes for any type of torpedo acoustic transmission, by means of wide band signal processing and separate acoustic receiver and transmitter.

The countermeasures system consists of:
- The countermeasures launching system, mounted externally on the pressure hull of the submarine
- The control computer equipped with a MMI, which controls the launch of the countermeasures.

The jammer features a highly efficient transducer, covering the whole torpedo bandwidth, with a switching power amplifier and high-energy density thermal battery. The jammer generates a very high amount of energy spread over the entire reception band of the acoustic head of the torpedo. By emitting a high intensity broadband noise, the jammer masks the target echo as well as target radiated noise, preventing target acquisition by the torpedo.

To achieve the deception effect, the mobile decoy uses a sophisticated transponder to simulate a real target, generating in real time acoustic echoes to any multifrequency coded pulse emitted by the torpedo. The echo structure is equal to the one of a real target (acoustic length, highlights) and, in order to represent a moving target, applies Doppler and coherent range rate to the echo and radiates noise independently from the transponder function. Decoys feature, over a wide band, a constant target strength, and are compatible with the jammer's presence, also a short distance from these.

The modular design and commonality with existing devices, combined with simple functional architecture enables the effectors to be easily interfaced with the majority of existing platforms.

The countermeasures are deployed from a dedicated launching system, one for each side of the submarine, comprising a multibarrelled module fitted externally to the pressure hull. The number of barrels per module and the number of modules can be tailored to meet customer requirements. Each barrel, loaded with appropriate countermeasure, contains its own air bottle, electro-valve and launching tube, thus remaining independent of all the other launch barrels. Such an arrangement provides defence against up to six torpedo engagements. The launchers are in fixed positions (no movement of the launching tubes is required to launch the countermeasures) and leave unchanged the external profile of the submarine.

The system is controlled from a control computer in the operations room where the operator selects the type and number of effectors for the salvo to be deployed. The panel of the control computer displays the status of the launchers and countermeasures. The system can be controlled automatically via a link with the torpedo alert system.

Operational status
1989 - Development of the devices commenced.

Successful sea acceptance trials have been conducted on a submarine (understood to be Indian).

Specifications
Jammer: stationary
Length: 1,125 mm
Diameter: 76.2 mm
Weight: 10 kg

Decoy: stationary
Length: 1,125 mm
Diameter: 76.2 mm
Weight: 10 kg

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

C303/S

Type
Submarine anti-torpedo countermeasures system.

Description
This is an anti-torpedo countermeasures system designed to counter attacks by acoustic homing, active/passive, lightweight and heavyweight, wire and non-wire-guided torpedoes, using expendable stationary jammers and decoys. The decoys are able to produce echoes for any type of torpedo acoustic transmission, by means of wide band signal processing and separate acoustic receiver and transmitter.

The countermeasures system consists of:
- The countermeasures launching system, mounted externally on the pressure hull of the submarine
- The control computer equipped with a MMI, and linked with the torpedo detection system to control the launch of the countermeasures.

The jammer features a highly efficient transducer, covering the whole torpedo bandwidth, with a switching power amplifier and high-energy density thermal battery. The jammer generates a very high amount of energy spread over the entire reception band of the acoustic head of the torpedo. By emitting a high intensity broadband noise, the jammer masks the target echo as well as target radiated noise, preventing target acquisition by the torpedo.

To achieve the deception effect, the mobile decoy uses a sophisticated transponder to simulate a real target, generating in real time acoustic echoes to any multifrequency coded pulse emitted by the torpedo. The echo structure is equal to the one of a real target (acoustic length, highlights). During its run the mobile decoy radiates noise to be representative of a moving target. The noise radiation is independent of the transponder function. Decoys feature, over a wide band, a constant target strength, and are compatible with the jammer's presence, also a short distance from these. The mobile decoy is powered by a high energy density thermal propulsion battery.

The underwater trajectory of the mobile decoy is preset immediately prior to launch. The vectors of the mobile target emulator are derived from the A200 mini-torpedo developed by WASS within the frame of the LCAW.

The modular design and commonality with existing devices, combined with simple functional architecture enables the effectors to be easily interfaced with the majority of existing platforms.

The countermeasures are deployed from a dedicated launching system, one for each side of the submarine, comprising a multibarrelled module fitted externally to the pressure hull. The number of barrels per module and the number of modules can be tailored to meet customer requirements. Each barrel, loaded with appropriate countermeasure, contains its own air bottle, electro-valve and launching tube, thus remaining independent of all the other launch barrels. The launchers are in fixed positions (no movement of the launching tubes is required to launch the countermeasures) and leave unchanged the external profile of the submarine.

The system is controlled from a control computer in the operations room. The panel of the control computer displays the status of the launchers and countermeasures. The system operates automatically via a link with the torpedo alert system. The submarine's sonar provides threat detection and alarm signals which are continuously fed to the system, which remains in constant standby ready to respond to any alert. Manual control of the system is also possible.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

Specifications
Jammer: stationary
Length: 1,125 mm
Diameter: 127 mm
Weight: 15 kg

Decoy: mobile
Length: 1,125 mm
Diameter: 127 mm
Weight: 15 kg

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

NEW ENTRY

C309

Type
Surface ship anti-torpedo countermeasures system.

Description
The C309 anti-torpedo countermeasures system is designed to deal with the current generation of active and/or passive torpedoes in service, wire or non wire-guided, launched singly or in salvo mode.

The expendable effectors are based on low-cost, lightweight, high performance devices. Surface vessels deploy the devices during the course of special evasive counter-manoeuvres that are designed to maximise a ship's survivability in the face of modern torpedo tactics and against multiple torpedo attack.

The C309 system comprises two types of effectors – stationary jammers and stationary decoys – and a launching system. The latter comprises a control computer, junction boxes and trainable launchers. The launch system comprises two trainable launchers carrying a number of barrels. The number of barrels per launcher is tailored according to customer requirements. Each barrel is loaded with the relevant effector (jammers and decoys). Each barrel consists of a launch tube, an air bottle and an electro-valve.

The system control computer mounted in the ship's combat centre supervises deployment of countermeasures. The control computer carries out selection of type, number, deployment angle and range of countermeasures and suggests the best counter-manoeuvre to perform in order to optimise the reaction to the attack; displays the status of the launch tubes (whether they are loaded or not) and from linkage with the ship's torpedo alert system, automatically controls the launch sequence through launcher rotation and the provision of activation signals for the air bottles attached to each barrel. The control computer also displays the post-deployment scenario. Countermeasures can also be launched manually.

The jammer features a highly efficient transducer, covering the whole torpedo bandwidth, with a switching power amplifier and high-energy density thermal battery. The jammer generates a very high amount of energy spread over the entire reception band of the acoustic head of the torpedo. By emitting a high intensity broadband noise for a long time, the jammer masks the target echo as well as the radiated noise, preventing target acquisition by the torpedo. The jammers, like the decoys, are maintained at the operative depth by an air bag, after the flight phase.

To achieve the deception effect the decoy uses a sophisticated transponder to simulate a real target, generating in real time, acoustic echoes to any multifrequency coded pulse emitted by the torpedo. The echo structure is equal to the one of a real target (acoustic length, highlights) and, in order to represent a moving target, applies Doppler and coherent range rate to the echo, and radiates noise independently from the transponder function. Decoys feature, over a wide band, a constant target strength, and are compatible with the jammers presence, also a short distance from these.

Specifications
(both countermeasures)
Length: 1,200 mm
Diameter: 127 mm
Weight: 16 kg

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

VERIFIED

C310

Type
Surface ship anti-torpedo countermeasures system.

Description
The C310 anti-torpedo countermeasures system is designed to deal with current and future generations of active and/or passive torpedoes, wire or non wire-guided, launched singly or in salvoes.

The expendable effectors are based on low cost, lightweight, high performance devices. Surface vessels deploy the devices during the course of special evasive counter-manoeuvres that are designed to maximise a ship's survivability in the face of modern torpedo tactics and against multiple torpedo attack.

The C310 system comprises two types of effector – stationary jammers and mobile decoys – and a launching system. The latter comprises a control computer, junction boxes and trainable launchers. The launch system comprises two trainable launchers carrying a number of barrels. The number of barrels per launcher is tailored according to customer requirements. Each barrel is loaded with the relevant effector (jammers and decoys). Each barrel consists of a launch tube, an air bottle and an electro-valve.

The system control computer, mounted in the ship's combat centre, supervises deployment of countermeasures. The control computer carries out selection of type, number, deployment angle and range of countermeasures, selects the underwater trajectory of the mobile decoys and suggests the best counter-manoeuvre to perform, in order to optimise the reaction to the attack; displays the status of the launch tubes (whether they are loaded or not) and from linkage with the ship's torpedo alert system, automatically controls the launch sequence through launcher rotation, mobile decoy pre-setting and the provision of activation signals for the air bottles attached to each barrel. The control computer also displays the post-deployment scenario. Countermeasures can also be launched manually.

The jammer features a highly efficient transducer, covering the whole torpedo bandwidth, with a switching power amplifier and high-energy density thermal battery. The jammer generates a very high amount of energy spread over the entire reception band of the acoustic head of the torpedo. By emitting a high intensity broadband noise for a long time, the jammer masks the target echo as well as target-radiated noise, preventing target acquisition by the torpedo. The jammers are maintained at the operative depth by an air bag, after the flight phase.

The mobile decoys must draw the torpedo away from its real target. To achieve the deception effect the mobile decoy uses a sophisticated transponder to simulate a real target, generating in real time acoustic echoes to any multifrequency coded pulse emitted by the torpedo. The echo structure is equal to the one of a real target (acoustic length, highlights). During its underwater run the mobile decoy radiates noise in order to be representative of a moving target. The noise radiation happens independently from the transponder function. Decoys feature, over a wide band, a constant target strength, and are compatible with the jammer's presence, also a short distance from these. After the flight phase, the decoys perform their underwater trajectory at the operative depth. The vector of the mobile target emulator is derived from the A200 mini torpedo developed by Whitehead Alenia Sistemi Subacquei, within the frame of the LCAW.

Operational status
On order for the MEKO A 100/Project 621 class corvettes of the Polish Navy currently under construction.

Specifications

	Jammer	Mobile target emulator
Length:	1,150 mm	1,150 mm
Diameter:	127 mm	127 mm
Weight:	16 kg	16 kg

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

VERIFIED

Romania

STAT-100

Type
Towed torpedo decoy system.

Description
The STAT-100 towed torpedo decoy system comprises two towed bodies, a hydraulic launch and recovery system with two hoists and three control units, two of which are mounted centrally and one in a remote control position. The bodies are streamed at a distance of 400 m behind the ship at speeds up to 30 kt. The decoys operate passively or actively, simultaneously or alternately, generating noise in up to five frequency bands.

Specifications
Length: 120 cm
Diameter: 15 cm

Contractor
Military Equipment and Technologies Research Agency, Bucharest

VERIFIED

United Kingdom

Barracuda

Type
Surface ship torpedo decoy.

Description
The Barracuda is a passive shipborne torpedo decoy rocket designed to provide the host vessel with a versatile self-defence capability against anti-ship torpedoes.

The system uses the 102 mm Barracuda rocket family to deploy acoustic torpedo decoys to provide all-round protection. The lightweight decoy is easily installed or retro-fitted and being a rocket powered decoy develops little deck recoil.

The decoy can be fully and easily loaded into the launch system or combined with other rockets to provide defence against both aerial, surface and sub-surface threats.

The decoy is compatible with the SuperBarricade, SCLAR and SCLAR-H anti-ship missile countermeasures launching systems.

Operational status
Fully developed and available.

Specifications

	Long range decoy	Medium range decoy	Short range decoy
Length:	1,080 mm	1,080 mm	1,090 mm
Diameter:	102 mm	102 mm	102 mm
Weight:	10.5 kg	10.5 kg	7 kg
Range:	1,700 m	500 m	15 m
Launch mode:	rocket	rocket	piston eject
Time to full deployment:	30 s	15 s	10 s

Contractor
Flight Refuelling Ltd, Wallop Defence Systems Division, Middle Wallop, Hampshire.

NEW ENTRY

LEAD

Type
Anti-torpedo countermeasure effector.

Description
The LEAD (Launched Expendable Acoustic Device) effector uses the body of a standard chaff round (without the chaff) into which is fitted a floatation bag and the front end payload of the Mk 2 Bandfish. This can be rocket (Mk 2 16) or mortar (Mk 1 84) launched from a Sea Gnat or SRBOC Mk 36 launcher. At the 'torpedo alert' signal a pattern of LEAD rounds is launched, the pattern being defined by the relative bearing of the launcher barrel and selection of LEAD cartridge – rocket for medium range and mortar for close range.

Operational status
Developed.



Loading a LEAD effector into a Sea Gnat launcher (Ultra Electronics) 0064613

Specifications
Diameter: 130 mm
Length: 1,224 mm (mortar cartridge 1,226 mm)
Weight: 25.9 kg

Contractor
Ultra Electronics Ltd, Sonar and Communications Systems, Greenford, Middlesex.

VERIFIED

MEAD/MSCAD

Type
Anti-torpedo effectors.

Description
Developed by Ultra under contract to Northrop Grumman in the US for the J-SSTD Programme, the MEAD (Mobile Expendable Acoustic Device)/MSCAD (Mobile Softkill Countermeasures Acoustic Decoy) is a mortar launched mobile effector that follows a programmed heading pre-set before the round is launched. This effector also uses the Bandfish Mk 2 payload, but mounted in a body developed by Sippican in the US from the Mk 39 EMATT torpedo target. MEAD/MSCAD is deployed by surface ships from a SRBOC Mk 36 or Sea Gnat launcher. The effector can be deployed in combination with the LEAD effector.

Operational status
Developed and ready for service.

Specifications
Diameter: 130 mm
Length: 1,224 mm (mortar cartridge 1,226 mm)
Weight: 25.9 kg

Contractor
Ultra Electronics Ltd, Sonar and Communication Systems, Greenford, Middlesex.

VERIFIED

Sea Siren

Type
Towed anti-torpedo decoy system.

Description
Sea Siren is a microprocessor-based torpedo decoy system developed from the G 738 towed torpedo decoy which was originally based on the Royal Navy Type 182 system.

The system produces a realistic noise signature of the ship to decoy passive homing torpedoes, and generates sonar-like echoes to confuse active homing torpedoes. User programmable parameters are employed to ensure total confidentiality and the decoy can be easily updated to counter the latest threats.

Against active homing torpedoes the decoy produces a continuous wave signal in up to five programmable sweep frequency bands covering a wide range of torpedo frequencies. The pulse rate of transmission is programmable by the user. Four output modes are available: CW only; noise only; CW and noise simultaneously with independent control; and CW and noise alternately. The decoy produces a pseudo-random noise spectrum band to cover a wide range of torpedo frequencies. There is a choice of modulation envelope shape and programmable modulation depth. The modulation frequency is dependent on rpm and number of propeller blades of a hostile torpedo. The pulse rate of the transmission is programmable by the user. The decoy also produces a simulated ship's propeller noise, the signal generating circuit being fully programmable via a touch panel plasma display to match the noise signature of the vessel which is designed to decoy passive homing torpedoes.

Easy deployment and handling is assured using a davit or gantry system. One or two decoys can be used and can be controlled remotely from any position in the ship over a serial datalink.

The device is designed to be streamed 400 m astern of the ship and is currently housed in a modified Type 182 tow body. An advanced tow body development programme which will further increase the system's capabilities, is nearing completion.

Operational status
In service aboard two Malaysian frigates of the Lekiu class.

Contractor
MARCOM Defence, Chichester.

VERIFIED

SSE Mk 10

Type
Submerged signal ejector system.

Description
The SSE Mk 10 is a pneumatic/hydraulically operated water ram system for firing 3 in and 4 in stores through the pressure hull of a submarine.

A set of equipment for a submarine comprises one manual SSE and two automated SSEs.

The automatic SSE uses hydraulically actuated valves operating through a sequencing manifold and electrical control system to eject stores.

Operational status
Began to enter service on board 'Vanguard' SSBNs in 1995.

NEW ENTRY

Submarine Signal and Decoy Ejectors (SSDE)

Type
Reloadable submarine discharge systems.

Description
Submarine signal and decoy ejectors provide a small reloadable discharge system, capable of launching cylindrical stores approximately 100 mm in diameter and 1,250 mm in length, over the complete submarine operating envelope. These ejectors can also be designed and manufactured to meet particular requirements.

Existing ejectors currently in service are used to deploy communications buoys, bathythermal probes, exercise and emergency signalling stores, decoys and countermeasures, including programmable stores and stores requiring datalinks. The ejectors can be configured for purely manual operation, or they can be provided with an automatic operating capability, enabling discharge to be initiated either locally or from a remote position.

The submarine signal and decoy ejector contains two main assemblies built into a common hull insert; the launch tube assembly, into which the store is loaded prior to launch, and a ball valve closure outboard. Mounted alongside is the water/air ram assembly. The hull insert is normally positioned radially in the pressure hull, discharging across the ship's flowfield. It can be positioned with its exit flush with the pressure hull, or it can be moved radially outboard if required to bridge the space between the pressure hull and the free-flooding casing.

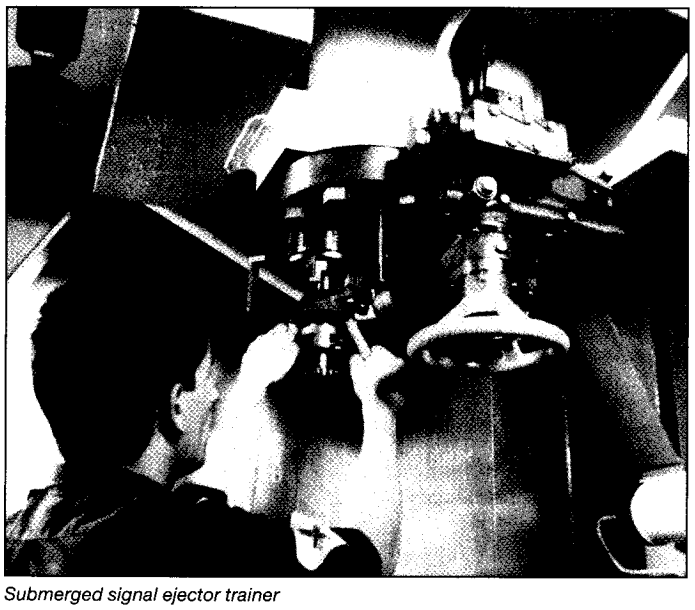
The stores are loaded into the ejector which is then automatically flooded and equalised at depth pressure. Launch is effected by admitting high-pressure air to the air ram causing it to move and discharge water into the tube, thereby ejecting the store. Ejectors of this type combine a virtually instantaneous discharge capability with a very rapid cycle time, and have a proven record of high reliability and low maintenance.

In the submarines of the Royal Navy two SSDEs are fitted, one forward and one aft. Three variants are currently fitted: Mk 6 (Swiftsure class), Mk 8 (Trafalgar class) and Mk 10 (Vanguard class). All three variants can launch both Type 2066 and Type 2071 decoys and also communications buoys ECB-680 and ECB-699.

Operational status
In operational service aboard submarines of the Royal Navy.

Contractor
Strachan & Henshaw, Bristol.

UPDATED



Submerged signal ejector trainer

Thales Underwater Systems acoustic countermeasures

Type
Range of acoustic countermeasures units.

Description
The company designs and produces a range of acoustic countermeasures units. These are high-power, high-efficiency devices for deployment against acoustically guided weapons to protect both surface vessels and submarines. Both spatial targets and jammers have been designed and can be tailored to individual requirements in submarine or surface (air-launched) configurations. These devices are available in formats, which can be deployed by most standard launch systems. Special requirements, such as overall frequency bands, source levels and noise structures can be made available as required.

An anti-torpedo acoustic countermeasure referred to, as ATAAC is a noisemaker launched from a standard chaff launcher. There are both 76 mm and 100 mm versions and the rounds are programmed before launch to produce broadband noise. A 203 mm version, for discharge from a submarine countermeasures tube, is also available.

Operational status
In production.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Type 182/G 738 decoy

Type
Towed torpedo decoy equipment.

Description
The G 738 is an improved and re-engineered version of the Royal Navy Type 182 towed torpedo decoy. The equipment uses solid-state signal generation equipment and compact, lightweight deck machinery.

G 738 is designed to decoy both active and passive homing torpedoes. Decoy signals are electronically generated within the ship and fed via the towing cable to electro-acoustic transducers within the towed body. The signals thus produced divert passive homing torpedoes astern and confuse or jam the steering mechanisms of active homing torpedoes. It can also be used as a high-frequency noise source for trials purposes.

The G 738 simultaneously produces two independently controllable output signals which are radiated from the towed decoy.

An amplitude modulated noise signal is provided to simulate the ship's propeller noise and to cause passive homing torpedoes to be seduced away from the ship towards the towed decoy.

A swept CW signal is provided to simulate sonar echoes to confuse or jam the guidance system of active homing torpedoes, and cause them to miss the ship.

The frequency bands covered by both types of output are switchable, as required for tactical scenarios and to enable concurrent operation of other sonar and communication equipments.

A variety of deck handling arrangements are produced, and dual systems may be fitted. Remote control selection of signal characteristics provides for instantaneous changes from operations room or bridge. The equipment can incorporate handling systems for open deck on extended flight deck ships.

Specifications

Dimensions and weights	Height	Depth	Width	Weight
Electronics cabinet	1,725 mm	640 mm	585 mm	375 kg
Remote-control unit	152 mm	190 mm	305 mm	2.3 kg
Deck connection box	203 mm	115 mm	265 mm	13 kg
Resistance box	444 mm	115 mm	381 mm	14.3 kg
Towed decoy	533 mm	2,005 mm	457 mm	74 kg
Cable reel	1,245 mm	2,340 mm	1,390 mm	2,540 kg
Gantry	203 mm	5,918 mm (retracted)	440 mm	810 kg
Davit	3,500 mm (Jib raised)	3,400 mm (max)	1,270 mm	818 kg
Triple control unit	357 mm	240 mm	440 mm	188 kg

Towing cable
Length: 411 m
Diameter: 14.48 m
Weight: 269 kg

The operating characteristics remain confidential between the manufacturer and the purchaser.

Operational status
No longer in production. In service with Brazil (Broadsword class 4 units), Ecuador (Leander class 2 units), India (Godavari class 3 units, Brahmaputra class 2 units), Pakistan (Leander class 2 units and 'Tariq' 6 units classes), Portugal (Rover class tanker 1 unit) and UK (Type 42 destroyers 11 units, Broadsword class 4 units, Rover class tankers 3 units, Fort Victoria class 2 units, and aviation training ship *Argus*) navies. An updated version with integral detection capabilities is currently being considered.

Contractor
MARCOM Defence, Chichester.

VERIFIED

Type 2066/Bandfish

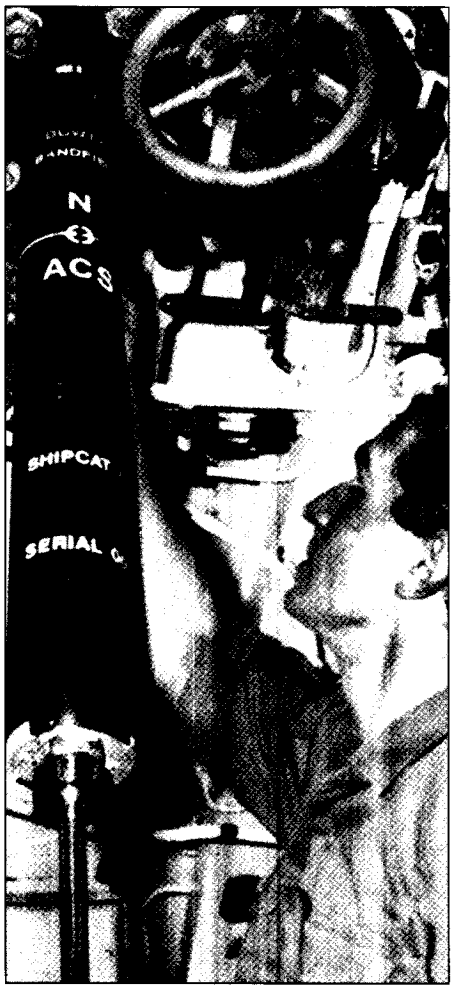
Type
Expendable torpedo countermeasures system.

Description
Bandfish (UK Royal Navy designation Type 2066) is an expendable countermeasures system for use against acoustic torpedoes. It is designed to be launched from a submarine's submerged signal ejector or from a surface ship launcher. Once launched, the device operates independently of the launch platform.

In operation, Bandfish hovers in mid-water and transmits a high-intensity broadband acoustic signal. The operating depth and acoustic pattern can be designed to meet the customer's requirements. The buoyancy control system and hovering depth is preset before launch. It has a minimum shelf life of five years and requires no user or depot maintenance. Simple tests are provided to ensure that it can be launched with maximum confidence.

Bandfish Mk 2, incorporating its own self-contained launcher for mounting externally to the pressure hull, offers enhanced acoustic performance and an upgraded signal generator that allows users virtually unlimited scope in programming acoustic signals.

Operational status
In full production and currently in use aboard UK Royal Navy submarines of the Vanguard class (four units), Trafalgar class (seven units) and Swiftsure class (four units).



Bandfish expendable torpedo countermeasure

Specifications
Length: 995 mm
Diameter: 102 mm
Weight: <12 kg

Contractor
Ultra Electronics, Sonar and Communications, Greenford, Middlesex.

UPDATED

United States

ADC Mk 1 Mod 0

Description
127 mm diameter expendable acoustic countermeasures device produced by Conax Corporation. Procurement quantities have exceeded 2,000 units.

Operational status
In service aboard all US classes of submarine.

VERIFIED

ADC Mk 1 Mod 1

Description
152 mm diameter expendable acoustic countermeasures device. The device is a salt-water battery powered system weighing about 18.75 kg.

Operational status
In service aboard all classes of US submarine.

VERIFIED

ADC Mk 2 Mod 1 countermeasure

Type
Expendable acoustic torpedo countermeasure.

Description
The ADC (Acoustic Device Countermeasure) Mk 2 Mod 1 is a submarine-launched expendable decoy designed to counter acoustic torpedoes. The device is internally launched from the submarine's signal ejector and hovers vertically at a preselected depth, emitting an acoustic signal. The vertical depth is set before launch and maintained by a pressure-controlled motor, driving a small, shrouded propeller in the tail of the decoy. Power for the motor and electronics is provided by a thermal battery mounted beneath the electronics section.

In the electronics section mounted below the acoustic projector section the signals are generated and amplified, while the uppermost acoustic projector section consists of ceramic transducers and impedance-matching networks.

Operational status
In production since 1978, more than 10,000 ADC Mk 2 units have been produced. In service aboard all classes of US Navy submarine and is being exported.

Specifications
Length: 1,000 mm
Diameter: 76 mm

Contractor
Ultra Electronics Ocean Systems, Braintree, Massachusetts.

UPDATED

ADC Mk 3 countermeasures

Type
Submarine countermeasures equipment.

Description
ADC Mk 3 is a wideband 152 mm diameter unpowered jammer device externally launched from submarines, designed primarily to jam torpedo sonar homing heads. Information on this device is restricted and no other technical details have been released.

Operational status
In production. Over 500 systems have been manufactured. In service aboard all classes of US submarine.

Contractor
Ultra Electronics Ocean Systems, Braintree, Massachusetts.

UPDATED

ADC Mk 4 countermeasure

Type
Expendable acoustic countermeasure.

Description
Developed in 1988, the ADC (Acoustic Device Countermeasure) Mk 4 is a submarine-launched acoustic countermeasure. The countermeasures are carried external to the pressure hull and are launched from the CSA Mk 2 launcher using a gas generator. The mobile device is designed to counter hostile sonars and can be pre-programmed to hover at any depth. No other details are available.

Operational status
Completed development in FY93, and is currently in production to equip all US SSNs and SSBNs. A total of 335 units are on order.

Contractor
Ultra Electronics Ocean Systems, Braintree, Massachusetts.

UPDATED

AN/SLQ-25A

Type
Torpedo countermeasures transmitter (Nixie).

Development
The AN/SLQ-25, also known as the Nixie System, was first developed under a US Navy project in the mid-1970s. This project was involved with the development of systems to enable ASW and non-ASW ships to evade torpedo attack. The first production contract was awarded in 1975.

More recently, the US Navy has supported the advancement and improvement of the towed countermeasure. The current Nixie System, named the AN/SLQ-25A, provides a significant improvement in operational capability, maintenance reduction and cost. The 25A System has been designed for simplified integration with new torpedo defence systems and has automated fault identification, commercial-off-the-shelf electronics, and improved programmable countermeasure signalling.

Description
The AN/SLQ-25A is a towed electro-acoustic device that uses a sophisticated, programmable digital signal generator to provide surface ships with passive/active detection, location and threat identification of torpedoes and other acoustic targets. The Nixie device is programmed to jam the acoustic sensor in the threat torpedo and decoy the torpedo away from the ship.

Nixie consists of two small lightweight towed bodies (TB14A), manufactured by Ultra Electronics, which are streamed and recovered from a dual-drum winch. Below deck equipment consists of a single electronics cabinet and a control console located either in the command centre or near the sonar control room. The decoys on some Canadian ships are deployed by an all-weather handling system developed by Indal Technologies. A single operator is able to quickly launch, retrieve and stow the towed body at the touch of a button.

Sensytech has also developed a torpedo defence controller unit that can interface with the Mk 36 launcher to control the firing of decoys. This provides a layered torpedo defence command and control capability and simplifies command/control functions. The torpedo defence controller is design for both surface and subsurface applications. The unit displays the torpedo location and track, and recommends manoeuvres and displays progress during evasive manoeuvres.

Operational status
The AN/SLQ-25A is still in production and 14 additional units were ordered in September 2002. The device is in operational use in the US Navy and a number of other navies, including those of Australia, Bahrain, Belgium, Canada, Egypt, France, Germany, Greece, Italy, Japan, South Korea, Mexico, Netherlands, Poland, Portugal, Spain, Taiwan, Thailand and Turkey.

The original Nixie System (AN/SLQ-25) is still operational and supported by the contractor. A number of navies operate the AN/SLQ-25 system and are reviewing plans to upgrade to the AN/SLQ-25A. A further order for 11 AN/SLQ-25A systems announced in August 2004 resulted in a single system for Turkey and two for Taiwan under FMS sales and eight systems for the US Navy.

Contractor
Sensytech Inc, Newington, Virginia.

UPDATED

AN/SLX-1 MSTRAP

Type
Multisensor torpedo recognition and alertment processor.

Description
Designed for installation aboard surface ships and submarines, the AN/SLX-1 is a COTS-based system providing automatic alert of incoming torpedo threats on an easy-to-read display on any x-windows based multifunction console. (See also entry on AN/SLX-1 in Sonar Systems - Surface Ship Sonar Systems). This multifunction system provides information, signal processing, and the controls necessary to detect, classify and localise threat torpedoes. It also offers command and control functions, TMA threat evaluation and tactical advice. Displays with automatic visual and audio alarm of torpedo threats, allow sufficient time to make tactical decisions and effective deployment of countermeasures, and appropriate ship evasive manoeuvres. Data is received simultaneously from either an existing ASW hull sonar, towed array or sonobuoys. MSTRAPs open system architecture ensures easy installation, hardware/software upgrades, and future improvements.

The MSTRAP is designed to be integrated with the AN/SQQ-89(V) ASW combat system, receiving acoustic data from the AN/SQR-19 TACTAS, AN/SQQ-28(V) SSPS and AN/SQS-53C hull-mounted sonar via the AN/SQQ-89(V) system.

Operational status
The first unit of MSTRAP was delivered in June 1995, 14 months after receipt of the contract. MSTRAP has been operationally tested aboard the USS *Arleigh Burke* (DDG-51) and proven at sea. Over 30 units have been delivered and equip Spruance and Arleigh Burke Flight IIA class destroyers.

Contractor
Northrop Grumman Corporation, Oceanic and Naval Systems, Annapolis, Maryland.

VERIFIED

AN/WLY-1

Type
Acoustic intercept and countermeasures command and control unit.

Development
The AN/WLY-1 is being developed to replace the AN/WLR-9A/12 series of acoustic intercept receivers currently installed in all US submarines.

On 4 February 1999, Northrop Grumman was awarded a contract for two AN/WLY-1 low-rate initial production systems.

Description
The AN/WLY-1 is an advanced submarine countermeasures controller unit with an expandable capability for countermeasures device inventory management, processing tactical solutions, target data management (detection, classification and tracking with range and bearing data) and launch sequencing of all externally configured countermeasures launchers. The system includes a control subsystem for launch management of all onboard countermeasure devices and launchers. The equipment was an early design with engineering development models being delivered in 1993-94. The system will provide data on threat platform sonar and torpedo recognition for the early detection, classification and tracking of threats. It will take into account radius of curvature and multipath ranging.

Operational status
Under development. The AN/WLY-1 will equip the Seawolf and Virginia class SSNs.

Contractor
Northrop Grumman, Oceanic and Naval Systems, Annapolis, Maryland.

VERIFIED

AN/WSQ-11

Type
Torpedo defence system.

Development
The AN/WSQ-11 torpedo defence system is intended to provide aircraft carriers, destroyers, amphibious vessels and fast combat support vessels protection against wake homing and other modern torpedoes.

Description
The AN/WSQ-11 will comprise an integrated system of sensors, processors, a high power active search sonar, towed countermeasures, displays, and an anti-torpedo torpedo and its launcher.

The design of AN/WSQ-11 will draw on technology being developed by the Pennsylvania State University Applied Research Laboratory for the canistered countermeasure anti-torpedo torpedo (CCAT).

Advanced Acoustic Concepts is carrying out work on the design, development and testing of the Tripwire Sensor Processor System prototype. The work is designed to support a torpedo detection, classification and localisation sensor to be deployed as an integrated towed array, forming part of the AN/WSQ-11.

Operational status
Five CCAT advanced development models are being built for use in the system integration phase of the WSQ-11 system development and demonstration programme in FY04-05. The system development and demonstration phase is expected to employ 10 engineering development models of the CCAT, with 7 being built by Pennsylvania ARL and 3 by the selected contractor.

Up to 30 enhanced engineering development models may be built during low-rate initial production. Low rate initial production is scheduled to start in late FY06. Full rate production of the entire AN/WSQ-11 system could begin in FY08.

NEW ENTRY

CSA Mk 2 Mod 0/Mod 1

Description
152 mm diameter launching system for acoustic countermeasures stores. Individual devices are remotely selected and launched. In the Ohio class each boat is fitted with 14 launchers.

Operational status
In service aboard Ohio class SSBNs.

VERIFIED

Mobile multifunction device

Description
152 mm diameter expendable submarine-launched advanced countermeasures device.

Operational status
In early development.

Contractor
ESCO Electronics Corporation, St Louis, Missouri.

VERIFIED

NAE Beacon Mk 3

Description
127 mm diameter sonar countermeasures device produced by Pique Engineering. Procurement quantities scheduled have exceeded 3,000 units.

VERIFIED

ELECTRONIC WARFARE

Table XI

Operational electronic warfare systems as at August 2004[1]

System	Manufacturer	Country	Installed on	Navy	No units
921-A	CNEIEC	China	Xia	China	1
921-A	CNEIEC	China	Han	China	4
921-A[4]	CNEIEC	China	Ming	China	20
921-A	CNEIEC	China	Song	China	8
921-A	CNEIEC	China	Romeo	Korea North	22
AR-700	EDO RSS	USA	Type 209/1500 (Shishumar)	India	4
AR-700	EDO RSS	USA	Walrus	Netherlands	4
AR-700	EDO RSS	USA	Type 207 (Kobben)	Poland	4
AR-700-S5	EDO RSS	USA	Näcken A 14	Denmark	1
AR-700-S5	EDO RSS	USA	Romeo	Egypt	4
AR-700-S5	EDO RSS	USA	Type 209/1100-1200 (Glavkos)	Greece	4
AR-700	EDO RSS	USA	Type 209/1200 (Chang Bogo)	Korea, South	9
AR-700-S5[5]	EDO RSS	USA	Västergötland A 17	Sweden	4
AR-900	EDO RSS	USA	Scorpene	Chile	1
Arud	Thales Airborne Systems	France	Hashmat (Agosta)	Pakistan	2
Arud	Thales Airborne Systems	France	Hangor (Daphne)	Pakistan	4
Arur/DR 3000U	Thales Airborne Systems	France	Daphne	Pakistan	4
Arur/DR 3000U	Thales Airborne Systems	France	Albacora (Daphne)	Portugal	2
Arur/DR 3000U	Thales Airborne Systems	France	Le Triomphant	France	2
Arur/DR 3000U	Thales Airborne Systems	France	L'Inflexible	France	2
Arur/DR 3000U	Thales Airborne Systems	France	Rubis	France	6
Arur/DR 3000U	Thales Airborne Systems	France	Agosta	Malaysia	1
Arur/DR 3000U	Thales Airborne Systems	France	Khalid (Agosta)	Pakistan	2
BLD-1	Amecon	USA	Seawolf	USA	3
BLD-727 Thetis	Elettronica	Italy	Improved Sauro	Italy	4
BLD-727 Thetis	Elettronica	Italy	Sauro Type 1081	Italy	2
BRD-7	USA	USA	Los Angeles	USA	51
Brick Group[3]	Russian Federation	Russian Federation	Kilo Type 877E	Algeria	2
Brick Group[3]	Russian Federation	Russian Federation	Kilo Type 877EM	Poland	1
Brick Group[3]	Russian Federation	Russian Federation	Kilo Type 877E	Romania	1
Brick Group[3]	Russian Federation	Russian Federation	Kilo Type 877EKM/636	China	4
Brick Group[3]	Russian Federation	Russian Federation	Delta III	Russian Federation	7
Brick Group[3]	Russian Federation	Russian Federation	Delta IV	Russian Federation	6
Brick Group[3]	Russian Federation	Russian Federation	Victor III	Russian Federation	5
Brick Group[3/4]	Russian Federation	Russian Federation	Kilo type 877K/877M/636	Russian Federation	13
CS-5600	EDO RSS	USA	Collins	Australia	6
DR 2000U	Thales Airborne Systems	France	Type 209/1200 (Salta)	Argentina	1
DR 2000U	Thales Airborne Systems	France	Type 209/1200 (Pijao)	Colombia	2
DR 2000	Thales Airborne Systems	France	Type 209/1300 (Sabalo)	Venezuela	2
DR 2000U	Thales Airborne Systems	France	Type 209/1300 (Thomson)	Chile	2
DR 2000U	Thales Airborne Systems	France	Type 209/1300 (Shyri)	Ecuador	2
DR 2000U	Thales Airborne Systems	France	Type 206A	Germany	11
DR 2000U	Thales Airborne Systems	France	Type 209/1200 (Glavkos)	Greece	4
DR 2000U	Thales Airborne Systems	France	Type 209/1300 (Cakra)	Indonesia	2
DR 2000U[4]	Thales Airbroen Systems	France	Type 209/1200 (Atliay)	Turkey	6
DR 4000	Thales Airborne Systems	France	Type 209/1,400 (Tupi)	Brazil	4
Manta E	Thales Sensors Ltd/Inisel	UK/Spain	Galerna (Agosta)	Spain	4
Manta	Thales Sensors Ltd	UK	Delfin (Daphne)	Spain	2
Manta S	Thales Sensors Ltd	UK	Gotland A 19	Sweden	3
NZLR 1	Japan	Japan	Harushio	Japan	7
NZLR-1B	Japan	Japan	Oyashio	Japan	7
Porpoise	Thales Sensors Ltd	UK	Type 209/1400 (Preveze)	Turkey	4
Quad Loop	Russian Federation	Russian Federation	Kilo Type 877 EKM	Iran	3
Quad Loop	Russian Federation	Russian Federation	Kilo Type 877E	Poland	1
Quad Loop	Russian Federation	Russian Federation	Kilo Type 877E	Romania	1
Quad Loop	Russian Federation	Russian Federation	Kilo Type 877/877K/877M	Russian Federation	13
Rim Hat	Russian Federation	Russian Federation	Oscar II	Russian Federation	7
Rim Hat	Russian Federation	Russian Federation	Typhoon	Russian Federation	3
Rim Hat	Russian Federation	Russian Federation	Akula	Russian Federation	8
Rim Hat	Russian Federation	Russian Federation	Sierra II	Russian Federation	1
Sarie 2	THORN EMI	UK	Type 206A	Germany	11
Sealion	Thales Sensors Ltd	UK	Type 207 (Tumleren)	Denmark	3
Sealion	Thales Sensors Ltd	UK	Ula (P 6071)	Norway	6
Sealion[4]	Thales Sensors Ltd	UK	Type 209/1200 (Atilay)	Turkey	2
Sealion	Thales Sensors Ltd	UK	Type 209/1400 (Preveze)	Turkey	2
Sea Sentry III	Kollmorgen	USA	Santa Cruz TR 1700	Argentina	2
Squid Head[2]	Russian Federation	Russian Federation	Kilo Type 877EKM636	China	4
Squid Head	Russian Federation	Russian Federation	Kilo Type 877EM	India	10
Squid Head	Russian Federation	Russian Federation	Kilo Type 877EKM	Iran	3
Squid Head[2]	Russian Federation	Russian Federation	Kilo Type 877/877K/877M	Russian Federation	13

[1] According to information available
[2] Brick Pulp or Squid Head
[3] Includes Brick Pulp and Brick Spit in some cases
[4] In some units
[5] Being replaced by CS 3701 system

System	Manufacturer	Country	Installed on	Navy	No units
Stop Light	Russian Federation	Russian Federation	Romeo	Bulgaria	1
Stop Light	Russian Federation	Russian Federation	Foxtrot Type 641	India	2
Stop Light	Russian Federation	Russian Federation	Foxtrot Type 641	Libya	2
Stop Light	Russian Federation	Russian Federation	Foxtrot Type 641	Ukraine	1
Stop Light	Russian Federation	Russian Federation	Sava	Serbia & Montenegro	1
Stop Light	Russian Federation	Russian Federation	Heroj	Serbia & Montenegro	1
Timnex	Elbit	Israel	Dolphin	Israel	3
Timnex	Elbit	Israel	Hai Lung	Taiwan	2
UAP 1	Thales Sensors Ltd	UK	Trafalgar	UK	7
UAP 1	Thales Sensors Ltd	UK	Swiftsure	UK	4
UAP 3	Thales Sensors Ltd	UK	Vanguard	UK	4
WLR-1/3	USA	USA	Guppy II	Taiwan	2
WLR-1	USA	USA	Tang	Turkey	2
WLR-1	USA	USA	Los Angeles	USA	3
WLR-8(V)2	GTE	USA	Los Angeles	USA	48
WLR-8(V)5	GTE	USA	Ohio	USA	18
WLR-10		USA	Los Angeles	USA	51
WLR-10	GTE	USA	Ohio	USA	14
WLQ-4	GTE	USA	Virginia	USA	1
WLQ-4(V)1	GTE	USA	Seawolf	USA	3
ZLR 5-6	Japan	Japan	Yuushio	Japan	5

[1] According to information available
[2] Brick Pulp or Squid Head
[3] Includes Brick Pulp and Brick Spit in some cases
[4] In some units
[5] Being replaced by CS 3701 system

UPDATED

China

921-A ESM

Type
Shipborne radar ESM receiver.

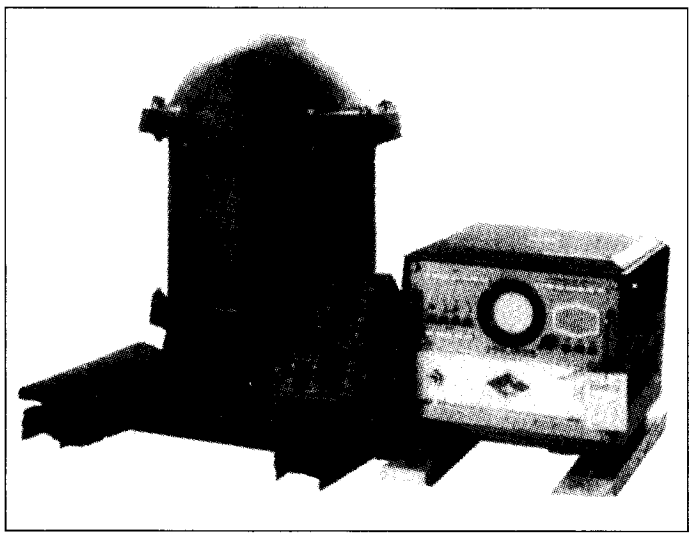
Description
The 921-A (NATO codename Golf Ball) is a wideband pulse radar direction-finding receiver and is installed on submarines to detect emitters of airborne, shipborne and shore-based radars. It provides coarse measurement of azimuth, frequency band and operational state of the hostile emitters. The equipment is derived from the Russian Stop Light EZM system.

Operational status
In service with the Navy of the People's Liberation Army (PLA-N) on Xia, Han, Song, Romeo and some Ming class, and North Korean Romeo class submarines.

Specifications
Frequency: 2-18 GHz in four bands
Sensitivity: 1.5×10^{-3} to 10^{-4} W/M^2
Bearing accuracy: Better than ±30°
Dimensions and weights
Antenna unit: 560 mm (diameter) × 515 mm (high); 80 kg
Receiver and display: 450 × 468 × 124 mm; 40 kg
Distribution unit: 145 × 214 × 291 mm; 6 kg

Contractor
China National Electronics Import & Export Corporation (CNEIEC), Beijing.

VERIFIED



921-A ESM equipment

France

DR 2000U ESM

Type
Submarine radar threat warner.

Description
The DR 2000U is the submarine variant of the DR 2000 series of ESM systems. The system incorporates a crystal video receiver and has some analysis capability. When coupled with the Dalia analyser, it can be converted into a basic ESM suite.

The intercept receiver is built up of six DF antennas and one omni-antenna and a processing control/display console. It provides a virtual 100 per cent probability of intercept over the complete 360° of azimuth. The system carries out passive search and detection of all pulse and CW signals and gives an instantaneous audible and visual alert. The DR 2000U Mod 3 is an improved version covering the D to J frequency bands and with better sensitivity (DF accuracy 5° RMS).

The Dalia analyser provides alarm analysis and identification facilities through a library of 1,000 radar modes and parameters and is easily reprogrammable.

It is believed that the DR 2000U forms the basis for the PRC Navy Model 921-A intercept ESM system.

Operational status
No longer in production. In service on board Argentina Navy *Salta*, Chilean Thomson class (two units), Columbian Pijao class (two units), Ecuador Shyri class (two units), German Type 206A (11 units), Greek Glavkos (four units), Indonesian Cakra class (two units), some Turkish Atilay class and Venezuelan Sabalo class (two units).

Contractor
Thales Airborne Systems, Elancourt.

UPDATED

DR 3000U ESM

Type
Submarine ESM system.

Description
The DR 3000 series is available in a number of variants. The submarine version is the DR 3000U, French Navy designation ARUR 13. The surface ship configuration equips the French navy La Fayette class frigates and nuclear-powered aircraft carrier *Charles de Gaulle* as well as ships of several foreign navies.

The DR 3000U is a fully automatic system providing 360° coverage over an elevation arc of −10° to +45° in the C to J frequency bands (0.5 to 20 GHz). DF accuracy is said to be in the order of 3°. It uses GaAs technology and radar identification algorithms developed in an expert system, supplemented with a high-IFM receiver. The lightweight (150 kg) system uses autonomous air cooling of low-power consumption units. Features include: a high probability of intercept against modern radars; high sensitivity (said to be up to −68 dBmi with a dynamic range of 60 dB) providing range advantage compared with other systems; accurate direction-finding; and reliable instantaneous identification of radars and platforms. The DR 3000U can operate in a high-pulse density of up to 1 million pulses per second. The emitter library can store data on up to 4,000 radar models related to 192 platforms. Using special signal processing algorithms, DR 3000U is claimed to offer high dependability in the presence of unknown signals, ensuring instant and appropriate response (launching of decoys or jamming operation) in the presence of unclassified threat transmitters.

DR3000U missions include radar threat warning, tactical situation build-up and updating, target designation, ECM control and ELINT.

The DR 3000 is offered in a variety of configurations. The basic system comprises six antennas, a reception and processing unit and a display console. Different types of antennas are available, including a lightweight periscope miniature aerial, small standard DF antenna and a high-accuracy DF unit. The associated console is a high-definition colour TV display. A bus interface is provided to facilitate integration of the DR 3000U unit with multipurpose consoles in different submarine combat systems.

Operational status
In production. In service aboard French nuclear submarines and equips the new Agosta-90B submarines for Pakistan. The ESM system is also on order for the two Scorpene class boats ordered for Malaysia.

Contractor
Thales Airborne Systems, Elancourt.

UPDATED

DR 4000U ESM

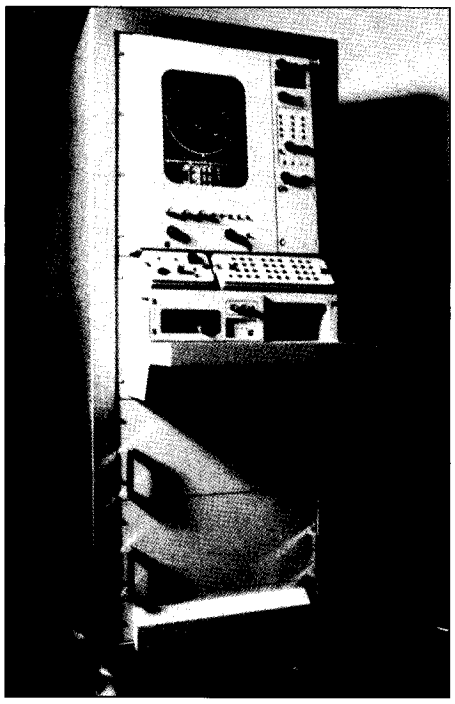
Type
Submarine ESM surveillance system.

Description
The DR 4000U is a variant of the DR 4000 series of surface ship and submarine ESM systems. It is a radar detection, analysis and identification system which has an extremely fast reaction time and a high instantaneous data collection capability. High-sensitivity IFM receivers allow 100 per cent intercept probability, even on a short single pulse. Combining crystal video and IFM receiver technology on both omni-directional and DF channels, the system offers threat warning, surveillance, emitter identification, electronic intelligence, and automatic electronic warfare system control capabilities. The highly automated system has an instantaneous 360° DF capability with bearing accuracies of about 5°. Frequency coverage is over the C- to J-bands with the possibility of extension to the range as an option.

Data is displayed in graphic and alphanumeric formats on a three-colour display giving azimuth and amplitude, with the tactical situation in the upper part and intercept parameters below.

The highly sensitive antenna system includes an omnidirectional unit for frequency measurements and two concentric six-port DF arrays, one for C- to G-bands (0.5 to 6 GHz) and the other for H- to J-bands (6 to 20 GHz).

Operational status
In service aboard the four Tupi Type 209 boats of the Brazilian Navy and ordered for the *Tikuna*, and on board French nuclear submarines where with the DR 2000U it forms the ARUR 13 EW suite.



DR 4000 U IFM ESM system console

Contractor
Thales Airborne Systems, Elancourt.

UPDATED

Germany

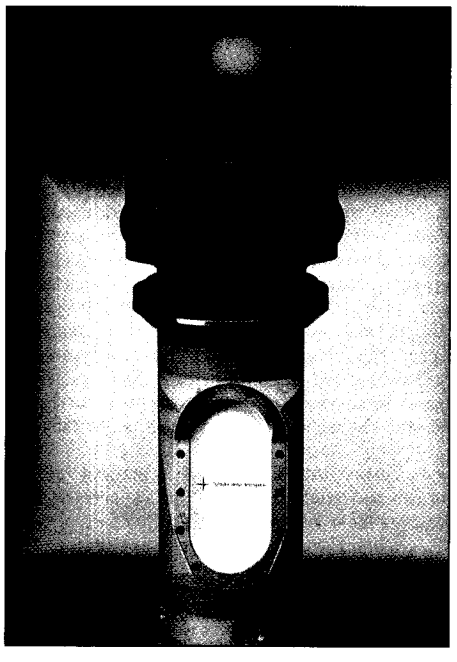
FL 1800U

Type
Submarine ESM/DF system.

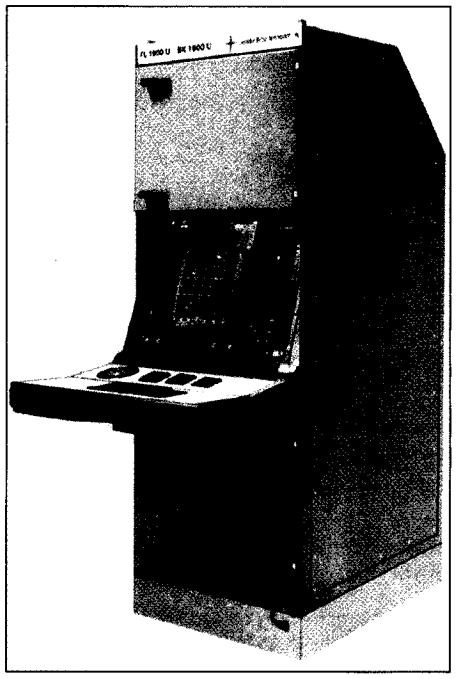
Description
The fully automatic, modular FL 1800U ESM system incorporates the direction-finding sensor USK 800/4 for submarines. The system provides interception across the 2 to 18 GHz band, automatic analysis, automatic DF, classification and display of all signals within its coverage of the radar frequency range. The processed, analysed and classified signals are presented on a tactical picture of the radar environment. Emitters are classified against a stored library and automatic visual and external warnings are given of signals that exhibit certain types of radar characteristics, such as lock on.

The display features a snapshot mode in which emitter track data can be frozen and reviewed after the ESM sensor has been lowered. Finally the FL 1800U is able to transfer all selected data to the main combat system if required.

The compact sensors of the USK 800 series can be integrated easily in all common periscopes or optronic masts. In one sensor head the OD/DF antennas



Periscope antenna OD/DF sensor USK 800/4 for Type 212
0006976



FL 1800 U operator console for Type 212
0006977

can be combined with any electronic modules of ESM, navigation (GPS) and communications (VHF/UHF) systems according to customer requirements. This overcomes the necessity to have a dedicated ESM mast and ESM is available immediately after the periscope penetrates the surface, allowing simultaneous optical and electromagnetic search and correlation of detected targets.

Operational status
The system has been selected for the new U212 class of submarines to be built for the German and Italian navies.

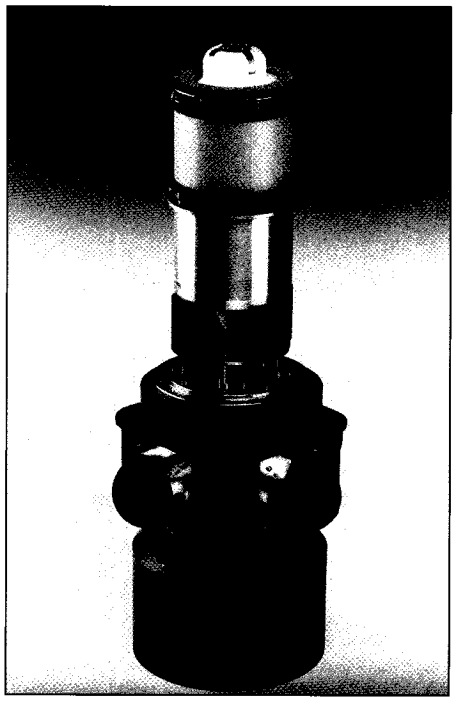
Contractor
EADS Defence Electronics, Ulm (Donau).

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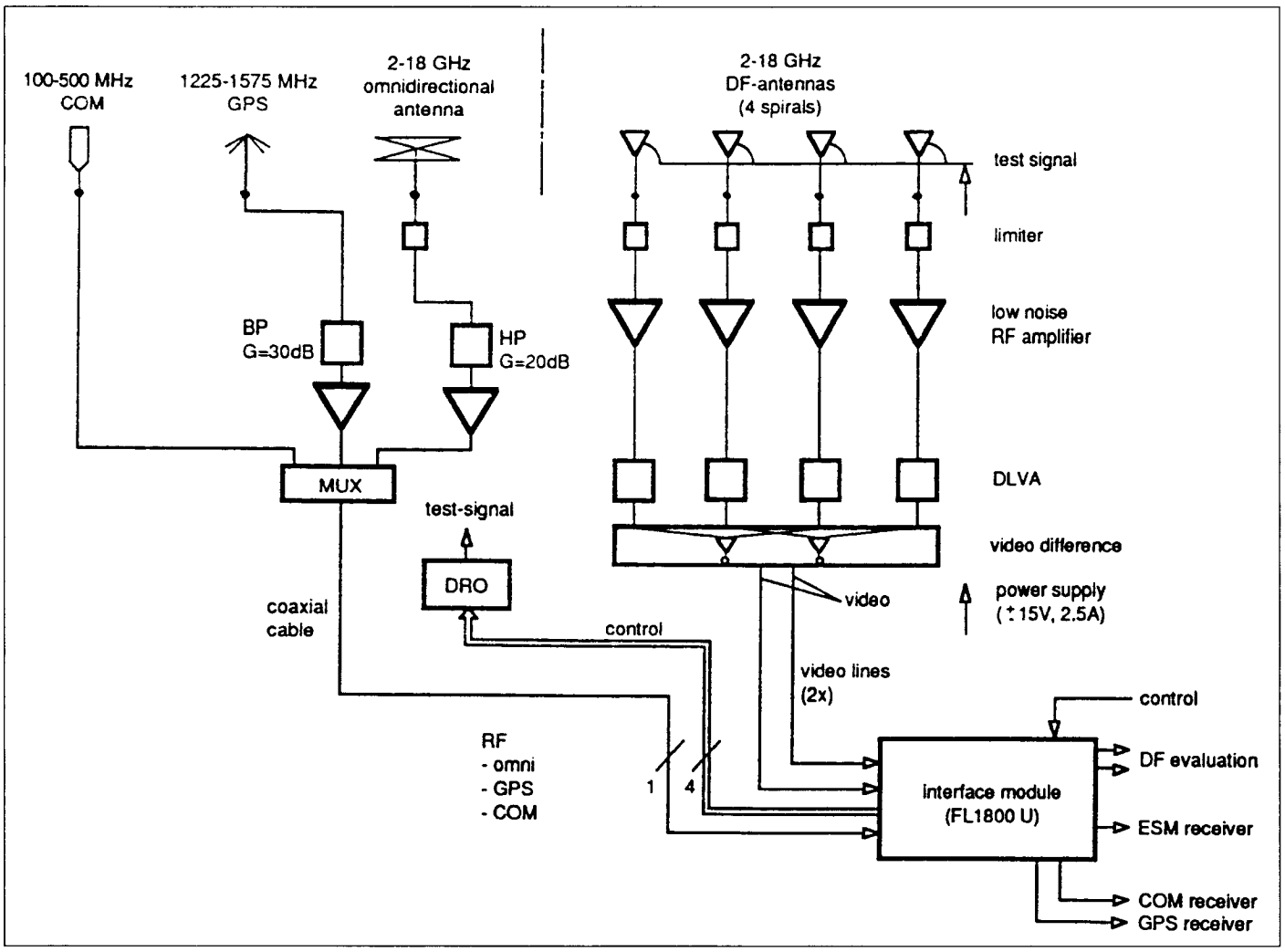
USK 800 series

Type
Modular family of ESM antenna for submarines and surface vessels.

Description
The USK 800 is a modular family of DF systems offering the following capabilities:
- USK 800/1: ESM omnidirectional reception;
- USK 800/2: ESM omnidirectional reception and GPS;
- USK 800/3: ESM omnidirectional reception, GPS and VHF/UHF omnidirectional receive;



Periscope antenna DF sensor USK 800/5
0006978



Block schematic of the USK 800/5 system

- USK 800/4: ESM omnidirectional reception, GPS and ESM 4-port direction-finding reception;
- USK 800/5: ESM omnidirectional reception, GPS, VHF/UHF omnidirectional transmit/receive and ESM 4-port direction-finding reception;
- USK 800/6: ESM omnidirectional reception, GPS and ESM 6-port DF reception.

Sensor electronics in the USK 800/1-3 are housed in the head, while in the case of the USK 800/4-6 the electronics can be accommodated in a remote housing, its position depending on the mast version. Interfaces from the various sensors are kept to a minimum, different channel functions being combined or separated in the sensor head through frequency separating networks. Data is passed to the control room via a single RF coaxial cable (with rotary joint) in the periscope mast.

All antenna elements are protected by radomes and, to reduce radar cross-section, the metallic side surfaces of the sensor element are covered with RAM. All elements are designed to withstand pressures of 60 bar.

ESM reception is achieved using a biconical antenna with the modelling of the cone contour designed for wide elevation coverage and the greatest possible acquisition range (>40 km). To permit the acquisition of vertically, horizontally and circularly polarised EM radiations, the aperture of the antenna is provided with a 45° polariser. A built-in high-pass filter suppresses any disturbances and interferences caused by strong VHF/UHF signals, such as might be experienced from TV and radio broadcast stations near the coast. Additional limiters prevent damage to the input branch when receiving extremely strong radar pulses.

ESM DF information is derived from signal levels received from the four/six special broadband directional receiving antennas, together covering the 0 to 360° azimuth range. The signals are processed through a low noise RF preamplifier and detector log video amplifier to a video differential network, which combines two opposite antenna branches. This reduces the number of video lines in the sensor mast to two (USK 800/4).

Bearing is calculated by a DF processor of the ESM unit. Different levels of the two DF video channels and of the pattern data of the antennas permit determination of the incident angle of the signal in azimuth.

Operational status
A variant of the USK family has been selected for the Type 212 submarines to be built for the German and Italian navies, and other variants in service worldwide.

Contractor
EADS Defence Electronics, Ulm (Donau).

UPDATED

Israel

C-Pearl-S

Type
Submarine ESM/ELINT system.

Description
The C-Pearl-S system is based on Rafael's surface ship C-Pearl-ES ESM system with a unique integrated antenna array adapted to the submarine's ESM mast, search periscope and attack periscope. The system features an enhanced ELINT capability. The C-Pearl-S offers low antenna RCS, wide frequency coverage, high DF accuracy, intimate signal measurements and fast reaction time. A unique digital receiver processor drives the system. The modular architecture system uses qualified and seaborne tested units.

Contractor
Rafael, Armament Development Authority Ltd, Systems Division, Haifa.

VERIFIED

Timnex II

Type
ESM/ELINT/COMINT system.

Description
Timnex II is an advanced IFM channelised ESM receiver for ESM/ELINT operations. It provides omnidirectional detection, intelligence gathering and direction-finding in the 2 to 18 GHz band, performing in-depth tactical analysis on up to 256 detected emitters in real time. Bearing accuracy is believed to be in the region of 1.5° and the emitter library holds up to 10,000 parameters.

Detected emitters are identified and data on them displayed on a sophisticated graphic and alphanumeric operators console equipped with one or two high resolution displays, a keyboard and trackball. Processed radar pulses are digitally recorded for replay and selected radar video signals are recorded in analogue. The continuously open system provides instantaneous frequency coverage and

direction-finding with real-time signal processing and features automatic high amplitude, CW alarm and automatic identification of pre-defined targets.

The system is fully automatic in operation with a manual control. It assures short response time and high omnidirectional detection probability in dense environments.

Timnex systems can be configured for both surface and subsurface applications and two main configurations are available:

- ESM/ELINT system integrated within the combat system
- Integrated ESM/ELINT and COMINT system operated from one or more operator consoles.

Operational status
Operational in submarines of several navies. The system is operational on the Dolphin class submarines of the Israel Navy and is on order for the four Type 214 Katsonis class boats building for the Greek Navy. Earlier variants of the system are fitted to the Israeli Gal and Taiwanese Hai Lung classes of submarine.

Specifications
Frequency coverage: 2-18 GHz
Frequency accuracy: 1.5 MHz
Sensitivity: –68 to –70 dBm
Bearing accuracy: better than 2° (phase comparison antenna array)
Hydrostatic pressure: in excess of 50 bars

Contractor
Elbit Systems Ltd, Haifa.

UPDATED

Italy

Thetis/BLD-727 ESM

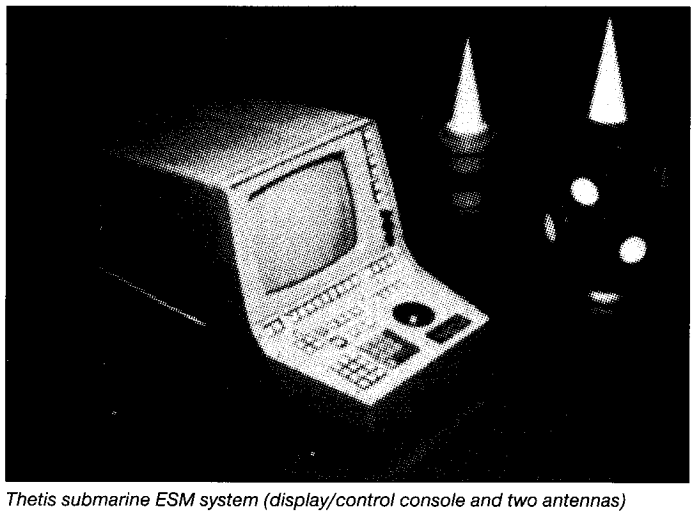
Type
Submarine ESM surveillance system.

Description
Thetis is a modular ESM system designed to fulfil the EW requirements of a submarine. The system is produced in two configurations. The first and simpler of these, the ELT/124-S, performs high-sensitivity instantaneous threat warning and DF functions, while the second, the ELT/224-S, extends these functions to those of a full ESM system or tactical ELINT. Both variants use the same DF antenna as the sensor, and both can be fitted with an additional and separate RF preamplified omnidirectional antenna as an option. This latter antenna is very small and can be installed on top of the submarine's attack or search periscope for primary warning.

The ELT/124-S variant consists of a threat warning and DF receiver system. The hardware comprises a DF antenna and receiver, a processor unit and a warning display. It provides instantaneous, high-sensitivity, warning of threats programmed into the processor and continuous surveillance of the radar environment with 100 per cent intercept probability. A dedicated operator is not required.

The ELT/224-S consists of the units of the ELT/124-S plus an IFM receiver and an ESM display. It provides instantaneous DF with 100 per cent intercept probability of pulse and CW emissions, display of all intercepted emissions, IFM, automatic technical analysis and identification of emitters and their platforms. It will also provide warning that the vessel is entering an area under hostile radar surveillance. A single operator is required for this system.

The antenna assembly consists of one conical spiral omnidirectional antenna plus eight plane spiral DF antennas assembled in a single casing. It has a very low radar cross-section and is also covered with microwave absorbing material. It is light but strong enough to be mounted on the search periscope. The small, lightweight optional antenna can be mounted on the attack periscope and will provide the submarine commander with a first alarm facility without DF.



Thetis submarine ESM system (display/control console and two antennas)

Operational status
In production and operational service aboard Italian Navy submarines.

Contractor
ABE Elettronica SpA, Rome.

VERIFIED

ULR-741 ESM/ELINT

Type
Submarine ESM/ELINT automatic system.

Description
An improved version of the Thetis ESM system is being commercialised under the designation ULR-741.

The system features fully automatic ESM operation with an environment 'snapshot' capability and fast, high-quality ELINT analysis and data recording.

The system uses the same antenna unit of the ELT/244-S, with minor circuit changes, while the internal units are derived from the latest generation of airborne automatic ESM/ELINT systems, manufactured by Elettronica SpA.

Operational status
Ready for series production.

Contractor
ABE Elettronica SpA, Rome.

UPDATED

United Kingdom

Manta ESM system

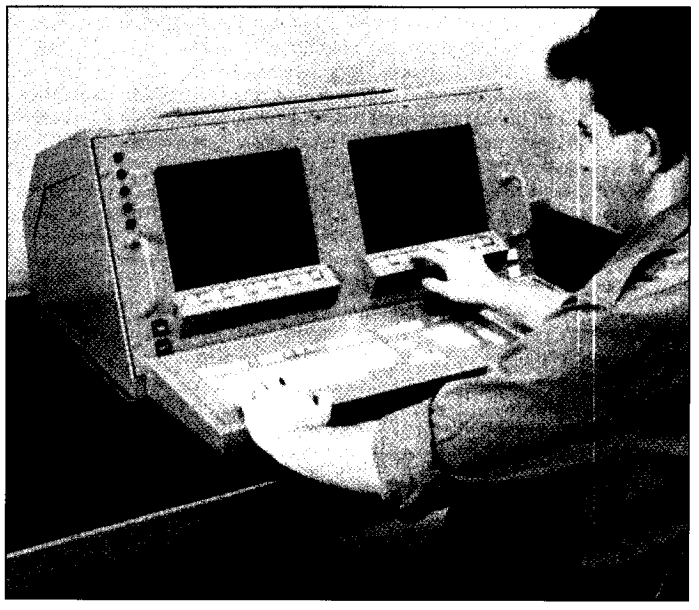
Type
Submarine radar detection and analysis system.

Description
Manta is a range of advanced ESM systems optimised for submarine applications. Each of the Manta systems intercepts, analyses, classifies and identifies enemy radars operating in the 2 to 18 GHz frequency band.

Instantaneous detection of radar threats at long range provides submarine commanders with maximum warning of the presence of enemy surface ship or airborne ASW systems. In addition, Manta provides information for tactical battle management, targeting and information gathering. Instantaneous warning enables the submarine commander to maintain a covert posture.

Manta is designed as a modular equipment that enables the most cost-effective system to be built up to match the operational requirement for a particular class of submarine.

Different antenna configurations provide options for extended frequency coverage and high-resolution targeting. Digital processing modules can extend the pulse density and library capacities. The ESM can be interfaced with the central command system and the output data may be recorded on either magnetic tape and/or hard-copy.



Operator's console for Manta ESM system

Using wide open ESM techniques, the systems provide 360° coverage and 100 per cent probability of intercept. Intercepted signals are automatically analysed and identified by reference to a comprehensive library of known radar types covering simple pulse, frequency agile, PRF agile, CW high duty cycle, FMOP and PMOP flags. Processed data is immediately displayed to the operator in both Cartesian and alphanumeric formats on two interchangeable colour displays. Manta uses a central management computer controlling subsystems, each containing advanced microprocessors carrying out local processing.

A version of Manta, with DF accuracy down to 2° is available for use in long-range weapon targeting. Manta variants are available for ocean-going and patrol submarines, and the Manta antennas can be mounted on a dedicated EW mast, or elsewhere as requested.

Operational status
In production. Sea trials of a variant of Manta on an Oberon class submarine, were completed in August 1988 as part of a programme to update the Royal Navy's submarine ESM system. The Manta E variant has been supplied to Inisel of Spain where it equips the Agosta and Daphné class submarines of the Spanish Navy. The Manta S outfit also equips the Swedish Gotland class submarines.

Specifications
Frequency range: 2-18 GHz (optional extensions either end are available)
Azimuth coverage: 360°
Elevation coverage: –10 - +30°
Signal polarisation: horizontal, vertical and either RH or LH circular
Bearing accuracy: 6° RMS
PRF: 50 ns to 100 µs
Scan: circular, sector, steady (simple and complex)
Scan periods: 0.02-40 s
Mission library: 2,000 emitter modes

Contractor
Thales Sensors Ltd, Crawley, West Sussex.

VERIFIED

Porpoise

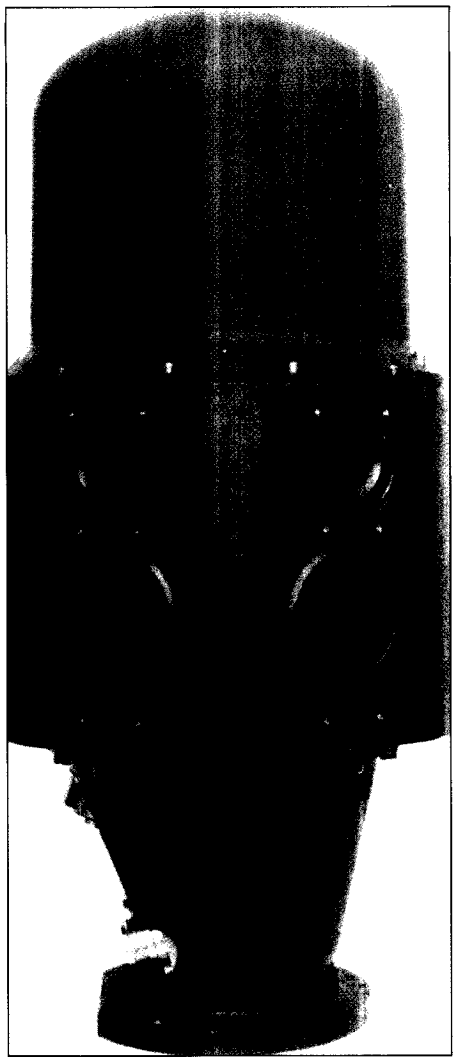
Type
Submarine radar surveillance system.

Description
A submarine version of the Cutlass ESM equipment, Porpoise is a fully automatic ESM system operating throughout 360° of azimuth. The equipment receives signals in the 2 to 18 GHz frequency range, measures their parameters and compares these with those contained in a preprogrammed radar threat library. Processing of the radar emitter signals is carried out against the library to give the operator an alphanumeric or graphic display of identification and threat significance. Up to 2,000 radar modes are held in the library and the operator can feed in data on up to 100 other emitters.

Intercepted signals are preamplified in the mast unit before being passed to the processing and analysis equipment inside the hull. Bearing data is extracted using amplitude comparison. Amplitude, pulse width, frequency and time are combined in a single digital word before being passed to the processor unit in the operator's console. There the pulse trains of the different radars are deinterleaved and identified from the library information.



Porpoise console unit



Porpoise antenna unit

The system is capable of integration with the vessel's fire-control and communications systems and may also be integrated with periscope-mounted radar warning equipment. Porpoise also has the ability to give an alert warning when prime threats, such as helicopter or maritime surveillance radars, reach a preprogrammed danger level.

The Porpoise antenna is a compact six-port system giving good bearing accuracy and may be mounted on either hull penetrating or non-hull penetrating masts. It is built of titanium to reduce weight and overcome corrosion, and is pressure resistant to 60 bar. With the exception of the antenna system, the primary subassemblies of Porpoise are fully compatible with those of Cutlass and so enable common logistic facilities.

Operational status
In service with the Turkish Navy (the first four of the Preveze class Type 209 and some of the Atilay class Type 209s).

Contractor
Thales Sensors Ltd, Crawley, West Sussex.

UPDATED

Sealion

Type
Submarine ESM search and warning system.

Description
The Sealion ESM system (the submarine variant of the Cutlass ESM system), is configured to address a wide range of submarine EW requirements including: threat warning; tactical surveillance; assistance in targeting, and intelligence gathering.

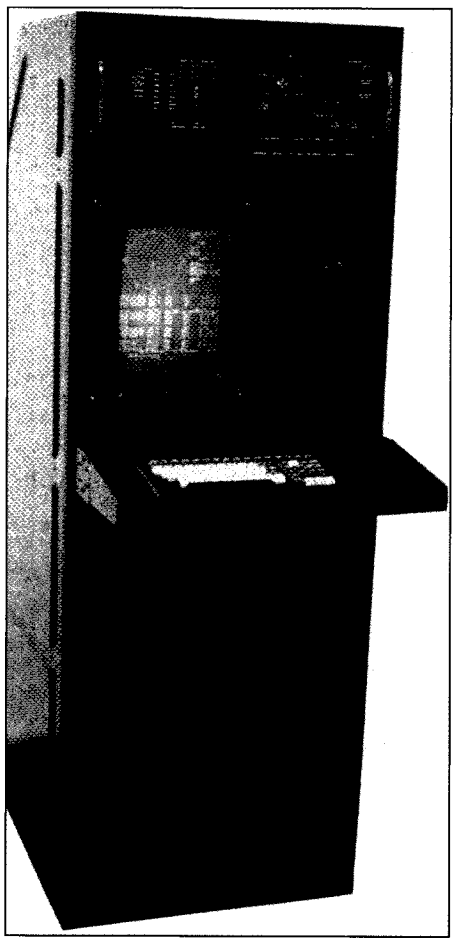
The system operates in dense pulse environments providing accurate instantaneous bearing and frequency measurement over a full 360° azimuth, giving a Probability Of Intercept (POI) of 100 per cent in the frequency range 2 to 18 GHz. The advanced system architecture is modular in design with a variety of options available to extend its performance to satisfy future operational requirements.

Key system features include:

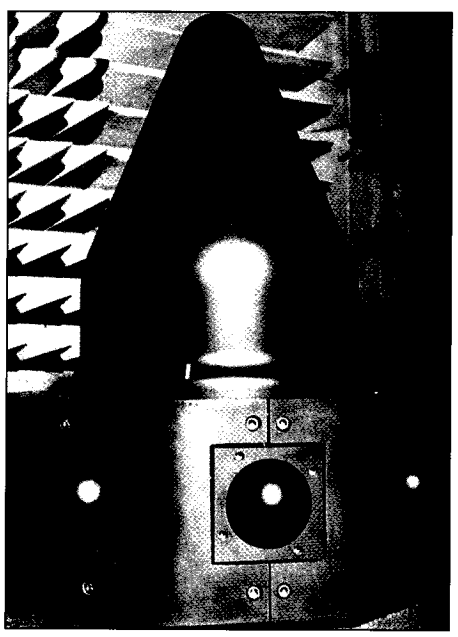
- near instantaneous parameter measurement. The wide open receiver architecture uses a highly reliable omnidirectional channel
- accurate DF; the eight element bearing measurement system, using Racal Radar Defence System's advanced proprietary quadratic fit algorithm combined with squint correction and gain calibration, provides exceptional DF accuracy
- state-of-the-art pulse train de-interleaving system
- a modern user-friendly Windows-based operator interface
- extensive BITE
- compact size, high reliability and low power consumption.

The system consists of an omni-directional antenna, a receiver processor unit and a low volume/lightweight operator console. The antenna may be installed in a penetrating or non-penetrating mast configuration. The main antenna assembly consists of two omni-directional antennas, an optional GPS antenna and an eight port (four active) DF array. The system switches between the elements of the DF array on a pulse-by-pulse basis and, the entire assembly can be configured for installation on penetrating or non-penetrating masts. The receiver incorporates an advanced ESM processor using VLSI integrated circuits to provide fast analysis of complex RF environments. Real-time comparison with the pre-programmed library of 10,000 radar emitter modes provides rapid emitter recognition with the processor automatically tracking over 200 emitters simultaneously. An auxiliary library of 100 emitter modes is provided to hold operator loaded data. The compact operator console is fully ruggedised to meet the demands of the naval environment and has a high resolution colour display. This provides the operator with a tabular or graphic display of emitter identity, bearing and threat significance. The processor provides a continuous update on emitter status. Data may be recorded onto magnetic disc for subsequent detailed analysis. The system runs on Windows® NT using a variety of COTS flat panel displays.

The masthead also houses a GPS unit and has provision for UHF communications antennas (300 MHz to 1 GHz) if required.



Operator's console of the Sealion ESM system



Sealion antenna
0006979

Operational status

Sealion has been selected in a hull-penetrating mast configuration for installation in a number of modernised submarines. Submarine classes equipped with Sealion include: 'Ula' (Norway), 'Tumleren' (Denmark), 'Atilay' (Turkey – some of class) and 'Preveze' (the last four boats).

Specifications

Frequency range: 2-18 GHz
Bearing accuracy: <3° rms
Sensitivity: –60 dBmi
Dynamic range: 55 dB
Elevation coverage: –30 to +30°
Azimuth coverage: 360°
Pulse density: 1,000,000 pulse/s

Contractor

Thales Sensors Ltd, Crawley, West Sussex.

UPDATED

UAP 1/3/4 family

Type

ESM systems for submarines of the Royal Navy.

Description

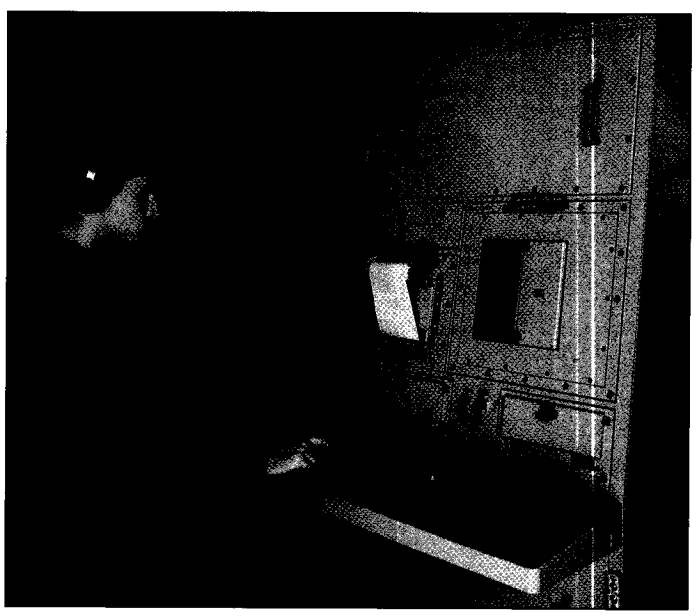
The UAP family of equipment consists of outfits UAP(1) in the Swiftsure and Trafalgar class SSNs and UAP(3) in the four Vanguard class SSBNs.

Outfit UAP(1) is a submarine radar ESM system designed, developed and manufactured by Thales Sensors Ltd. The equipment has successfully completed the full range of UK MoD-specified harbour and sea acceptance trials, exceeding its declared performance specification in a number of key areas.

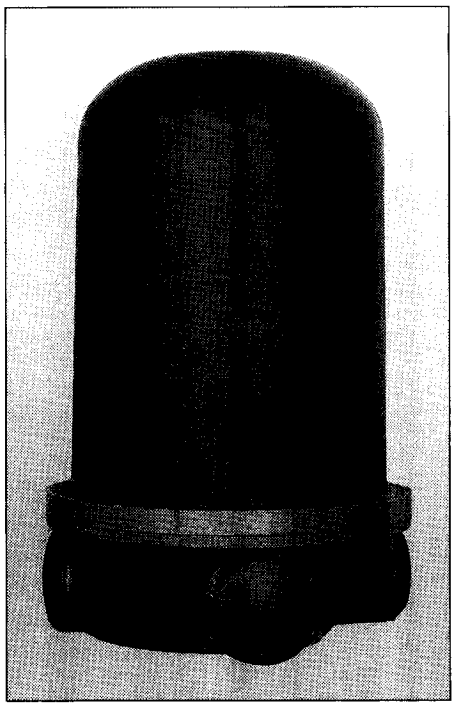
Outfit UAP(1) has a frequency range covering all the required radar bands (1-18 GHz) and a frequency extension capability is already in place in anticipation of future operational requirements.

The UAP(1) and UAP(3) equipments fulfil the four principal submarine ESM requirements of self-protection, surveillance, data gathering and over-the-horizon targeting for weapon release. They also benefit from a number of operational and technical enhancements as follows:

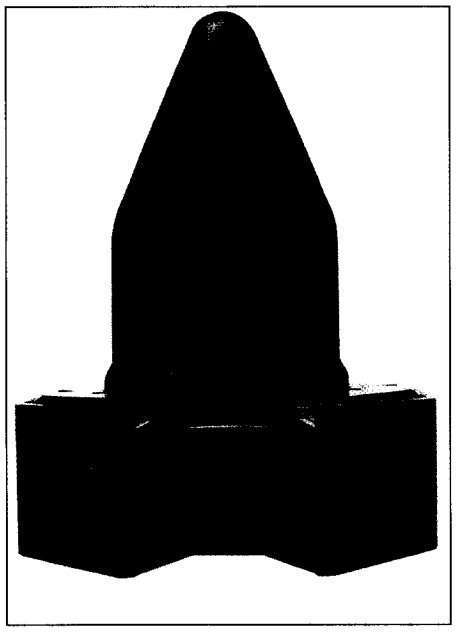
- automatic alarm levels – the calculation of the alarm level, which indicates that the submarine is at risk of detection by radar, has been automated.
- disposition of antennas – the minimising of mast exposure is a critical requirement of submarine ESM. The disposition of the UAP(1) antenna elements allows the command to carry out in excess of 95 per cent of the radar ESM role using the search periscope only. The main ESM mast is used only for high-accuracy direction-finder targeting, or as a reversionary mode in the event of search periscope failure.



UAP(1) operator's console unit showing two colour displays, advanced MMI, and an onboard training unit



UAP(1) ESM mast antenna



The AZE antenna

- Man/Machine Interface (MMI) – UAP(1) and UAP(3) are single operator systems employing a number of special function keypads, which together with a rollerball allow the operator to achieve the majority of his interaction with the system by using a single keystroke. The MMI features twin high-resolution colour displays which present unprocessed and processed data to the operator
- onboard training – UAP(1) and UAP(3) are the first submarine ESM systems to have an integral onboard trainer. This allows prerecorded scenarios to be played into the system while the submarine is deep.

  The onboard trainer is capable of simulating the most complex scenario with full environmental representation. Realistic onboard training is a critical asset in maintaining an operator's professional skill both at sea and in harbour
- data gathering – UAP(1) and UAP(3) allow the operator to log to disk data of any selected radar intercept. The recordings can be reviewed on board before submission for post-patrol analysis.

The UAP(4) is the latest development of the UAP family and will be the first application by the Royal Navy of a Thales Sensors antenna mounted on a non-hull penetrating mast. UAP(4) preserves a high degree of commonality with UAP(1) and UAP(3) systems.

Operational status
UAP 1 equips the Swiftsure and Trafalgar class, UAP 3 the Vanguard class and UAP 4 has been specified for the Astute class. It is proposed to give UAP 1 a MLU (mid-life upgrade).

Contractor
Thales Sensors Ltd, Crawley, West Sussex.

VERIFIED

United States

AN/BLD-1

Type
Submarine system.

Description
The AN/BLD-1 is a submarine-based precision radar direction finding system, installed in the US Navy's vertical launch system equipped Los Angeles class attack submarines, as an adjunct to the BRD-7 system. It detects passively and tracks airborne, surface and land-based radar threats, employing a mast-mounted antenna that is raised just above the sea surface for operation. The system delivers precise threat bearing information, which is integrated with other sensor data for tactical surveillance and over-the-horizon targeting for vertically launched Tomahawk missiles.

No technical details are available, although it is understood that Litton Systems has developed a number of complex algorithms required to solve the multipath problems caused by the close presence of surface waves. The system operates principally as a interferometric DF set, but can also provide frequency and PRF information if commanded. The equipment covers two frequency bands with two receivers covering each band.

Operational status
Entering service with the US Navy in 1985, some 38 systems have been delivered or are on order for the Los Angeles class submarines. Three systems have been ordered for the Seawolf class, where they form part of the AN/WLQ-4(V)1 EW system.

The system will also be installed in the Virginia class NSSN as part of the AN/WLQ-4(V)1 system.

Contractor
Amecon Division of Litton Systems Inc, College Park, Maryland.

VERIFIED

AN/BLQ-10

Type
Submarine ESM system.

Description
The AN/BLQ-10 ESM system (previously referred to ASTECS — Advanced Submarine Tactical ESM System) has been designed to equip the Virginia and Los Angeles class submarines.

AN/BLQ-10 is a fully integrated radar and communications ESM combining threat warning and intelligence gathering. The system incorporates extensive non-developmental items and COTS technology in all major functional areas to the extent of 92 per cent of hardware and 90 per cent of software. The system uses a new, integrated ESM mast interfacing with the photonics mast, external communications, sonar, C3IS and other ship systems aboard the Virginia class.

The radar ESM subsystem is believed to use a pair of narrowband radar tuners, with a single wideband receiver providing automatic detection, acquisition, identification and localisation of hostile, neutral and friendly emissions.

The communications subsystem will in all probability include receivers capable of detecting HF, VHF and UHF communications, as well as many other types of signal, including those from cellular networks and low probability of intercept signals.

The antennas of the system are being mounted in a new universal modular mast.

The open architecture, modular, upgradeable system collects and processes complex radar, communications and navigation low-level emissions from commercial shipping traffic and surface threats. These are rapidly analysed and critical signals of immediate tactical importance to the submarine commanding officer are reported. It incorporates a robust interface with the command, control, communication and intelligence system and other associated systems of the submarine.

Displays provided to the operator include: threat warning/mission tasking and a second tier tasking display. Other displays provide signal alerts and a summary from a quick search primary threat warning and a quick search secondary threat warning display with identification confidence. The operator is also presented with signal alerts and summary displays and a plot display from the precision and communications direction-finding equipment. The AN/BLQ-10 also provides analysis and situation assessment with signal exploitation, receiver control, contact manager, TRE display, geographic situation and details of non-interest signals.

Its ability to provide electromagnetic surveillance on the ocean surface is comparable to the traditional submarine undersea acoustic surveillance mission. This is critical to a battle group's requirements for a submarine to operate as effectively near the ocean surface as it has traditionally done while deeply submerged.

Operational status
Through 2002 - Production of a further eight units was projected.
October 2000 - System completes Operational Evaluation.

End 1999 - Limited production contract for six systems awarded. Two systems are for the Virginia class and four to replace existing equipment on Los Angeles class submarines.

The US Navy is currently studying the possibility of adapting the AN/BLQ-10 system for installation on Seawolf class submarines.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

UPDATED

AN/BRD-7

Type
Submarine communications DF system.

Description
The AN/BRD-7 system is a high-performance system designed to provide a DF capability over a wide frequency range.

The set features signal analysis capability and it uses an omni antenna mounted on a periscope.

Operational status
The AN/BRD-7 entered service in the early 1970s and it is estimated that around 100 systems were procured. The system now equipping Los Angeles class submarines.

Contractor
BAE Systems North America, Information and Electronic Warfare Systems, Nashua, New Hampshire.

VERIFIED

AN/WLQ-4(V)1

Type
Submarine SIGINT detection and analysis system.

Description
The AN/WLQ-4(V)1 (also known as Sea Nymph) performs SIGINT missions aboard attack submarines of the US Navy. It is an automated, modular signal collection system which allows for the identification of the nature and sources of unknown radar emitter and communications signals. It incorporates a network of mini-computers and microprocessors, and data from these computers is correlated with information received from satellite sensors. The system is part of Sea Nymph, a highly classified US Navy NAVELEX programme.

The AN/WLQ-4(V)1 system has a number of key features, including:

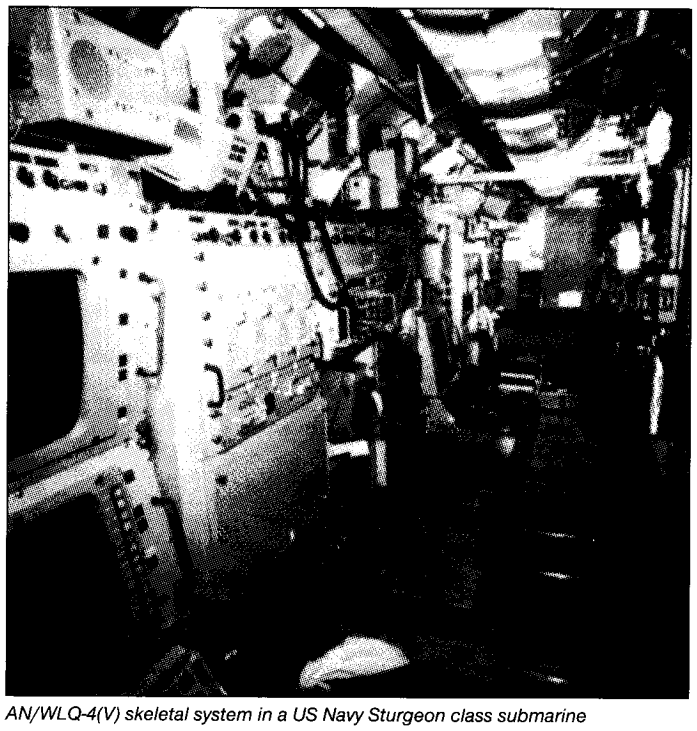
- automatic search, acquisition and signal processing
- automatic logging, book-keeping and reporting
- semi-automatic correlation of real-time measured data with input from an external system
- 400,000 lines of AN/UYK-44 source code
- 50,000 lines of executable code in 40 microprocessors
- a significant growth capability to handle new threats.

The AN/WLQ-4(V)1 forms part of the AN/BLD-1 system.

Operational status
In service on board the US Navy's Sturgeon and Seawolf class nuclear-powered attack submarines, and proposed for the Virginia class NSSN.

Contractor
General Dynamics Information Systems and Technology Business Group, Mountain View, California.

VERIFIED



AN/WLQ-4(V) skeletal system in a US Navy Sturgeon class submarine

AN/WLR-8

Type
Submarine tactical radar detection and analysis system.

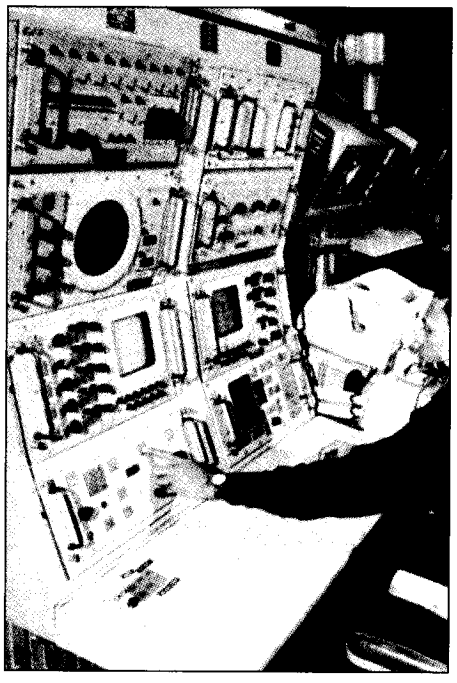
Description
The AN/WLR-8 is a solid-state tactical electronic warfare and surveillance receiver designed for fitting in both surface ships and submarines of the US Navy. The system is of modular construction and provisions are made for operation in conjunction with numerous types of direction-finding or omni-antennas, and a wide range of optional peripheral equipment, to provide comprehensive ESM (Electronic Support Measures) facilities. The WLR-8 is compatible with NTDS (Navy Tactical Data System) and similar action information automation systems. The system can be expanded in frequency or signal handling capability by means of simple additions and/or software changes. Four versions are available: V(1) for submarines, V(2) for Los Angeles class (SSN-688) submarines, V(4) for large surface ships and V(5) for Ohio class Trident submarines. Frequency coverage is from 50 MHz to 18 GHz V(2) variant.

Two digital computers are incorporated: a GTE PSP-300 for system control, automatic signal acquisition and analysis, and file processing; and a GTE PSP-200 microcomputer for hardware level control functions. Digital techniques are employed throughout the WLR-8 system, which is all solid state.

Operational facilities provided include:

- automatic measurement of signal direction of arrival
- signal classification and recognition
- sequential or simultaneous scanning over a wide frequency range
- signal activity detection for threat warning
- analysis of signal parameters such as frequency, PRF, modulation, pulsewidth, amplitude and scan rate
- logging signal parameters for display to operator (s), and printout of hard-copy to teletype or printer
- extensive built-in test equipment
- directed priority searches of specific frequency segments.

Direct reporting to onboard computers, such as NTDS, permits response times in the millisecond range with minimal operator involvement. A two-trace CRT is provided for display purposes and this can be supplemented by an optional five-trace panoramic display for presentation of signal activity data. Another CRT display is incorporated if the WLR-8 is used with automatic or manual DF antenna systems.



Operating console of AN/WLR-8 tactical EW receiver

Operational status
Operational with USN. More than 2,700 sets have been produced. The system is in use on board SSN-688 Los Angeles class submarines V(2), and the V(5) version is fitted to Ohio class ballistic missile submarines.

Contractor
General Dynamics Information Systems and Technology Business Group, Mountain View, California.

VERIFIED

AR-700(S)5

Type
Submarine ESM/DF system.

Description
The AR-700(S)5 ESM/DF modular electronic warfare system provides threat warning and DF capabilities over the frequency band 2 to 18 GHz. The system features a nominal sensitivity of –60 dBm, automatic signal/data processing and monopulse direction-finding. The DF element of the system features an accuracy of 5° rms, high sensitivity (–60 dBm), high-frequency accuracy using digital IFMs and advanced software technology including tactical graphics display.

Four other levels of extended performance are available for the ESM element, which allows the system to be upgraded to meet a variety of missions.

Five versions of the AR-700 are available covering the 2 to 18 GHz band and are wide open in frequency, bearing and time (no band stepping). All configurations include the ASP-32 advanced distributed signal multiprocessor specifically designed for operating in dense, complex naval electronic environments.

All configurations feature a 200 active signal handling capability, automatic signal and platform identification, high processing speed, a cassette recorder for loading/storing/changing library data while at sea, and an optional hard-copy printer for logging signal data. A weapon control system interface is also included.

The AR-700 consists of two subassemblies: an antenna unit with omnidirectional antenna channel for the frequency receivers and a six-element monopulse spiral array for DF (a rotating DF is optional); a control/display assembly with two high-resolution digital IFM receivers, bearing digitiser unit which processes direction-finding data from the spiral array, and ASP-32 advanced signal processor, digital cassette recorder, operator's tactical data display, and keyboard with function control keys.

Nine operator display formats are included with five alphanumeric formats which are used for reviewing signal intercept and library data. A graphics format summarises the overall tactical situation.

Operational status
No longer in production. The AR-700(S)5 configuration has been a standard fit for the German HDW Type 209 submarines. The system is operational aboard the Egyptian Romeo, Greek Glavkos, and Swedish Vastergotland class. It is also carried by the ex-Swedish submarine *Näcken* now serving with the Danish Navy under the name *Kronborg*. Other units fitted with variants of the AR-700 system are some of the Indian Type 209 submarines and the Dutch Walrus class. The AR-740 offers numerous performance extensions and improvements to the basic AR-700(S)5 for specialised applications and is installed in the Australian Collins class boats, and Taiwan's Hai Lung class.

Contractor
EDO Reconnaissance & Surveillance Systems, Morgan Hill, California.

VERIFIED

AR-900

Type
Tactical ESM system.

Description
The AR-900 tactical ESM/DF system from Condor Systems is designed for electronic warfare applications. The system consists of three subassemblies: the antenna, receiver/processor unit and operator workstation. The AR-900 provides a very high probability of intercept across the 2 to 18 GHz frequency band.

The antenna system features a new lower radar cross-section wideband omni-antenna and an eight-element wide-open amplitude monopulse DF array with a bearing accuracy better than 3° rms. The receiver features a 1 million pulse per second throughput capacity using 100 per cent probability of intercept architecture and –65 dBmi sensitivity. The receiver subassembly consists of two wideband digital IFM receivers, a monopulse bearing receiver and a VME-band Electronic Signal Processor (ESP). The ESP can process the up to one million pulses per second receiving digitised high-resolution frequency measurements for each received radio frequency pulse and continuous wave signals from the IFM receivers. Parameters measured include frequency, pulse repetition, pulsewidth, scan and amplitude. The monopulse bearing processor provides direction of arrival and amplitude of each pulse. Types of signal detected include conventional pulse train, agile frequency, staggered pulse repetition (2 to 16 positions), frequency/phase/amplitude on-pulse, jittered PRI, continuous wave, FMCW and pulse Doppler. The ESP processes both sets of data in parallel, compares the pattern with patterns held in a signal library to identify the emitter and its platform and alerts the operator to a high-threat signal within one second of acquiring the signal. Emitter libraries can be programmed with up to 10,000 emitter modes that can reference as many as 500 radar names and associated platforms.

The operator workstation comprises a keyboard with integrated trackerball; high-resolution, flat panel colour display; a floppy disk drive; a printer; and an embedded computer. The display provides the operator with tactical and intelligence information using simple, comprehensive displays incorporating Windows technology. The 'activity', 'tactical', 'graphics' and 'tactical summary' pages give the operator threat warning information, while the frequency/azimuth, frequency/PRI, and frequency/amplitude pages are for analysis. An intercept report generator is provided to prepare intelligence reports.

The system is available with or without an operator console and can be easily integrated into a submarine combat system via any standard interface. As an option, the system can be provided with integrated GPS or SATCOM antennas.

Operational status
The AR-900 is in service in a number of countries and is currently in production. The system is being installed in the Chilean O'Higgins class Scorpene type submarines.

Specifications

Frequency band:	2-6 GHz		6-18 GHz
System sensitivity:	–65 dBm		–65 dBm
DF measurement accuracy:	3.5°		2°
Dynamic range:		>70 dB	
Receiver recovery time:		<100 ns	
Azimuth coverage, instantaneous:		360°	
Displayed resolution:	1 MHz		1 MHz
Accuracy, rms:	2 MHz		3 MHz
Range:		0.05 to 230 µs	
Resolution:		0.5 µs	
Amplitude measurement:			
Range:		>60 dB	
Resolution:		1.0 dB	
PRI measurement:			
Range:		2 to 10,000 µs	
Resolution:		0.1 µs	

Contractor
EDO Reconnaissance & Surveillance Systems, Morgan Hill, California.

UPDATED

AU-506

Type
Submarine ESM antenna.

Description
The AU-506 ESM antenna is designed to provide both DF and signal acquisition outputs covering the HF/VHF/UHF bands in the 0.5 to 2,000 MHz frequency range. Parallel outputs are provided for sine, cosine and omnidirectional data. The AU-506 can be used with compatible narrow and wideband processing equipment, or integrated with existing arrays to provide an upgraded performance.

The equipment is designed to survive the hydrodynamic flow forces, hydrostatic pressure, vibration, shock and wave slap conditions experienced during submarine operations.

The AU-506A is a variant designed to offer an integrated COMINT/ELINT (communications and electronic intelligence) capability.

Operational status
The equipment is understood to have been 'proven' and is available.

Specifications
Frequency range: 0-5 to 2,000 MHz
DF accuracy: 5° RMS
Elevation coverage: –5 to +45°

Contractor
Southwest Research Institute, San Antonio, Texas.

UPDATED

CS-3701

Type
Tactical ESM system.

Description
The CS-3701 is a tactical monopulse DF system that provides continuous omnidirectional surveillance of the 2 to 18 GHz frequency band offering 100 per cent probability of detection. This is achieved using the latest phase measurement technology for high-precision monopulse direction finding combined with a patented autohet receiver designed to achieve the 100 per cent probability of intercept. The system can operate fully automatically displaying all intercepted signals, and generating audible and visual alarms for predefined threat signals.

The mast antenna array contains two DF arrays: one covering the 2 to 6 GHz band and the second array covering the 6 to 18 GHz band. These can be extended down to 0.5 GHz and to 40 GHz. Each interferometer array produces bearing and frequency.

The receiver unit contains a phase DF receiver and frequency measurement receiver. Various filters remove interfering signals.

Up to 500 signals can be tracked simultaneously while maintaining full sensitivity and can be compared with a library store of over 10,000 records. The system provides 2° AOA. The instantaneous dynamic range is 60 dB, while sensitivity is specified as –65 dBmi. DF accuracy over the entire dynamic range is 2° with 3 MHz frequency measurement accuracy. With an optional superhet receiver covering 0.5 to 18 GHz the sensitivity is raised to –80 dBmi. Resolution is 12.5 nsec. Graphical analysis and emitter display is presented to the operator on a standard Windows NT HMI format.

Operational status
The system is in operation in a number of countries navies and is currently in production. On order to upgrade the Swedish Vastergotland class submarines and entering service on the Visby class corvettes.

Contractor
EDO Reconnaissance & Surveillance Systems, Morgan Hill, California.

VERIFIED

ES and ADF system

Type
Submarine Electronics Support (ES) and Automatic Direction Finding (ADF) system.

Description
The ES and ADF system is currently being fitted to the Type 18 search periscopes of US Navy Seawolf, Sturgeon, Los Angeles and Virginia class SSNs. The equipment incorporates a mast-mounted antenna assembly (located above the periscope's gyro-stabilised optics), radio frequency receivers, a digital processor and a display.

Operational status
A total of 24 Type 18 Es and ADF systems are reported to have been procured by the US Navy with a potential for in excess of 60 systems.

Contractor
BAE Systems North America, Information and Electronic Warfare Systems, Lansdale, Pennsylvania.

VERIFIED

UNDERWATER COMMUNICATIONS

Introduction

This section covers those systems that are primarily devoted to underwater communications. Information on these is frequently sparse because of security restrictions. Equipments described cover communications between surface ship/submarine and vice versa, aircraft/submarine and vice versa, and submarine/submarine. Communications ESM forms part of the section on EW.

Radio communications between submerged submarines and ships, aircraft or shore-based stations pose many problems. As the need has increased for submarines to operate and co-operate more closely in the littoral scenario with surface task forces and aircraft, so too has the need for more effective communications between all these platforms and satellites. In fact it is not just text messages and data which need to be communicated but pictures as well – and all in real time if the concept of joint operations within the context of network centric warfare is to be realised. However, the major problem with underwater communications is the distortion suffered owing to the multipath effect – the large number of paths that a signal can pass along underwater. Sound travels relatively slowly through water, requiring much lower frequencies of transmission compared to radio. Furthermore, as only a fraction of the carrier wave frequency can be use to transmit a signal, the basic signalling rate is much slower than for radio. Hence, to transmit a sound signal underwater takes much longer to cover a set distance, during which it undergoes considerable distortion.

The multipath problem can be overcome using the considerable computing power now available in modern computers to sample and filter signals.

The US Naval Underwater Systems Center contracted Lockheed Martin Sanders to investigate the problems of underwater communication. Using two different frequency bands – one HF (20-30 kHz) with a high data rate (10 kbps), and one MF (2-4 kHz as in a submarine sonar) with a medium data rate (2.4 kbps as in Link 11), Lockheed demonstrated that it was possible to conduct effective communications at LF between a surface ship and a submarine over a range of 35 n miles. Using the HF link it showed that a submarine could communicate with a UUV (the Manta) over a range of 2.5 n miles at which it was possible to transmit pictures. This has opened up enormous possibilities in the use of UUVs as stand off sensors capable of transmitting data and pictures back to a submarine which in turn can re-transmit that data, together with data from its own sensors, back to surface ships and aircraft and in fact to receive such data itself from surface ships and aircraft.

The UK has also been investigating the need for more comprehensive and effective communications between SSNs and a wide variety of other platforms and is planning to introduce Link 11 tactical datalink and Link 16 satellite tactical datalink transmit and receive under the SSN TDL project. Link 11 is scheduled to be operational aboard all British SSNs by 2004 and Link 16 in service aboard Trafalgar class SSNs by 2006.

Waveband communication problems

Generally speaking, surface vessels communicate over long ranges using the 3 to 30 MHz HF band, since neither the 0.3 to 3 MHz MW nor the 30 to 300 MHz VHF bands offer adequate range. The possibility of detecting communications in this waveband is impeded by the use of burst transmission and wideband modulation. This is because the signal energy is distributed over a wide frequency band. For satellite communications the 3 to 300 GHz band is used.

However, submarines have difficulty in using any of these wavebands, as they are unable to penetrate the water. To establish two-way radio communication for urgent priority messages the submarine must therefore either surface or deploy an antenna while remaining submerged. Both options are unsatisfactory because they increase the indiscretion rate of the submarine. Any transmitter can be rapidly and accurately detected by modern electronic DF equipment, even if the message is sent as a digitised burst lasting only a few seconds. From this, the ASW aircraft can immediately determine the likely area of operation of the submarine and plan an effective search and attack. Submarines therefore have to use alternative methods to communicate from greater depths without direct physical contact with the surface.

Transmitter buoys

One method that enables the submarine to put itself at some considerable distance from its transmitter is the towed buoy. Tethered to the submarine by a datalink cable, the buoy houses an antenna, its own power supply and a wideband amplifier. However, given the high resolution of modern airborne search radars, this solution is also vulnerable to detection. Smaller buoys are therefore required which the submarine can launch at depth from its SSE. In addition to the transmitter and power supply, these free floating communications buoys feature a preset timer, an extending antenna and a recorder. When the buoy reaches the surface the timer triggers the deployment of the antenna and starts to count down the delay period preset by the submarine to allow it to clear the launching area. At this point the message stored on the recorder is transmitted. On completion of the transmission to a satellite the buoy scuttles itself.

ELF communications

The only way in which a submarine can covertly receive messages from its national command centre, without placing itself in a position where it is vulnerable to detection, is to use the ELF waveband (3 to 100 Hz). Transmissions in this waveband can travel down to a depth of around 122 m at ranges of over 6,000 n miles, enabling the submarine to remain discrete. Carefully sited over rock areas, exhibiting low conductivity to aid in the propagation of the ELF signal, the generated electric current transmits deeply into the earth from one low-resistance ground terminal to another which greatly extends the electric current loop and enables a signal to be transmitted with a wavelength of 2,500 miles. The ELF signal radiates through the atmosphere with the earth-ionosphere corridor acting as a waveguide with very low signal loss. In this way the ELF signal travels out to the operational area of the submarine where it descends deep into the sea to be received by the trailing wire antenna of the submarine.

The major problem with using ELF is the size of the required transmitter antenna system. For example, an ELF transmitter can only operate to its maximum efficiency at 75 Hz using an antenna array covering several square kilometres and in an area with very low conductivity characteristics. The power requirements are also heavy: sending an ELF signal of a few watts (typically 3 to 100 Hz) through the air demands a transmitter input to the aerial of several megawatts. Normally two transmitters operate in electrical synchronisation to increase signal strength. However, the two transmitters can operate independently on different frequencies thereby increasing message capacity over all but the most extreme ranges. To provide omnidirectional radiation patterns, orthogonal antennas are used. Another problem with ELF communication is that the data transmission speed is even slower than in the VLF band due to the limited bandwidth. This implies that the messages to be transmitted must be kept to a bare minimum using short, pre-established code groups. Such coding, encryption and formatting with well-established communication procedures does, however, allow a reasonable amount of information to be transmitted to a submarine. It has been established that over a 15-minute period a maximum three letter code system can be transmitted which would allow a large number of messages to be transmitted. In order to guarantee that the message is properly received, it is continuously repeated until a new message or a station standby tone is transmitted. This means that the ELF station has to remain continuously on air. Finally, to achieve the best possible reception requires the submarine to tow a very long antenna on an absolutely straight course in both horizontal and vertical planes.

Another drawback of the ELF band is the extreme vulnerability of the large ground-based antenna, which would obviously become a priority target in a major conflict. Although ELF signals are inherently resistant to the electromagnetic pulses that would arise from a nuclear explosion, the US system is not designed to survive a nuclear strike, and since the station transmits continuously, it acts as a 'fail-safe' system. This means that should the station cease to transmit, submarines would assume that war had broken out. In this case the submarine would rise to upper levels to communicate with its assigned command centre using the HF network, or contact a defence communication satellite for further orders.

Today, ELF transmitters are used by the Russian Federation and the US for the transmission of commands to their strategic missile submarines.

Satellite laser communications

Although the sophisticated VLF and ELF communications systems help submarines to remain undetected, they are hardly compatible with even the most basic requirements of current command and control concepts. The need for a two-way voice and/or data communications system for deep-diving submarines is paramount. Since over short distances sonar-based underwater telephony is feasible, surface ships can serve as relay stations to submarines while aircraft can drop buoys containing sonar-based data transmitters. Submarine hunter-killer groups that comprise all three elements of naval warfare (surface, sub-surface and airborne units) employ such methods. However, the use of sonars for longer-range two-way contact is, for a number of technical and tactical reasons, neither feasible nor desirable.

One possibility examined during the 1970s was the use of blue-green laser radiation in the visible light spectrum. This is capable of penetration to depths of more than 90 m. Towards the end of the decade experiments were underway to develop a submarine laser communication system. To obtain the widest possible coverage it was decided to use satellites as relays between ground stations and submarines, the messages being first directed to the satellites as microwave signals and then converted into modulated blue-green laser light. The concept called for a system comprising up to four satellites, several ground stations and laser receivers in virtually all US Navy ballistic missile and attack submarines. The scientists faced enormous problems in developing such a system, and although early trials showed that such a system would confer enormous advantages, particularly in trials with a system mounted in an aircraft, both budgetary constraints and the ending of the Cold War led to a reappraisal of the need for such a highly complex and costly system. However, the successful trials using a blue-green laser communication suite mounted in an aircraft led to a shift away from satellite communication for submarines to aircraft, with the intention of adapting the developing technology for use in aircraft engaged in tactical ASW scenarios.

For submarines to have to surface to establish a UHF/VHF link with a hunter-killer task force has never been regarded as an ideal means of communication. Neither has sonar telephony ever been rated as very reliable. Airborne laser communications, on the other hand, could radically change this unsatisfactory situation and increase the effectiveness of ASW teams.

Communications – the key to the future

Whatever new technologies may be developed and used in submarine communications in the future, it is now imperative that with the new roles being undertaken by all types of submarine, including ISR missions, the need for inclusive communications and wider connectivity is paramount in the new threat scenario. That this is essential will determine in all probability, the outcome of

future submarine operations in the littoral. Connectivity or Joint Operations is now becoming the rule rather than the exception and with Network Centric Warfare being the requirement not for the future, but for the present, real time high rate data communications with reliable data link capability are essential to Network Centric Warfare. Among the communication tools required by the submarine are SATCOM, encrypted e-mail (UHF/HF/SAT), Link (UHF/HF/SATCOM and shared electronics databases which are necessary to prevent information overload.

But it is not just for Joint Operations that good communications are required. As submarines begin to deploy UUVs and AUVs in the ISR they will need to co-operate with all other types of naval assets, and in this role connectivity will become a prime requirement if the full scope of these developments is to be realised, both for the submarine platform as well as for the rest of the task force. In totally integrated forces submarines must be able to communicate with the outside world using both receive and transmit functions. As well as the ISR role and deployment of SOF, the submarine can also be used as a relay to provide target data.

These were all factors that were highlighted over and over again at the SUBCON2003 conference held at Kiel in August 2003. Speaker after speaker emphasised the need for submarines to be reachable on a 24-hour basis, and this demands that the submarine has the ability to communicate at depth. Other speakers noted that submarine communications today require a long range, reliability and the possibility to allow the submarine freedom of movement while communicating. Another requirement that was noted related to the need for a very wide bandwidth and adapted signals (that is signals made to appear as something different to what they actually are) for covert acoustic communications and for underwater/underwater communication. If submarines are to remain effective platforms and be fully integrated into the battlegroup and network centric warfare concepts, then these problems must be addressed, and soon.

UPDATED

SUBMARINE COMMUNICATIONS SYSTEMS

France

TULIP NET

Type
Multimedia Communications Network.

Description
TULIP Net is a family of communications networks for warships and submarines including voice, data and video based on the Internet Protocol. The networks are divided into three configurations: basic, extended and wide offering secure internal and external communications. The system is global, limitless, easy to use, modular and interoperable.

The federated network communicates with internal and external systems using dedicated interface modules: PABX/IPBX, self-generating telephones, wireless communication networks (PMR), radio networks, underwater telephones, broadcast networks and so on. Security of communications is ensured by separating sensitive and non-sensitive audio messages. Transmission over TULIP NET is optimised in order to meet the needs of voice communications, operating in real time.

The modular design offers a system that is scalable and expandable according to requirements. Thus it can ensure all internal communications for small surface ships; provide internal and external communications needs; and federate all communications systems for large naval platforms.

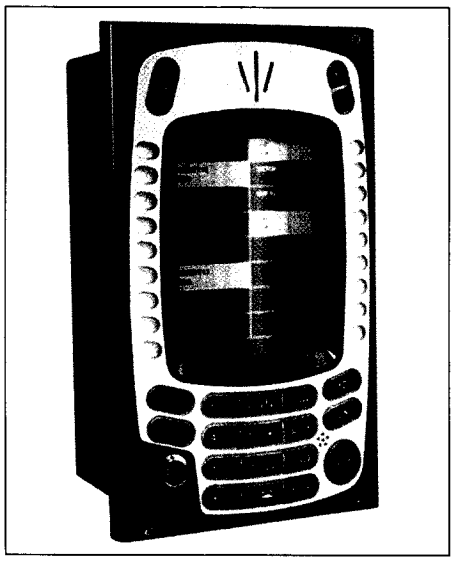
In its basic configuration, TULIP NET uses a digital loop comprising a number of TOMA IP voice terminals. Operation does not require a node or central system, each terminal being linked to adjacent ones by means of distinct links, to establish a loop configuration. The basic network for internal communications uses an Ethernet 10/100 base T.

By scaling the Basic configuration, the Extended configuration is activated, and TULIP NET allows external and internal communications for up to 40 subscribers. This version permits easy connection of all internal and external on board network communications systems through dedicated interfaces. This is achieved by using a range of interface modules in TULIP NET which link up to radios (MI-R), standard telephones (MI-T), PABX (MI-X), self-generating telephones (MI-L), and gateways for separating sensitive/non-sensitive data (MI-G). The available terminals range makes great use of IP possibilities such as videoconferencing, data transmission and so on.

The Wide configuration is achievable through the capability of TULIP NET to build limitless internal and external communication networks using the standard IP transit network. The Wide configuration is fully decentralised and its redundancy capacity can be user-defined allowing the construction of a network offering availability and maximum fault tolerance. The separation of sensitive and non-sensitive data is ensured by the network using an electronic signature recognition facility. The data is routed through "unciphered voice transmission" and "ciphered voice transmission" gateways to an external communication switching network.

Specifications

Networks	
Basic & Extended	Ethernet loop 10/100 Base T
Wide	Standard IP transit network
Terminals	
Dimensions	142 mm × 6 U × 1,200 mm
Screen	¼VGA
Channels	16 simultaneously
Microphone	Integrated electret
Loudspeaker	2 W integrated
Weight	2.4 kg
Power supply	24 48 V (220 V/50 Hz optionally)
Connector	For headset equipment



TOMA IP voice terminal
(Thales Safare)
0593007

Contractor
Thales Safare, Sophia Antipolis.

UPDATED

Germany

ICS

Type
Integrated Communications Systems for submarines and surface vessels.

Description
These systems contain components to facilitate full internal tactical communications, as well as external communications in the VLF, LF, MF, HF, VHF and UHF ranges appropriate to the warship type. This includes submarines, fast patrol boats, landing ships, corvettes, frigates and headquarters vessels. These components permit the allocation and management of radio channels from a minimum of user positions. At these user positions are voice, teletype and data terminals, recorders, monitors and encoding/encryption devices. Operation and control is decentralised.

The use of automatically tuned radios, together with the various protection and interlocking facilities of the ASYM 3000(A) communications control system, provides almost unrestricted simultaneous operation in all frequency bands. Control of allocated radio channels and full internal communications access is available from remote stations located in the command centre, wheelhouse, bridge and additional defined places.

Operational status
In service with NATO and other military customers since the early 1990s.

Contractor
AEROMARITIME Systembau GmbH, Munich.

VERIFIED

SEICAM 1001

Type
Internal/external audio distribution system.

Description
Employing digital technology, SEICAM 1001 is a modern integrated audio and data exchange for internal and external communication. It is designed for all kinds of shipborne applications as well as for shore stations.

Compared with conventional systems, the main advantages claimed for SEICAM 1001 are its flexible (programmable) configuration and minimised cabling. Only two wires (plus power) are required to connect a user station, which is an important consideration for cost saving in new systems as well as for refit programmes.

Equipment such as voice and data terminals, radio teletypes, and/or message handling systems, including different kinds of crypto devices, sound-powered telephones and public address systems, can be connected to SEICAM 1001 so that external and internal communication can be provided at the same assigned user station.

The user stations are designed to provide maximum flexibility. Because of its modular design the basic UST 1005 user station module with its seven tactical intercom circuits or one external communication circuit, can be extended by 50 circuits in the UST 1050 configuration. Stations can be mounted horizontally or vertically as built-in, desk- or wall-mounted units.

The user stations are connected to the ADM 1010 audio distribution matrix with two wires for audio/data and two wires for the power supply.

The matrix itself is designed for a centralised or decentralised set up. The ADM 1010 can be operated via the SCB 1010 status control board or a remote computer. The SCB 1010 is a panel with pushbuttons to initiate connection between user and radio equipment, and to display current communication status. In addition to the SCB 1010 functions, the remote computer provides control for internal communication settings and status display.

Operational status
The SEICAM 1001 has been selected by the German BWB for the new Type 212 submarines of the German Navy. The system has also been in service with a number of other navies since 1998.

Specifications
ADM 1010 Audio Distribution Matrix
Signal/noise ratio: >50 dB
Cross-talk attenuation: >92 dB
Temperature range: –10 to +55°C, operating

Contractor
Hagenuk Marinekommunikation GmbH (a subsidiary of EADS Defence & Communication Systems), Flintbek.

UPDATED

UT 2000

Type
Underwater communication system.

Description
The UT 2000 is a small, compact microprocessor-controlled, multifunction underwater acoustic system with graphic EL display and keyboard. In addition to telephony and telegraphy modes, various other additional functions and features are available. It fulfils the frequent demand for a wider and variable frequency range, adjustable output power and sector or omnidirectional operation. Depending on the acoustic propagation conditions, these features allow long- or short-range communication with the shortest possible intercept range, which is essential for submarines.

Operating modes and parameters are menu-guided and selected from the keyboard so that untrained personnel can use the system. The EL display always presents a Fourier analysis of the received signals with a resolution of 1 kHz over whole frequency range from 1 to 60 kHz. In addition operational parameters are displayed according to the selected mode (for example: output power, carrier frequency, modulation control and so on).

Control is simplified by an automatic switchover from receive to transmit.

Use of upper and lower sideband respectively with suppressed carrier (SSB-operation) guarantees a high signal-to-noise ratio at a high transmission bandwidth. In addition, while in telegraphy mode, the transmission bandwidth is reduced so that an optimum signal-to-noise ratio and consequently greater range can be achieved.

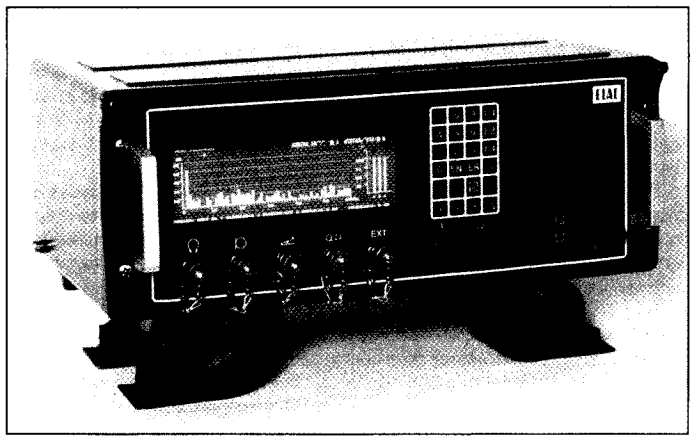
To cover the frequency range from 1 to 60 kHz it is necessary to operate with different sets of transducers for the preferred frequency bands; LF for long-range communication, HF for reduced range of intercept or for communication with divers, which can be further improved by adjusting the transmitting power to the distance of the transmission.

Operational status
More than 130 units have been sold worldwide in the last 10 years, equipping both submarines and surface vessels of most categories.

Specifications
Frequency: 1-60 kHz (tunable in steps of 50 Hz)
Power output: LF 300 W (max); HF 45 W (max)
Telephony signal: 300 Hz to 3 kHz (audio band)
Telegraphy signal: 712 Hz (reduced bandwidth of 700 Hz)
Audio output: 1 W, 4 Ω

Contractor
L-3 Communications ELAC Nautik, Kiel.

UPDATED



The UT 2000 underwater communication system control unit (L-3 Communications ELAC Nautik) 0129742

United Kingdom

15-300 series

Type
Submarine HF system.

Description
The 15-300 series submarine HF system is claimed to be the world's fastest tuned HF communications antenna with the ability to pin diode tune any frequency within the HF band in less than 1 ms. Designed initially for the Swedish Navy as a direct replacement to the existing in-service ITT NUS8300 (AN-BRA-29) antenna system, the 15-300 system equips the Gotland class submarines of the Swedish Navy. The antenna system is also suitable for surface ships where fast-tuned HF communications are required. The solid-state system covers 1.6 to 30 MHz with 15 kHz bandwidth at 2.0:1 VSWR. It is suitable for use with frequency-hopping transmitters.

Operational status
Operational aboard Swedish Navy Gotland class submarines.

Contractor
Techtest Ltd, Leominster.

VERIFIED

AVXD

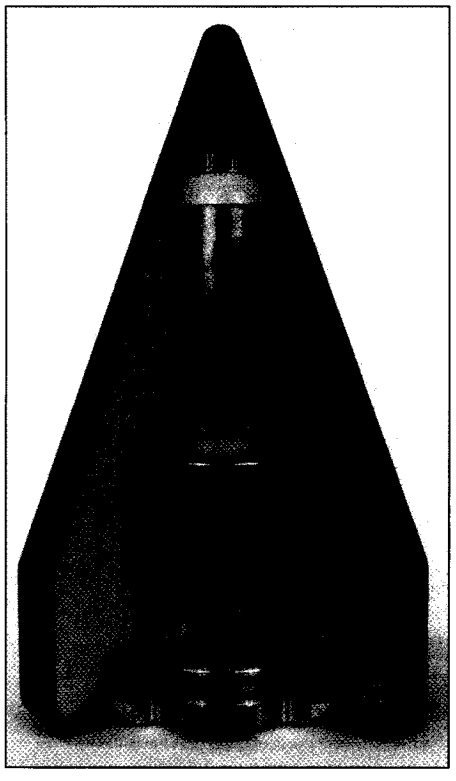
Type
Submarine SATCOM multifunction antenna.

Description
Thales Underwater Systems has developed a range of omnidirectional antennas, many of which can simultaneously accommodate transmit (Tx) and receive (Rx) over different frequencies. The Tx/Rx information, together with the facility selection, can be provided on a single RF coaxial conductor.

The Submarine SATCOM multifunction antenna AVXD consists of a pressure-tight broadband antenna system containing a head amplifier unit, together with an inboard control unit.

The compact, unobtrusive antenna affords excellent spatial coverage, from low angle Line Of Sight (LOS) to high angle satcom. The single antenna element is capable of performing many simultaneous communications functions in different frequency bands, covering VHF, UHF, line-of-sight, JTIDS, IFF, UHF satcom, and GPS.

AVXD has been developed specifically to provide the performance essential to operate DAMA (Demand Assigned Multiple Access) UHF satcoms. Within the conical envelope a vertically polarised dipole antenna provides VHF and UHF LOS communications, a conical logarithmic spiral antenna provides a circularly polarised hemispherical pattern for UHF satcoms and GPS reception, and a monopole antenna is provided for IFF, JTIDS and optionally, terrestrial cellular telephone operation.



Submarine communications multifunction antenna

The inboard antenna control unit provides all necessary RF and control interfaces between the submarine communication system and the antenna and is fitted with a 250 W power amplifier for UHF satcom transmissions. This unit also provides the means by which required antenna services can be selected and indicates which services have been selected. A head amplifier located within the antenna structure houses the required head amplifiers, filters, combiners, multiplexers and demultiplexers.

The antenna outfit has been fully tested under extreme depth conditions, and meets all the requirements of the Royal Navy communications antenna. Dimensions are 580 mm high with a maximum overall diameter of 356 mm, and a weight of less than 20 kg for the complete outfit of antenna, flange and electronics package. The single coaxial connection and universal adaptor flange permits easy retrofitting on existing masts.

Operational status
In service aboard all Royal Navy submarines and with variations aboard the submarines of Australia and Netherlands.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

MSK 5030 demodulator

Type
VLF/LF MSK demodulator.

Description
The compact, fully automatic MSK 5030 demodulator provides a standard VLF/LF receiver with NATO STANAG 5030 MSK compatibility.

The demodulator is connected to the output of any suitable receiver by means of a receiver headphone socket, or other audio interface. The output of the demodulator interfaces to the decrypting equipment or teletype. When connected to a radio receiver the device demodulates a received MSK transmission, regains the timing frame and demultiplexes the data to the original four individual channels.

Suitably modified, the MSK demodulator can also be used to provide redundancy coding.

Operational status
In use by NATO VLF/LF ground stations. Also in service with submarines of two European Union navies.

Contractor
Thales Underwater Systems, Templecombe, Somerset.

UPDATED

RICE 10

Type
Internal communication system.

Description
The RICE 10 (Rationalised Internal Communications Equipment), offers an extremely flexible internal communications capability and provides all the facilities required by a modern submarine. Facilities available include ship-wide broadcast, alarms, point-to-point communication and conference. These can be combined with the external communication components to form a fully integrated communications system.

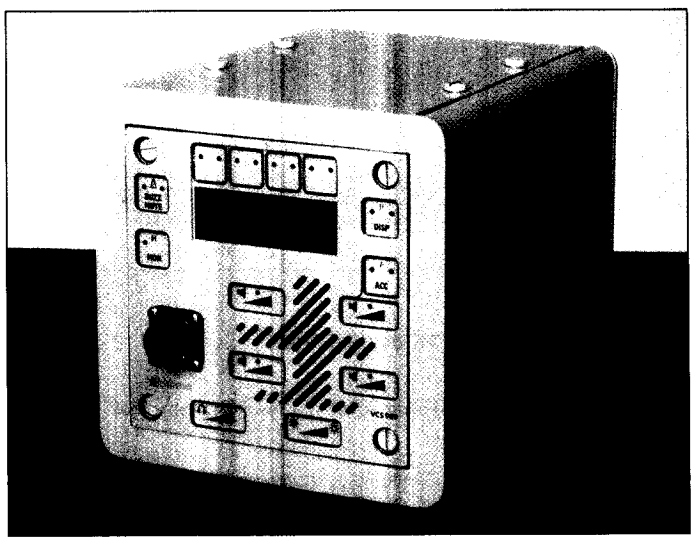
The RICE 10 is based on a digital mesh network that offers high survivability, by reconfiguring message paths automatically in the event of damage. Operation of the system is via a voice terminal outstation.

A numeric keypad allows the user to dial any other outstation on the system. The keypad is also used to reprogram the outstation in the event of system damage or to programme a user specific facility. This programmability allows the programmed outstation facilities to follow the individual user to other outstations. An incorporated dynamic tallying facility allows the operator to immediately ascertain the available functions. Two basic outstations are available and these, with their variants, cater for a wide range of operator requirements. A 16-channel outstation, which provides the full RICE 10 capability, is coupled with a smaller five-channel unit which offers limited functionality for those areas not requiring the full range of services.

Operational status
In production. In service aboard four Swiftsure and seven Trafalgar class submarines.

Contractor
Thales Communications Ltd, Crawley, West Sussex.

UPDATED



A typical outstation of the RICE 10 system (Redifon MEL Ltd) 0017499

RTOF

Type
Recoverable Tethered Optical Fibre (RTOF) buoy.

Development
The RTOF has been the subject of development by QinetiQ, DPA and Directorate of Equipment Capability in the UK for over nine years.

Description
The RTOF is the world's first device that will enable a submarine to communicate with a battlegroup from a safe depth.

The development of the RTOF will overcome the need for a submarine to come to periscope depth and raise a UHF mast, at considerable risk to the boat through leaving a visible wake in the water.

The RTOF features a recoverable buoy that can be rapidly deployed from the submarine at depth and rise to the surface where it presents a very small radar signature because of its stationary position.

Once at the surface a sweep is carried out to detect any hostile radar transmissions, after which the high data rate satellite communications (SATCOM) exchange takes place between the buoy and the satellite. When the exchange has been completed via the high capacity optical fibre the buoy is recovered by the submarine which can then exit the area at sprint speed if necessary.

Operational status
A contract award has been placed with Ultra Electronics for the industrial development of the RTOF which will be trialled in collaboration with the US Navy. Joint operational evaluation trials could be carried out in around October 2006. NSWC Carderock Division in Philadelphia will build a quarter section of a submarine hull to integrate the RTOF into a land-based site prior to equipping a submarine. Carderock will also arrange for trials and acceptance with the UK Royal Navy and the Prime Contractor. Following two operational patrols a final report will determine whether the system can be adopted into full operational service.

Contractor
Ultra Electronics Sonar and Communications Systems, Greenford, Middlesex.

NEW ENTRY

SAMHADS

Type
Distributed message processing system.

Description
The SAMHADS (Submarine Automated Message Handling And Distribution System) message system automates the telegraphic message handling process, utilising message formats ACP127, ACP126, and JANAP128, from a range of submarine radio and satellite equipment.

SAMHADS offers a range of features and facilities that includes audible and visual alarms for priority traffic; automatic filtering of unwanted messages; data rates of 50 to 9,600 bits/s; automatic preparation and distribution facilities; full message accountability; message sorting according to precedence and security classification; and reduction in operator workload and manning levels.

Operational status
In service on four Swiftsure and seven Trafalgar class submarine of the UK Royal Navy.

Contractor
BAE Systems, C4ISR, Plymouth, Devon.

UPDATED

SMBPS

Type
SubMarine Broadcast Processing System (SMBPS).

Description
The SMBPS provides a fully integrated VLF/LF and SSIXS communications management facility to Royal Navy submarine operations staff. It comprehensively updates and combines the roles of operations and communications management on to a single, highly secure and available platform.

The system is based on the security-enhanced variant of the highly reliable VMS operating system from Digital and the E3 assured OpenIngres database from Computer Associates. A client-server design takes advantage of the high availability characteristics of a VAX cluster, while optional site-to-site replication affords a further level of protection.

SMBPS provides complete separation and protection of secure information (based on the Bell and La Padula model) without compromise to the systemic usability.

A comprehensive application suite provides Security Officers with the capability to mix and match security clearances of users, workstations, message and broadcast channels and submarine clients. This provides F-B1 functionality and is evaluated to ITSEC E3 assurance level.

SMBPS provides interconnectivity to ACP 127 message networks and a complete messaging service for the operations and communications staff using the system.

The integrated vetting and scheduling applications applied to message traffic and the collation of VLF and satcom broadcasts which SMBPS provides, offers a significant manpower advantage over manual methods. Automatic vetting of traffic according to user-selectable criteria provides particular benefits, for example, in ensuring that the latest intelligence traffic is routed directly to the earliest appropriate broadcast. The multilevel secure design of SMBPS will prevent routeing of a message to a broadcast that is not cleared to carry that traffic.

The system supports the planning of transmitter usage and crypto allocation up to two years ahead. Detailed planning facilities include individual channel plans on MSK assets, the allocation of broadcast schedules to channels and the allocation of submarines to schedules. These plans are used by the system automatically to compile and key MSK VLF, LF and SSIXS broadcasts.

Full implementation for SSIXS protocol satellite communications is provided, supporting pre-planned satcom broadcast and random access query-response mode operation. The system is not dependent on transmitter hardware and is DAMA-ready.

Operations staff is provided with full Waterspace Management (WSM) tools using the proven Nauticus system from INRI UK. WSM is fully integrated into the SMBPS system, providing benefits in the speed and integrity of WSM communications.

SMBPS integrates geographic applications from INRI with the messaging and broadcast facilities to provide auto vetting of up-to-the-minute track information. Of particular value is the capability to filter information in user-definable areas of interest (AOI) on to specific submarine broadcast via the SMBPS vetting system.



SMBPS workstation (British Aerospace Land and Sea Systems) 0017500

Operational status
SMBPS provides the core operations and communications functions for the UK Royal Navy's CTF 345 Command Centre project.

Contractor
AMS, Christchurch, Dorset.

UPDATED

Submarine communications and NAVSTAR antenna

Type
Submarine broadband periscope-mounted antenna for communications and navigation.

Description
The compact submarine communications and NAVSTAR antenna consists of a pressure-tight broadband antenna system containing a head amplifier, together with an inboard control unit. The unit offers excellent spatial coverage, the antenna/head amplifier combination giving a signal-to-noise ratio at the receiver, which meets the NAVSTAR/GPS requirements for worldwide coverage.

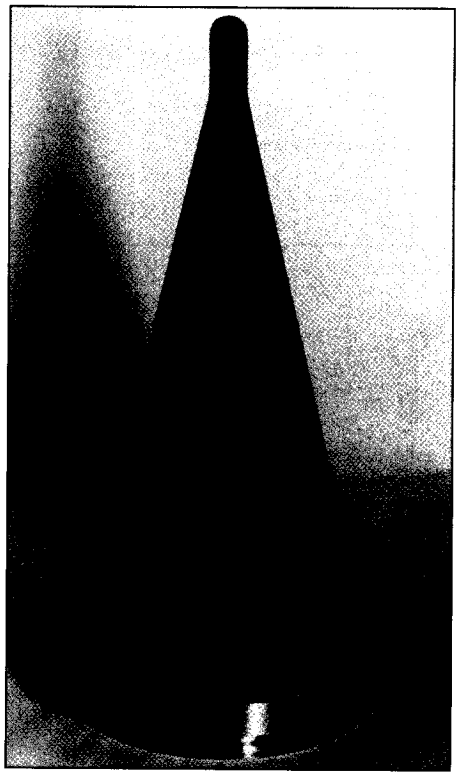
The single element antenna is capable of performing communication functions covering VLF, LF, MF, HF, VHF, UHF and D-band GPS reception (with simultaneous capability), and V/UHF line of sight transmission.

The antenna presents a very low visual profile, and its special water-shedding coating ensures quick response communications. It has been designed specifically for operation in highly reflective environments, thus ensuring full operational low-angle NAVSTAR coverage. It has been fully tested under extreme conditions.

A universal flange fitted to the base of the antenna provides a general purpose mounting suitable for a wide range of submarine periscopes. Size of the antenna is 323 mm high by 197 mm maximum overall diameter. Weight of the complete outfit, including the electronics package, is less than 6 kg.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

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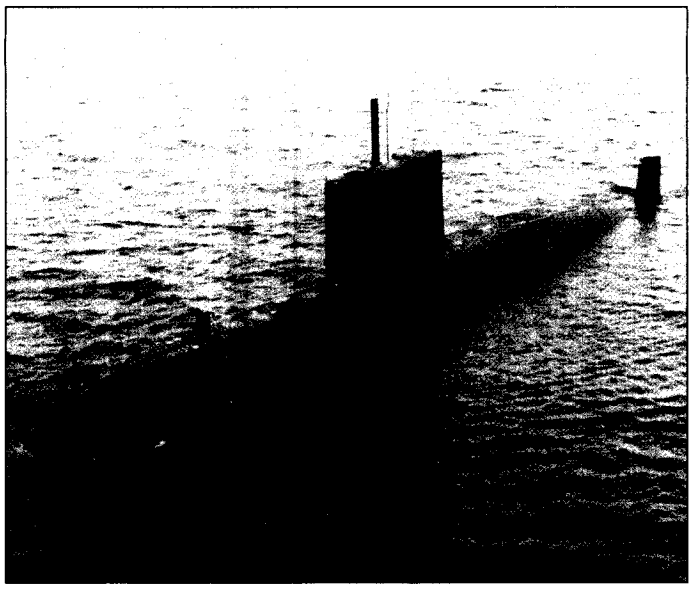


Communications and NAVSTAR antenna

Submarine communications mast

Type
Integrated non-hull-penetrating communications mast for submarines.

Description
The mast forms part of an integrated submarine communications system comprising HF, VHF and UHF aerials which are supported on a non-hull-penetrating low radar cross-section GRP mast. The mast is a one-piece GRP mast with fairing and is constructed of advanced composite materials.



AJU integrated communications mast fitted in HMS Upholder *(now Canadian Maritime Forces* Chicoutimi*)*

The integrated communications system performs multiple functions, from MF, HF, VHF and UHF communications through JTIDS and IFF, to SATCOM and SATNAV (both Transit and NAVSTAR), using only one mast. The system is capable of simultaneous transmission and reception for most functions, and reception only for others. Spatial coverage is from low-angle line of sight communications to high-angle SATCOM.

The hydrodynamic shape of the mast enables deployment while submerged, at high submarine speeds and in severely adverse weather conditions to provide high operational availability for radio communications.

The low drag, streamlined mast profile exhibits excellent vortex-shedding characteristics and provides extreme resistance to vibration while extended, thus conferring stability to the masthead payload at high speeds. With hydraulically actuated extension and retraction, the mast is reliable in operation under all conditions. Being non-hull-penetrating, the mast allows flexibility in submarine design and saves valuable space inside the pressure hull. The mast can be supplied as a single drop-in module which is ideal for retrofit programmes.

To minimise radar signature the upper portion of the mast incorporates multiband RAM in GRP laminate.

The submarine communications mast meets all the requirements of the Royal Navy AJU communications mast.

Operational status
Thales Underwater Systems communications masts are supplied to the Royal Navy and Royal Australian Navy. Thomson Marconi Sonar was awarded a third contract in June 2000 for the supply of one-piece GRP masts and fairings for the US Los Angeles class submarines.

Contractor
Thales Underwater Systems, Templecombe, Somerset.

UPDATED

AN/WQC-2A

Type
Sonar underwater communication set.

Description
The AN/WQC-2A is a sonar underwater communication set for surface ships, submarines and shore installations. The system provides an SSB general purpose voice and CW communication set consisting of a control station, remote-control station, receiver/transmitter and LF and HF transducers.

The system transmits and receives voice, audio and low-speed telegraphy in two frequency bands: high (8.3 to 11.1 kHz) for close range, and low (1.45 to 3.1 kHz) for long-range underwater communication. In addition, the system can be used to amplify and transmit signals from external sources in a frequency range of 100 Hz to 13 kHz.

The receiver/transmitter contains the main electronic assemblies of the sonar communication system. It consists of a rack-type cabinet with three removable drawer assemblies containing the power supply and test panel assembly, the receiver/transmitter assembly and the final amplifier assembly. The primary functions of the receiver/transmitter are to develop the high-powered, single sideband transmission from voice, audio and external source signals to drive the LF or HF transducers and to receive and demodulate LF, HF and CW signals received from the transducers. The receiver and transmitter outputs are made available to external tape recordings and monitoring equipment. The circuits are also capable of muting, or being muted by, other external equipment.

The control station contains the required controls, indicators, microphones and so on. The remote-control station is a secondary operating position, if required.

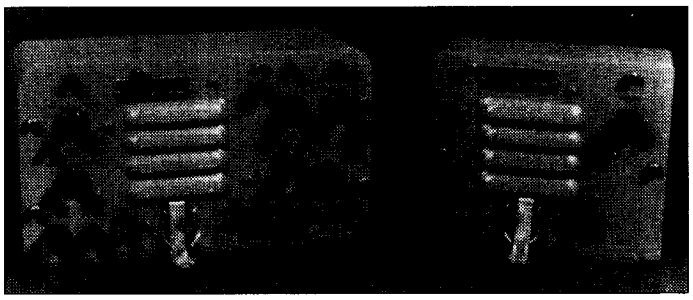
The two transducers (LF and HF) have a horizontal (radial) omnidirectional beam pattern. The electromechanical energy conversion is accomplished by piezoelectric ceramic elements which are totally encapsulated and covered by an acoustically transparent neoprene boot.

Operational status
In production and in service with the US Navy (over 300 units).

Specifications
Frequency bands: 1.45-3.10 kHz (LF); 8.3-11.1 kHz (HF); 100 Hz to 13.0 kHz (auxiliary mode)
Output power: 600 W (LF); 450 W (HF); 1,000 VA (auxiliary mode)
Weights
Receiver/transmitter: 220.5 kg
Control station: 5.8 kg
Remote control: 3.1 kg

Contractor
Harris Acoustic Products Corporation, East Walpole, Massachusetts.

VERIFIED



Control and remote-control stations for AN/WQC-2A system

United States

AN/URR-76

Type
VLF receiver set.

Description
The AN/URR-76 is a VLF receiver designed to provide communications with submerged US Navy submarines around the world. Installations are designed for submarines, surface ships, ground sites and TACAMO aircraft. Operating in FVLF, MEECN and NATO modes, the receiver operates from 14 to 175 kHz, has a MTBF of 3,000 hours and is EMI-, EMC-, EMP-, TEMPEST- and radiation-hardened.

Operational status
Installed on US Navy SSN-21 Seawolf class attack submarines.

Contractor
Telephonics, Farmingdale, New York.

VERIFIED

BWA

Type
Buoyant Wire Antenna (BWA) system.

Description
Buoyant wires are long, towed antennas that provide a submarine with the ability to communicate while remaining deeply submerged. The system consists of a buoyant wire antenna, a reeling machine that deploys, tows, and retrieves the antenna, reeling machine controls, a transmit/receive switch, and an antenna coupler. When the submarine wishes to communicate, the buoyant wire antenna is deployed via the reeling machine which can be mounted either inboard or outboard of the pressure hull. Two types of deployment can be provided: an electrically driven winch located outboard of the pressure hull and controlled by inboard electronics units, or a hydraulically driven winch located inboard of the pressure hull and controlled by manually operated hydraulic valves.

Deployment and retrieval of the antenna can be accomplished at speeds up to 45 m/m against hydrostatic pressures up to 42 bars and tensile loads of 1,360 kg on the antenna. A portion of the antenna floats at or near the sea surface and receives radio signals in the MF/HF (2 to 30 MHz) and VLF/LF (10 to 160 kHz) bands. The antenna is 610 m long with a diameter of 16.55 mm. Shorter and longer lengths are also available. An antenna that allows both transmit and receive in the

HF band (2 to 10 MHz) is also available. Signals received on the BWA are filtered and amplified in the antenna coupler located in the radio room. The in-line amplifier typically operates in the frequency range of 2 to 30 MHz, and in some variants below and beyond this range. The coupler is a broadband device that provides the interface between the special antenna and the standard submarine radio receivers. Because the system is broadband, it is Link 11 compatible.

Contractor
Sippican Inc, Marion, Massachusetts.

VERIFIED

Extremely Low-Frequency (ELF) communications programme

The concept of using extremely low-frequency radio signals to communicate with submerged submarines was first suggested over 30 years ago. However, the extremely large antenna size and environmental worries prevented its introduction until recently.

ELF signals can travel great distances with low loss and can penetrate seawater to considerable depths. In practice, an ELF consists of one or more shore-based transmitters, operating at around 40 to 80 Hz, connected to long horizontal wire antennas (either just above ground or buried for additional security) that are earthed at each end. Orthogonal antennas are used to provide omnidirectional radiation patterns. The transmitted signals are sensed by an antenna on the submarine and decoded by a sophisticated, computer-based receiver. Because the bandwidth is low at ELF, the message transmission rate is necessarily very slow but, even by employing a simple three letter code system, any of a great number of messages can be transmitted in reasonable time.

The most favourable site in the US for the installation of the system is in northern Michigan or northwestern Wisconsin, where the low-conductivity bedrock formations in the Laurentian Shield greatly enhance propagation.

Development
In 1969, the US Navy constructed an experimental transmitter in Wisconsin to study propagation and environmental effects of ELF. The antenna consisted of two 22.5 km long pole-mounted lines at right angles. In 1976, a message handling capability was added and a small quantity of shipboard receivers was built and installed to prove conclusively that an ELF system would perform as anticipated.

Encouraged by this trial, the navy planned to construct an operational ELF system with a completely buried antenna and redundant transmitters. Codenamed Sanguine, this vast system would have been highly resistant to blast overpressure and could have absorbed a moderate number of direct nuclear hits. However, in 1975, a defence analysis group reached the conclusion that the increasing accuracy and number of Soviet nuclear warheads could neutralise the system. Sanguine was, accordingly, downgraded and eventually cancelled.

The navy, undeterred by this setback, persisted and developed a more modest system with above ground transmitters and a pole-mounted antenna 45 km long. This system, called Seafarer and installed at Clam Lake, Wisconsin, immediately ran into opposition from the residents of Wisconsin and the environmentalist lobby, who were concerned about the environmental impact of the system and health issues. Despite numerous navy-sponsored biological studies showing no adverse environmental or ecological effects from ELF, and a 1977 study carried out by the National Academy of Sciences giving ELF a clean bill of health, the project was cancelled in 1978.

In 1981, President Reagan ordered that the Wisconsin transmitter be reactivated and upgraded to operational status and, at the same time, ordered the Department of Defense to conduct a study of ELF requirements. That study resulted in the conclusion that ELF would enhance the US strategic C^3 posture. It recommended that in addition to the upgrade of the Wisconsin system, a supplementary 90 km system should be constructed at the nearby Kl Sawyer Air Force Base on the Upper Peninsula of Michigan. Congress approved funds for the project in 1982 and research and development resumed. Construction commenced at both sites in 1983 but, in January 1984, a court injunction halted further work pending the preparation of a supplemental Environmental Impact Statement (EIS) to evaluate health effect studies of ELF fields performed since the original EIS was filed in 1977. A study was carried out by the American Institute of Biological Sciences which reaffirmed the results of previous investigations and the EIS was filed in 1985. Construction restarted following the cancellation of the injunction by the US Court of Appeal. The Supreme Court subsequently upheld that decision.

By the end of 1986, both stations were completed. Prototype submarine receivers were delivered in April 1985. The first test in May 1985 aboard a submarine of the Pacific Fleet was successful. In subsequent tests, submarines in the Mediterranean, the western Pacific and on patrol under the North Polar ice cap have successfully received signals from the Wisconsin station.

Description
There are four segments to the Wisconsin/Michigan ELF communications system: the Broadcast Control Segment (BCS), the Message Input Segment (MIS), the Transmitter Segment (TS) and the Receiver Segment (RS).

The main input port is the BCS, which is controlled by the Commander, Submarine Forces Atlantic (COMSUBLANT) in Norfolk, Virginia. The MIS, the secondary input port for ELF messages, is located at Kl Sawyer AFB and can take over from the BCS should that become disabled. It can if necessary pre-empt the BCS.

The TS comprises the ELF stations at Wisconsin and Michigan which normally operate simultaneously but can operate independently when required. Two frequency bands are used, 40 to 50 Hz and 70 to 80 Hz and each transmitter facility uses commercial prime power from its local utilities companies. In the event of power failure, each site has back-up diesel generators. Each transmitter facility has installed two spare back-up power amplifiers and an uninterruptible power system to ensure necessary reliability to continue transmitting in case mechanical or power failures occur. The TS is a soft, surface-deployed subsystem with ECCM and electromagnetic pulse protection. However, it is not expected to withstand a hostile physical attack.

Receiver Segments (RS) are fitted on all US Navy submarines, and the Broadcast Control Segment (BCS) and Message Input Segment (MIS) also incorporate receivers to perform monitoring functions. Messages are normally fed into the system at the BCS, although the MIS can also input messages if required. Messages are then sent to the Transmitter Segment (TS) via dedicated communication lines. Both the BCS and MIS include a message entry element consisting of a data terminal set (teletype Model 40), a link encryption device (KG-84) and a datalink selector panel. This arrangement allows the operator to enter messages into the message queue at the master transmitter facility via telephone company lines. The BCS and MIS also include an order-wire for operator-to-operator communications between facilities. The master transmitter facility is in contact with the BCS and maintains the message queue and automatically updates the back-up queue at the slave facility.

At each transmitter facility a processor element converts the encrypted ELF message from the message processor into drive signals for the power amplifiers, monitors antenna current and controls the transmitter facility master/slave protocol.

The antenna arrays at each transmitter facility consist of pole-mounted orthogonal antennas oriented north-south and east-west and strung horizontally over the rock formation between low-resistance ground terminals. Two pairs of power amplifiers exist at each facility, one pair for each antenna configuration. Only two power amplifiers are used at any one time, one for each antenna, and each is rated at an output level of 660 kW.

Signals which are picked up via the OE-315 towed antenna are then fed to the ELF receiver terminal group via an in-line amplifier. The receiver performs analogue and digital signal processing to detect any message that may be present. The receiver terminal group (OR-279(XN-1)/BRR) consists of five main units: the preamplifier, receiver timing and interface unit, the combined processor and key generator unit, time and frequency junction box and navigational interface junction box. To extract the ELF message, the receiver has first to filter out atmospheric and ocean noise and eliminate interference caused by the submarine's onboard power systems. This is achieved by a UYK-44 computer that sorts and decodes the ELF bit-stream and monitors signal strength.

The ELF system is synchronous requiring that the receiver know accurate time information relative to the transmission, and time compensation has to be allowed for the ELF signal propagation delay. A band spreading key stream is generated and removed from the message, which is then decrypted. By using an embedded AN/UYK-44 militarised reconfigurable processor, many of these functions are performed digitally.

Operational status
The system is in service with the US Navy. The base at Michigan became operational in 1986, and at Wisconsin in 1991. By the end of the 1980s some 90 receivers had been installed in US Navy submarines. All US Navy submarines are now fitted with ELF receivers as standard equipment.

Contractors
General Dynamics Systems Worldwide Telecommunication, Needham, Massachusetts.

VERIFIED

HF antenna

Type
Emergency HF communication antenna.

Description
The emergency HF communication antenna is used when the submarine's normal HF antenna systems are inoperable. The 14 kg system consists of a manually erectable antenna, an antenna base unit, an RF transmission line, and a hull penetrator. The telescoping antenna is approximately 11 m in length when fully extended and is capable of progressive adjustment and being locked to any desired length. The antenna collapses to approximately 2 m in length that allows for easy stowage inside the submarine when not in use. The antenna base unit is a pressure-proof assembly that is permanently located outside the hull of the submarine in the vicinity of the bridge. This unit contains broadband matching networks that allow for direct connection of the ship's HF transceiver to the antenna base unit, thereby eliminating the need for radio personnel to operate an antenna tuner. These broadband networks provide a match to the antenna such that the nominal VSWR at the inboard end of the transmission line is less than 3:1. The antenna base unit also houses integral ElectroMagnetic Pulse (EMP) and lightning surge protection and is totally compatible with the seawater environment.

Specifications
Frequency coverage: 2-30 MHz
Transmitter input: up to 400 W PEP
Antenna gain: -4 dB relative to a quarter wave monopole
Operating bands: 2-7 MHz and 7-30 MHz

Contractor
Sippican Inc, Marion, Massachusetts.

VERIFIED

IRR

Type
Integrated Radio Room (IRR).

Description
IRR is the automated exterior communications suite for the SSBN 726 Ohio class SSBNs. It is designed to provide reliable communications between the submarine and satellites, aircraft, shore facilities and other ships.

Operational status
Since 1977, 23 suites of equipment have been manufactured and delivered.

Contractor
L-3 Communications, Communications Systems East, Camden, New Jersey.

VERIFIED

Mast antenna

Type
Multifunction mast antenna.

Description
The standard MFM system is a high performance, mast-mounted, communication and navigation antenna that is intended for new construction or as a replacement upgrade for antennas on existing submarines. The system supports communications in several operating bands, which include VLF/LF receive, HF transceive, VHF transceive, UHF transceive and UFF transpond. GPS, Omega and Loran C navigation capabilities are also included. The individual antennas of this integrated communication and navigation system are housed in a hydrodynamically faired, non-penetrating mast assembly.

The MFM system is capable of simultaneous transmission and reception for all functions. The wide spatial coverage allows communication from low-angle, line-of-sight assets to high-angle satellite assets. The external mast is an extremely rugged hydrodynamically optimised assembly, allowing use from a submerged submarine operating at high speeds and in severe weather and sea state conditions. The small volume of the deployable mast allows impressive communications capabilities to be offered in a compact mast.

The standard MFM system comprises five units:
Unit 1. The antenna/radome is a pressure-proof radome that houses all antenna elements and associated outboard electronics; Unit 5. The antenna Control Unit (ACU) provides control of the antenna/radome and RF input/output ports for external receivers and transceivers; Units 2, 3 and 4 provide connectivity between the antenna/radome and the ACU.

Operational status
In service aboard US Navy submarines.

Specifications

Range	**HF**	**UHF (LOS)**	**VHF**	**UHF SATCOM**
Frequency range (MHz)	2-30	225-400	150-174	240-320
Antenna impedance	50 Ω	50 Ω	50 Ω	50 Ω
Power handling (max)	1 kW	200 W CW	50 W CW	200 W CW
Polarisation	Vertical	Vertical	Vertical	RHCP
Radiation pattern				
Horizontal	Omni	Omni	Omni	Omni
Vertical				Hemispherical

Range	**IFF**	**VLF and LF**	**GPS**
Frequency range (MHz)	950-1,150	0.01-0.17	1,227/1,575
Antenna impedance	50 Ω	50 Ω	50 Ω
Power handling (max)	1 kW (peak)	Receive only	Receive only
Polarisation	Vertical	Vertical	Circular
Radiation pattern			
Horizontal	Omni	Crossed figure-eight	Omni
Vertical		Similar to Monopole	Hemispherical

Contractor
Sippican Inc , Marion, Massachusetts.

VERIFIED

OE-538/BRC Antenna

Type
Multifunction mast (MFM) antenna.

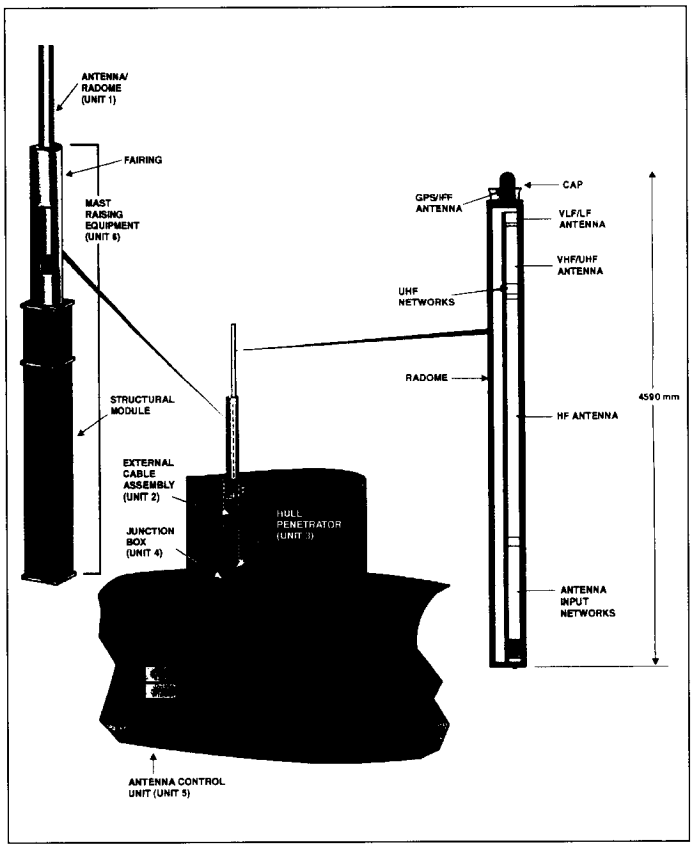
Description
The standard MFM system is a high-performance, mast-mounted, communication and navigation antenna that is intended for new construction or as a replacement upgrade for antennas on existing submarines. The system supports communications in several operating bands that include VLF/LF receive (10 to 170 kHz), MF/HF transceive (2 to 30 MHz), VHF LOS transceive (30 to 174 MHz), VHF/UHF LOS transceive (225 to 400 MHz) VHF/UHF SATCOM transceive (240 to 400 MHz), IFF transpond and GPS receive. The MF/HF capabilities include both conventional narrowband and broadband modes. When used for satellite communications, the antenna is capable of full duplex UHF Demand Assigned Multiple Access (DAMA) communications with the FLTSATCOM, AFSATCOM, UFO and Milstar (LDR) Satellites.

The individual antennas of this integrated communication and navigation system are housed in a hydrodynamically faired, non-penetrating mast assembly.

The MFM system is capable of simultaneous transmission and reception for all functions. The wide spatial coverage allows communication from low-angle, line of sight (LOS) assets to high and low angle satellite assets. The external mast is an extremely rugged hydrodynamically optimised assembly, allowing use from a submerged submarine operating at high speeds and in severe weather and sea state conditions. The small volume of the deployable mast allows impressive communications capabilities to be offered in a compact mast.

The standard OE-538/BRC antenna system comprises six units:

The antenna/radome assembly - a pressure-proof radome that houses all antenna elements and associated outboard electronics; the Antenna Control Unit (ACU) - provides control of the antenna/radome assembly and RF input/output ports for external receivers and transceivers; three units (external cable assembly, hull penetrator and junction box) that provide connectivity between the antenna/radome and the ACU; a sixth unit that incorporates the mast raising equipment which includes the fairing, structural module and all related hydraulic and mechanical components.



Multifunction mast antenna 0006981

Specifications OE-538/BRC Antenna

Range	**HF transceive**	**UHF (LOS) transceive**	**VHF transceive**	**UHF SATCOM transceive (SAFS, FLTSATCOM)**
Frequency range (MHz)	2-30	225-400	30 -174	240-400
Antenna impedance	50 Ω	50 Ω	50 Ω	50 Ω
Power (max)	1 kW CW	200 W CW	100 W CW	200 W CW
Polarisation	Vertical linear	Vertical linear	Vertical linear	Circular
Radiation pattern				
Azimuth	Omni	Omni	Omni	Omni
Elevation	Equivalent to a half wave dipole	Equivalent to a half wave dipole	Equivalent to a half wave dipole	Hemispherical*

Range	**IFF transpond**	**VLF/LF receive**	**GPS receive**
Frequency range (MHz)	980-1,120	0.01-0.17	1,227.6 ±10 MHz /1,575.42 ±10 MHz
Antenna impedance	50 Ω	50 Ω	50 Ω
Power handling (max)	1 kW (peak)	Receive only	Receive only
Polarisation	Vertical linear	Vertical linear	Circular
Radiation pattern			
Azimuth	Omni	Crossed figure-eight	Omni
Elevation	Equivalent to a half wave dipole	Equivalent to a half wave dipole	Hemispherical

Note: * System provides both high angle and low angle modes for SATCOM operation. Elevation pattern is hemispherical in either mode, but gain is optimised at high (30° to 90° elevation) or low (horizon to 30° elevation) angles.

The antenna/radome contains four higher frequency antenna elements (HF/VHF, UHF, IFF and GPS) utilised for the capture and transmission of RF signals. Signals are routed to/from these antenna elements via appropriate matching networks, bandpass filters, and amplifiers. All RF signals are multiplexed onto a single, coaxial RF line by duplex filter units. VLF/LF reception is accommodated via a VLF/LF crossed loop antenna with integral pre-amplifiers. The VLF/LF signals appear on a dedicated set of signal lines at the base of the antenna.

Operating power, control and status information to and from the antenna radome is routed to and within the radome via separate, dedicated conductors. The RF, VLF/LF and power/control/status signals are routed through a single connector at the base of the antenna/radome to the external cable assembly and then to the hull penetrator. The junction box may be mounted either directly at the hull penetrator or within 7 ft of the penetration point. The junction box provides for distribution of the VLF/LF and other antenna/radome signals.

Antenna RF signals and control/status signals are routed from the junction box to the ACU. The ACU separates the single, RF signal into four separate signals: HF/VHF, UHF, IFF and GPS. It also provides for both local and remote control of the antenna/radome assembly and for presentation of the system status on front panel system status displays or at a remote location via a control/monitoring port.

Operational status
The multifunction mast antenna has been proven at sea as being suitable for netcentric warfare and equips US Navy submarines.

Contractor
Sippican Inc, Marion, Massachusetts.

UPDATED

SUBTACS

Type
Submarine ELF tactical communications system.

Description
The Submarine Tactical Communications System (SUBTACS) is designed for land-based transmission, as well as tactical battle group communications, to submarines with the installation of shipboard transmitters. With a data rate 300 times faster than the original Extremely Low-Frequency (ELF) systems, SUBTACS functions at ranges in excess of 1,000 n miles, and at submarine operating depths and speeds.

The system is more jam-resistant than a VLF system, is less expensive to install, has a greater range and far greater water penetration. The ELF system operates at frequencies between 30 and 300 Hz. (See ELF entry.) The hardware exhibits commonality with the onboard ELF equipment allowing the submarine's ELF receiving equipment to accept SUBTACS signals.

Contractor
General Dynamics C4 Systems, Taunton, Massachusetts.

VERIFIED

V-COM

Type
Underwater Swimmer Delivery Vehicle communications system.

Description
V-COM is a trimode vehicle communications system used by the US Naval Special Warfare Group on its swimmer delivery vehicles. The electronic subsystems consist of an intercom, an underwater telephone and HF radio, each housed in a pressure-tight aluminium container. The intercom provides communication between the pilot, navigator and the crewman of the vehicle. The underwater telephone is compatible with standard US Navy acoustic communications systems and provides a communication link between the underwater vehicle and its support ship. The HF radio contains a modified man-carried unit (AN/PRC-104) and enables radio communications when the vehicle is surfaced.

Operational status
In operational service.

Contractor
Allen Osborne Associates, Inc, Westlake Village, California.

VERIFIED

VLF/LF antennas

Type
VLF/LF antennas.

Description
The ability to effectively copy VLF/LF broadcast while submerged, has long been a requirement for submarines. The high-performance, VLF/LF crossed-loop antennas needed to accomplish this have been designed and manufactured by Sippican for many years. Although the more advanced VLF/LF BWA type receiving antennas are available, virtually all submarines in service are equipped with a crossed loop antenna.

The crossed loop military quality antennas are designed to operate in the submarine environment and to interface directly with standard VLF/LF communication receivers. The antennas can be configured in varying sizes and shapes, which makes for easy mounting to the submarine.

The Sippican VLF/LF crossed loop antennas consist of five units:

The antenna/pre-amplifier is an integral low noise unit designed for mounting on top or within the fin of the submarines and can be provided with or without a fibreglass fairing. The pre-amp consists of a ferrite loaded, crossed loop antenna and a matched set of VLF/LF low noise preamplifiers. One loop is oriented in the fore-aft plane of the ship and the other athwartships. The VLF/LF signals are pre-amplified by the matched low noise amplifiers, which are housed in an electronics space located at the centre of the antenna, which is in the shape of a picture frame. The antenna is fully encapsulated for environmental protection while the pre-amplifiers are accessible through an access port at the top of the watertight electronics space. The balanced output of each preamplifier is provided at a single watertight connector located at the bottom of the antenna/pre-amplifier unit.

The outboard transmission line is a shielded, watertight cable that carries the RF signals form the outboard antenna/pre-amplifier unit to the inboard amplifier/combiner, which provides two identical omni-azimuthal outputs and an orthogonal figure eight output as inputs to any standard VLF/LF receiver.

The third unit is the hull penetrator, which provides the electrical connection through the submarine's pressure hull.

The fourth unit is the inboard transmission line that is the same cable type that is used for the outboard transmission line.

The fifth unit is the amplifier/combiner, which is located in the submarine's radio room. This unit provides the interface between the antenna/pre-amplifier and standard shipboard receivers. It contains low noise amplifier, an omni-azimuthal pattern generator, output drivers, and the required power supplies for both inboard and outboard use. The pre-amplified VLF/LF signals from the antenna/pre-amplifier arrive art the amplifier/combiner input as orthogonal figure of eights. These signals are amplified and then combined in an omni pattern generator to provide the omni-azimuthal signal. Separate output drivers provide this omni signal to two, balanced 50 Ω output jacks which can be cabled to any standard VLF/LF communication receiver.

The antenna/preamplifier covers the range from 10 to 160 kHz, with extended coverage up to 300 kHz.

Contractor

Sippican Inc Marion, Massachusetts.

VERIFIED

UNDERWATER TELEPHONES

Australia

Acute 9000

Type
Underwater telephone unit.

Description
The Acute 9000 UWT is designed to perform underwater voice and telegraphic communications from surface ships and submarines. It can also ensure communications with a diver carrying autonomous equipment with compatible characteristics.

The Acute 9000 UWT has been developed and tested to operate on naval vessels where compliance to military standards is required. The telephone is normally supplied with an omnidirectional transducer, although sectorial operation is available.

The UWT unit consists of a transmitter and receiver, which are mounted in a common cabinet, and is supplied with an accessories set (headset, handset and morse key).

The underwater telephone unit operates in a number of modes (listed below) which the operator selects from the front panel. These modes operate in conjunction with transmit power selection, receiver sensitivity and volume controls to enable the operator to select the setting best suited to the conditions of the day. Manual/automatic AGC control of the receiver enables the operator to adjust the receiver gain to enhance the quality of the received signal.

Operational modes:
Watch: silent mode – allows listening for incoming communications, with transmitter inhibited.
Phone: intercommunication by voice.
Transp: automatic reply to a CW call.
CW & Reception: two-way morse communication.
CW: one-way morse transmission with receiver inhibited.
Test: self-test of UWT unit.
Auto: automatic transmission of CW pulses, with reception between pulses.

Operational status
The Acute 9000 is currently in service in the Royal Australian Navy and Royal New Zealand Navy on board Anzac class frigates.

Specifications
Height: 404 mm
Width: 546 mm
Depth: 428 mm
Weight: 54 kg
Nominal frequency: 8,087 Hz (carrier frequency)
Maximum input (Pmax): 1,000 VA
Input voltage: 115 V AC, 60 Hz, 3-phase; (115 V between phases)
Maximum output voltage: 140 V rms
Maximum output power: 400 W/50 Ω

Contractor
Thales Underwater Systems, Rydalmere, New South Wales.

VERIFIED

France

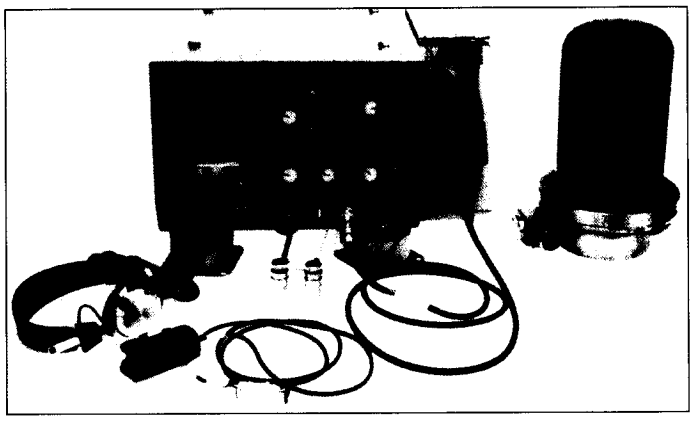
TSM 5152A, 5152B

Type
Transmitter/receivers for underwater telephony.

Description
The TSM 5152 transmitter/receivers (TSM 5152A for submarines and TSM 5152B for surface vessels) allow two-way telephony and telegraphy between submerged submarines, between surface ships and submarines, and between surface ships.

The system has a range of operating modes which include: a watch mode for silent survey when the receiver is normally silent but which is activated by reception of a call; a phone mode for communication; a CW transmission mode controlled with the signalling key; a CW and reception mode with the equipment automatically switched to reception during breaks of transmission; an automatic transmission mode used to obtain a first contact; a transponder mode in which a pulse is automatically transmitted on receipt of a CW transmission; and a test mode to allow the operator to test the equipment automatically.

Operational status
In production for the French and other navies.



TSM 5152 transmitter/receiver and associated projector

Specifications
Mode: USB transmitted-call FM
Carrier frequency: in accordance with NATO or other specifications
Power output: 400 W for 0.33 form factor with AC supply
Power supply: 115 V AC ± 5%, 48-63 Hz, 3-phase
Consumption: 800 VA (max)
Weight: 33 kg

Projector
Type A
Each one of three groups includes two independent and identical hydrophones
Bearing aperture: 120° (3 dB)
Elevation aperture: 50° (3 dB)
Operating depth: 300 m (max)
Type B
Omnidirectional in bearing
Elevation aperture: 50° (3 dB)
Range: 10.75 n miles (approx)

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

TUUM-4

Type
Multifrequency underwater telephone.

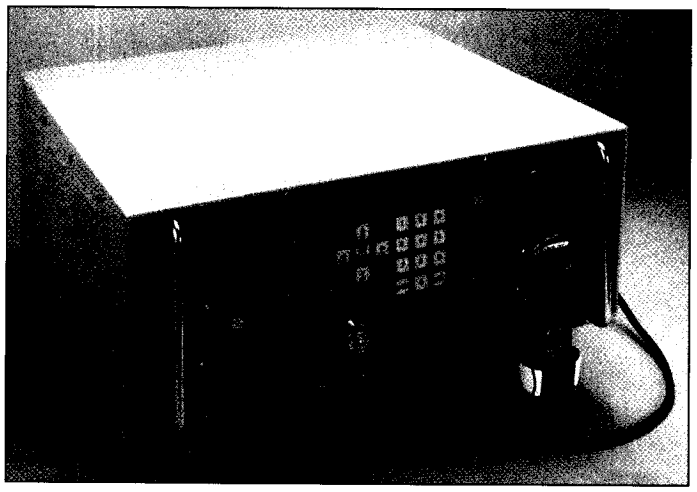
Description
The modular TUUM-4 multifrequency, dual-watch synthesised transceiver, with continuous monitoring of the NATO frequency, covers the frequency range 1.45 to 50 kHz with preprogrammed or user-defined channels. All operations are controlled from a front panel keyboard and display.

The equipment is compatible with all types of underwater telephone and most transducers already in service and is suitable for both surface ships and submarines. As with other external communications systems, the TUUM-4 can be interfaced with the ship's internal communication system.

TUUM-4 comprises the ER 4A/U transceiver and associated transducers (carrier frequency 1.45 to 50 kHz, modulation LSB (Lower Side Band), USB (Upper Side Band) and AM with carrier frequency). For submarines it can be combined with four sets of directional transducers for increased range and discretion (see table of transducers below). For surface vessels there are two omnidirectional transducers (2Z9B and SGP35) and optionally a remote-control power amplifier (AM5300) and a remote-control station.

Among the operational features of the system are 20 programmable channels, with two channels for automatic message transmission and six channels for increased intelligibility. Transmission is omnidirectional or directional (90°). Operational modes provided are: voice, data, TTY and standby. Other features of the TUUM-4 include: transmission and reception of telegraphic signals manually or automatically from a serial link; distance measurement (0 to 20,000 m with 5 m resolution); Doppler compensation (±50 kt manual); automatic recording of received messages, and BITE at start-up. The equipment is compatible with the communication and navigation system for divers. Remote control through the integrated internal communication system or from a dedicated remote station is available as an option.

The output power of the unit is adjustable to 1.4 - 140 W switchable in steps of 10 dB (1 kW with AM5300 amplifier).



TUUM-4 underwater telephone (Thales Safare) ***NEW***/1035059

Specifications

Carrier frequency	1.45-50 kHz
Standard channels	20 programmable
Specific channels	2 channels for automatic message transmission
	6 channels for increased intelligibility
Modulation	LSB
	USB
	AM
Practical range	>20,000 m on NATO frequency
Output power	1.4-140 W switchable in 10 dB steps (1 kW with AM5300 amplifier)
Standby mode	Simultaneous
	Selected channel + NATO
Communication	Surface ships, divers, submarines
Transmission	Omnidirectional or directional (90°)
Distance measurement	0-20,000 m, 5 m resolution
Operating modes	Voice - data - TTY - Standby mode
Doppler compensation	±50 kts
Messages	Automatic recording
Test	Built-in
Remote control	Optional

Transducers	**2Z9B**	**SF09**	**SF35**	**SGP35**
Operational frequency range	6–16 kHz	6–16 kHz	22–45 kHz	30 kHz-42kHz
Directivity	Omni directional	Directional	Directional	Omni directional

The TUUM may be used with other kinds of transducers following analysis.

Operational status
In service in the French Navy since the early 1990s.

Manufacturer
Thales Safare, Sophia Antipolis.

UPDATED

TUUM-5

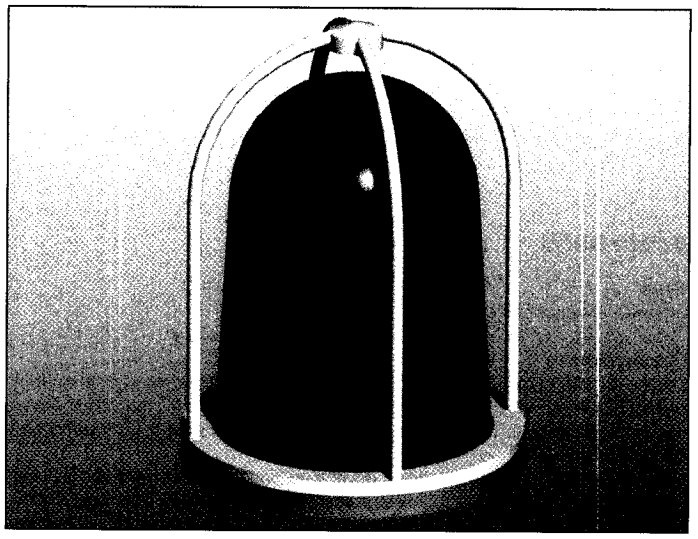
Type
Portable underwater emergency telephone.

Description
TUUM-5 is compliant with STANAG 1074, 1298 and 1382 requirements. These require that available in each manned, watertight compartment of a submarine is a self-powered underwater telephone using the NATO standard channel and three selectable channels. The equipment gives submarines in distress, rescue boats and divers the capability to communicate with each other. The equipment is linked to the energy network and can be used as an on board telephone unit by small units, or be connected to a mobile transducer by cable where it can be used from a fixed ground station, a helicopter or a light craft.

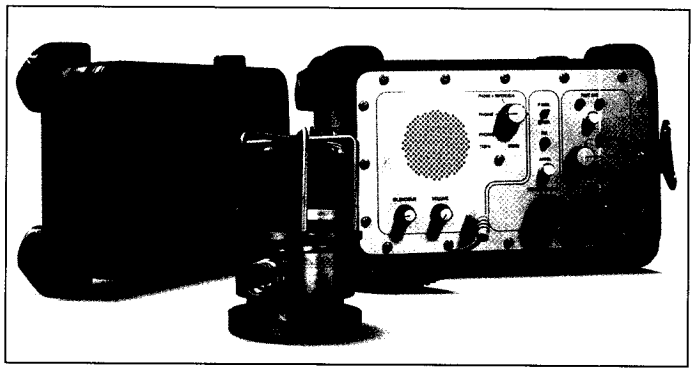
A number of operating modes is available including: voice transmission and reception; voice and diver; and voice and transponder. Transmission/reception is omnidirectional.

Three operating channels are available (NATO, 25 kHz, 40.2 kHz with pinger at 37.5 kHz) and the equipment is modulated using the Upper Side Band (USB). The system covers a range of between 1.6 and 7.5 n miles. The 16 kg unit has an autonomy in excess of 20 days in pinger mode with a transmission power of between 1.5 and 55 W, depending on frequencies and selection. The power supply is a Li-ion battery.

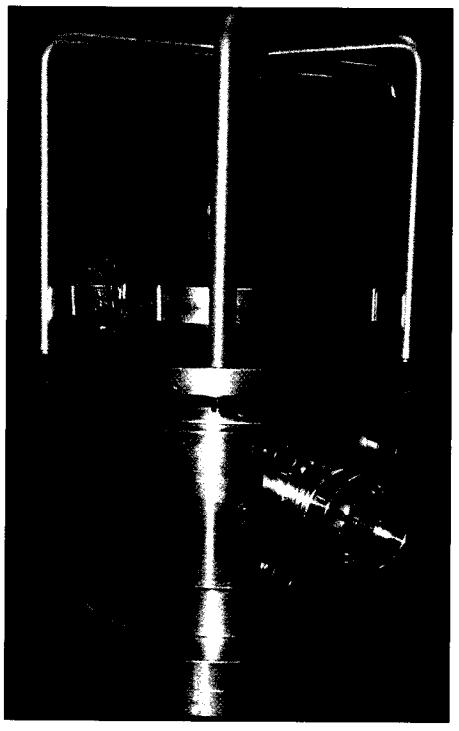
Three transducers are available.



TUUM-5 transducer SGS2540 (Thales Safare) 0122905



TUUM-5 (Thales Safare) 0593008



Transducer of TUUM-5 (Thales Safare) 0122904

Specifications

Operating modes	Voice, Voice + transponder, Voice + diver
Packaging	Waterproof polyester case
Available versions	1-3 channels: NATP, 25 kHz, 40.2 kHz with pinger at 37.5 kHz
Modulation	USB
Range	3-14 km
Power supply	1.5-55 W depending on frequencies and selection
Autonomy	>20 days in pinger mode

Dimensions	370 × 350 × 230 mm
Weight	16 kg
Watertightness	IP 67

Transducers	**SGE09**	**SGS2540**	**SGP35**
Operating frequency range	7-14 kHz	16-42 kHz	30-42 kHz
Directivity	Omnidirectional	Omnidirectional	Omnidirectional
Pressure control	75 hPa	75 hPa	75 hPa

Operational status
Fully developed.

Contractor
Thales Safare, Sophia Antipolis.

UPDATED

United Kingdom

ABLO36

Type
Emergency portable underwater telephone.

Description
The ABLO36 portable underwater telephone has been designed for communication from a ship or helicopter to a submarine, submersible or diver.

The equipment can operate on any of three standard frequencies compatible with other in-service equipment allowing communication in a search and rescue role to divers or other ships. The equipment also has a high power mode for longer distance communication to other sonars.

A robust and efficient multifrequency omni-directional transducer is supplied which can be deployed from the ship or helicopter by suspension from its own strain-relieved cable.

The ABLO36 underwater telephone is built to withstand the severe conditions in which it will have to operate. It can operate from its own integral battery, DC or AC supplies for maximum versatility.

Operational status
In production.

Specifications
Frequency: Voice 10, 27 and 43 kHz
Pinger: 10 or 35.5 kHz

Contractor
AB Precision (Poole) Ltd, Poole, Dorset.

UPDATED

Type 185/G732 Mk II

Type
Acoustic throughwater communications system.

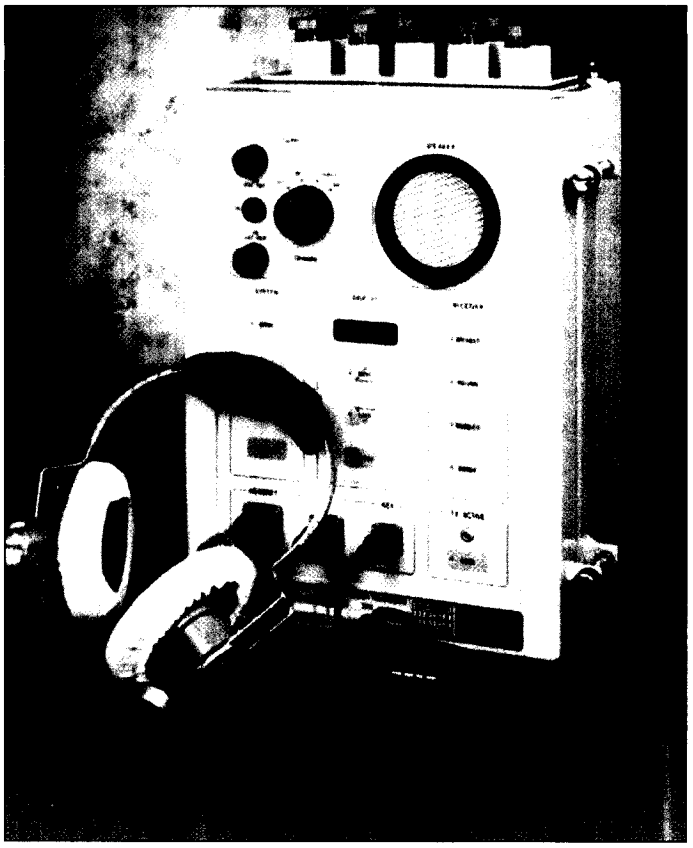
Description
The G732 Mk II is an improved underwater telephone system for use in submarines and surface vessels. It provides communications facilities for speech, morse, digital and coded messages, plus an emergency pinger mode of operation.

The system operates on the standard NATO frequency of 8.0875 kHz using upper single sideband transmission. Alternative operational frequency bands can also be supplied and a choice of transducer installations is available to suit customer requirements. The transmit direction, which can be omni, port, starboard, ahead and above, is user selectable, as also are the transmit source levels to maintain security. A narrowband is also available via a suitable transducer.

The receiver/transmitter electronics are housed in a ruggedised bulkhead-mounted unit which connects to one or more transducers to produce directional transmissions as required by the user. The system normally operates from the main power supply but a battery-powered unit can be supplied to maintain communication in the event of complete failure of the vessel's own electrical power supplies.

A combined lower and upper sideband version of the G732 Mk II is available to communicate with ex-Russian ships and submarines.

Operational status
In service with Ecuador (Leander class, 2 ships), Pakistan (Type 21, 6 ships) and UK Royal Navy (Invincible class, Type 42 destroyers, 11 ships and RMAS *Newton*).



G732 Mk II underwater telephone 0099441

Specifications
Operating frequency: 8.4-11.3 kHz (nominal)
Mode: upper SSB (NATO compatible)
Transmitter source level: 186 ± 2 dB/µPa/m (max) (port, starboard, ahead, upper); 183 ± 2 dB/µPa/m (max) (omni)
Dimensions: 400 × 300 × 200 mm
Weight: 18 kg (max)

Contractor
MARCOM Defence, Chichester.

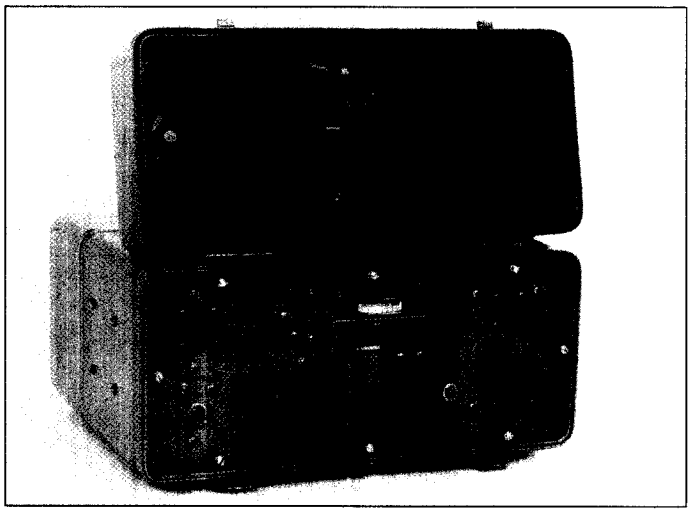
VERIFIED

United States

Model 505

Type
Emergency underwater telephone.

Description
This is a compact, rugged, self-contained emergency underwater communications system featuring single sideband, suppressed carrier operation. The unit provides both voice and keyed CW operation at three power levels for both optimum



Model 505 underwater telephone

performance and for conserving battery power. Power can be supplied by batteries or by ship's DC power. The Model 505 is designed for use with the vessel's installed UQC/BQC transducers. The unit is housed in a portable case suitable for bulkhead, overhead or under-seat mounting which provides easy access to the telephone handset, system controls and self-contained batteries.

Operational status
The system is in service in the US Navy and Japanese MSDF for deep submergence/submarine rescue programmes and special operations.

Specifications
Height: 386 mm
Width: 342 mm
Depth: 172.5 mm
Weight: 18 kg

Contractor
EDO Electro-Ceramic Products, Salt Lake City, Utah.

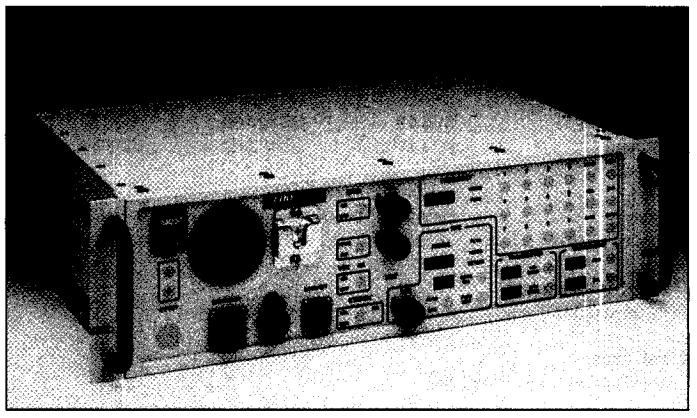
VERIFIED

Model 5400

Type
Acoustic underwater telephone system.

Description
The Model 5400 underwater telephone features extensive communications and navigation functionality in a modern, lightweight, compact design. Intended for single sideband voice communications and modulated CW operation, the equipment is based on a synthesised transceiver and is compatible with all commonly used underwater telephone modes, including, UQC, ATM-504a and BQC modes of operation. The unit covers the frequency band 5 to 45 kHz in 1 Hz steps plus the AN/WQC and ARD8000 frequencies. Up to 50 frequency combinations can be stored in memory for easy recall at any time. Upper and lower sideband modulation is operator selectable, as is output power in five steps: 2, 10, 50, 100 and 200 W.

The system includes auxiliary modes of operation which support submerged navigation of manned submersibles and submarines, with frequencies selectable from 5 to 45 kHz in all modes. The unit is fitted with TIPE (Transponder, Interrogator, Pinger/Echo-sounder). The transponder/interrogator functions provide automatic ranging between two Model 5400s (or any other compatible device, such as ATM-504A equipped with TIPE). The pinger and echo-sounder mode offers acoustic tracking, depth sounding and echo ranging. Used with a vertically directed transducer, the Model 5400 can provide digital readout of depth below the surface or distance to the seabed. Transducers are available for operation to full ocean depth. The operating frequencies for the TIPE mode are operator selectable within the system's entire frequency band.



Model 5400 underwater telephone

The Model 5400 is controlled by an operator using a touch front panel, hand microphone and operator headset. Squelch control enables background noise to be reduced or eliminated.

Remote control is available using separate Model 5400 remote-control units, or via an RS-232/RS-422 interface.

Operational status
The system is in service in the US Navy, NATO and other foreign navies. A modified version of the unit will be fitted in the Virginia class SSNs under a contract awarded by the Raytheon Company. The Model 5400 also equips the US Navy ASDS vehicles. The Model 5400 has also been delivered for the Alvaro de Bazan class frigates of the Spanish Navy.

Specifications
Height: 132.5 mm
Width: 431 mm
Depth: 352.5 mm
Weight: 16 kg

Contractor
EDO Electro-Ceramic Products, Salt Lake City, Utah.

VERIFIED

COMMUNICATIONS BUOYS

United Kingdom

ECB-680(1)

Type
Expendable communications buoy.

Description
The Expendable Communications Buoy ECB-680(1) system has been developed by Thomson Marconi Sonar Ltd for Royal Navy operations to provide a one-way line of sight VHF/UHF radio communications relay between a submerged submarine and surface receivers.

The ECB-680(1) is designed for launching from either forward or aft Submerged Signal Ejector (SSE) tubes at all operational depths and up to 15 kt. Before launch, the ECB is programmed by means of an inboard control interface unit, with its operating parameters and plain or encoded messages as dictated by the tactical situation. Alternatively, in an emergency, the ECB-680(1) can be launched with no programme input; in this mode of operation a preprogrammed distress SARBE signal is transmitted.

On release, the buoy ascends to the surface after a preset transmission delay has elapsed, allowing the submarine to leave the area discreetly. The aerial unit with its flotation collar is then deployed and message transmission is initiated. Transmissions are made in the VHF/UHF band between 168 and 310 MHz; modulation may be programmed for either AM or FM transmissions.

The message cycle allows up to 3 minutes of message with a 1 minute gap and may be repeated up to 60 times, allowing the buoy 4 hours transmission time. For the emergency role, an unlimited number of cycles may be selected, in which case the buoy will transmit in excess of 8 hours. On completion of the preset number of message cycles, the buoy scuttles automatically.

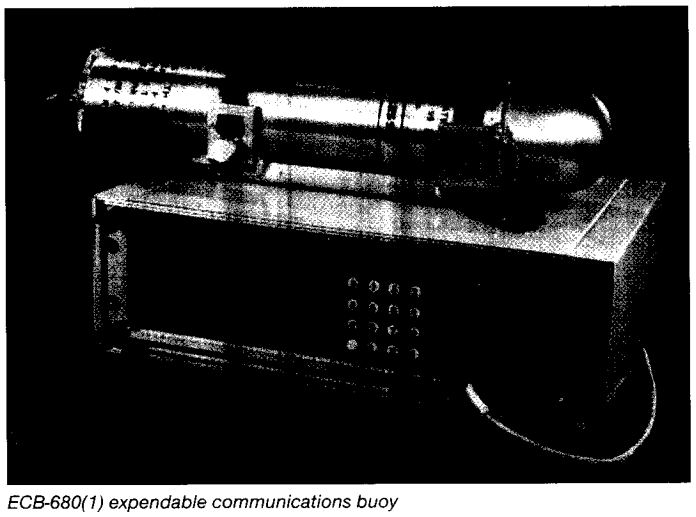
The buoy's aluminium hull is capable of withstanding the extreme water pressures experienced during normal submarine operations, and is reinforced to permit launch at high speed for suitably equipped submarines.

The ECB-680(1), operating in conjunction with the submarine's communication system, provides a comprehensive capability for emergency distress and tactical communications. By employing existing submarine SSE launch facilities, the ECB-680(1) is easy to install, requiring minimum maintenance and support.

Operational status
Entered service in 1996. Widely fitted to submarines of the Royal Navy and other navies.

Contractor
Thales Underwater Systems, Templecombe, Somerset.

UPDATED



ECB-680(1) expendable communications buoy

RTOF

Type
Recoverable Tethered Optical Fibre (RTOF) communications buoy.

Description
The RTOF wideband communications buoy has been developed by QinetiQ (formerly DERA) and Thales Underwater Systems as a means of enabling wideband covert two-way data exchange between a submerged submarine and surface task forces operating at speed and depth.

The buoy is deployed by a computer controlled winch that ensures that it remains virtually stationary on the surface without creating a plume or wake that would increase its indiscretion, while allowing the submarine to manoeuvre at will at high speed and a safe depth. With the submarine operating at a safe depth the RTOF is released and ascends vertically to the surface under its own buoyancy. The tether cable is deployed at a variable rate to ensure negligible cable tension. As the boat manoeuvres additional tether cable can be spooled out ensuring that the buoy remains stationary. Once communications have been completed the buoy can be recovered. The hydrodynamic design of the buoy minimises the probability of detection during recovery.

Operational status
Development and testing in progress.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

United States

AN/BRR-6

Type
Submarine towed buoy communications antenna.

Description
The AN/BRR-6 is a towed GRP buoy RF receiver communications antenna system which is installed on the Ohio class Trident submarines. It receives transmissions across the VLF to HF bands.

Operational status
In production and in service.

VERIFIED

AN/BRT-6

Type
UHF satellite communications buoy.

Description
The AN/BRT-6 UHF satellite communications system was developed by BAE SYSTEMS Aerospace Inc, Advanced Systems (formerly Hazeltine Corporation), in conjunction with the US Naval Underwater Systems Center (now Naval Undersea Systems Center) and the US Naval Electronics System Command (now Space and Naval Warfare Systems Command), as a digital communications link from submarines at operating depth to shore communications stations and operating naval forces. The system comprises the T-1455 expendable buoy, a Buoy Interface Unit (BIU) and a battery charger. The expendable UHF SATCOM buoy provides reliable, high-fidelity, one-way communications using a uniquely designed right circular polarised floating antenna. The SATCOM buoy is manually or automatically launched from standard 3 in signal ejectors on fleet submarines and can be operated in conditions up to Sea State 5.



The AN/BRT-6 buoy deployed

The expendable buoy is a transmit-only digital communications device. After launch it rises to the surface at a speed in excess of 3 ft/s. After a suitable delay period the buoy automatically extends its antenna and transmits to the Submarine Satellite Information Exchange System (SSIXS) receiving system via operational satellite communications channels.

The buoy operates on multiple programmable frequencies between 290 and 315 MHz in channel increments of 25 kHz. The modulation is compatible with the AN/WSC-3 transceiver. Messages are digitally formatted and are selectable for 1 to 15 transmissions. Data is transmitted at a preset rate of 2,400 bits/s and selectable for 75, 300, 600, 1,200, 4,800 and 9,600 bits/s. The delay between message transmissions is selectable in 5 minute increments.

The buoy incorporates a self-scuttling device which is activated within 30 minutes of the last transmission.

Operational status
No longer in production. In service and deployed by submarines of the US Navy.

Contractor
BAE Systems North America, Advanced Systems, Greenlawn, New York.

VERIFIED

AN/SSQ-86(XN-1)

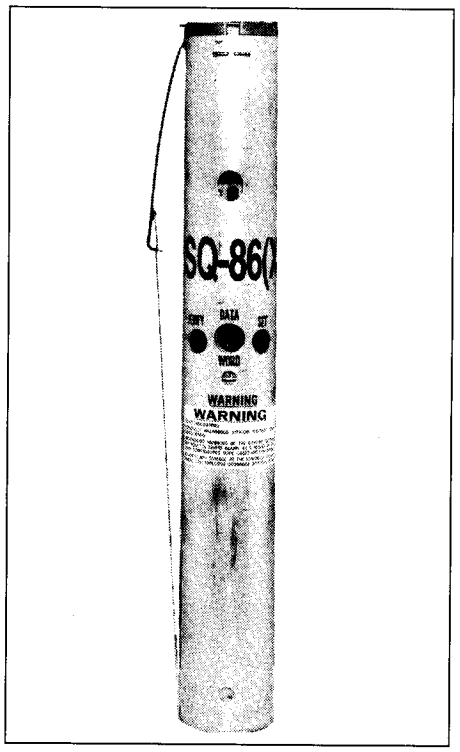
Type
One-way down-link surface-to-submarine communication equipment.

Description
The AN/SSQ-86(XN-1) 'A' size DownLink Communication (DLC) sonobuoy is a one-way communication device designed to transmit a preprogrammed message to a submerged submarine. Developed to meet the need for a reliable means of transmitting a message without revealing the receiving submarine's position, the DLC is compatible with existing sonobuoy launch platforms. The unit is packaged in a standard 'A' sized sonobuoy envelope and can be launched from any properly equipped fixed-wing aircraft or helicopter, or from a surface ship.

The desired message is programmed into the DLC using a single push-button switch and four seven-segment LED displays. Four groups of three digits make up the message. The message can be verified and corrected if necessary with a second push-button, provided to ensure proper data insertion. Once programmed, all remaining operational functions are automatic. The buoy is tunable to one of 99 RF channels.

When air-launched, the DLC buoy is slowed and stabilised by a small parachute. For launches from surface vessels, it is merely thrown overboard. Upon water entry, the DLC buoy immediately deploys. As soon as the subsurface unit reaches the shallow operating depth, the message, coded into appropriate tones, is acoustically transmitted. The first transmission is followed by a 5 minute pause while the subsurface unit deploys to the greater depth. The message is repeated at the greater depth; after a second 5 minute pause, the message is transmitted a third time. At the end of the final transmission the buoy automatically scuttles. The nominal life of the buoy from water entry to scuttle is 17 minutes.

The omnidirectional projector is a simple resonant bender element designed to operate efficiently at the desired bandwidth and power is supplied by a lithium battery.



AN/SSQ-86(XN-1) downlink communication sonobuoy

Operational status
No longer in production but still in service. During 1996, Sparton refurbished over 1,000 buoys for the US Navy, thus extending their useful life for another five years.

Specifications
Operating depth: shallow and deep
Dimensions: 'A' size (91.4 cm × 12.4 cm diameter)
Weight: 11.4 kg
Operating life: 17 mins (nominal)

Contractor
Sparton Corporation, Electronics Division, DeLeon Springs, Florida.

VERIFIED

Mk 84 SUS

Type
Air-to-submarine communications device.

Description
The SUS Mk 84 Mod 1 underwater sound signal device is an expendable electro-acoustic device which provides one-way acoustic communications with submarines. It may be dropped or deployed from fixed-wing aircraft or helicopters as well as by over-the-side ship-launched methods. It can also be used to simulate the drop of an ASW weapon during a tactical exercise. The low centre of gravity and spin stabilising design of the tail allows launches from altitudes up to 10,000 ft and speeds up to 380 kt without parachutes or other descent stabilising systems. The device activates within 2 seconds after entry into the water to provide a source level of 160 dB/µPa throughout the 1 minute life of the units.

The SUS Mk 84 is able to transmit any one of five prelaunch-selected coded acoustic signals, each of which may convey a predetermined message to the submarine. The device transmits four continuous acoustic tonals, alternating in frequency according to the timing sequence provided in the code table at between 3.3 and 3.5 kHz, each of which may be pulsed for either ½ or 1½ seconds. The fifth code setting generates a continuous 3.5 kHz tone. Third harmonics of the fundamental frequencies are also generated at levels slightly less than those of the fundamentals. The coded sequences are selected using a five-position switch on the side of the unit. The submerged submarine may use either passive sonar or underwater telephone to receive the SUS output.

A heavy zinc nose houses a seawater battery, a hermetically sealed inlet port to the battery compartment and most of the electronics.

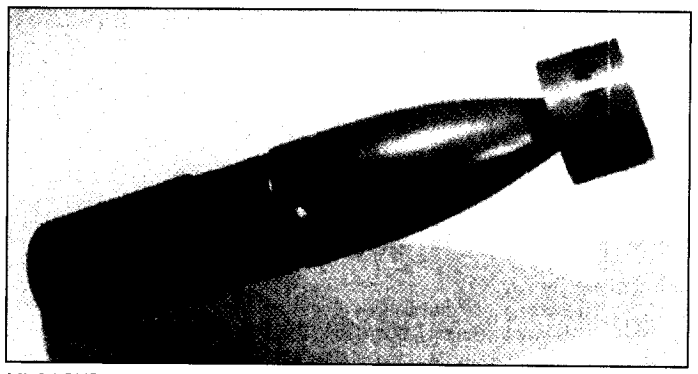
Operational status
In production and in service with the navies of Australia, Canada, France, Greece, Italy, Netherlands, New Zealand, Norway, Portugal, Spain, Turkey, UK and USA.

Specifications
Length: 381 mm
Diameter: 76.2 mm
Weight: 3.175 kg
Launch altitude: 0-3,000 m
Launch speed: 0-300 kt
Operating life: 70 s
Frequencies: 3.3, 3.5 kHz (plus third harmonics)
Source level: 160 dB
Code table: (long 1.5 s, short 0.5 s)

Code	F1 (3.3 kHz)	F2 (3.5 kHz)
1	Long	Long
2	Short	Long
3	Short	Short
4	Long	Short
5	Off	Continuous

Contractor
Sparton Corporation, Electronics Division, DeLeon Springs, Florida.

VERIFIED



Mk 84 SUS

Towed buoys

Type
Towed communication buoy systems.

Description
The major submarine navies of the western world have employed towed communication buoys for many years. These systems allow for maximum operational flexibility by placing minimal restrictions on the boat's speed and depth while offering a wide range of communications capabilities. Today's towed buoys offer a stable platform that can be outfitted with communications antennas and electronics that will allow a wide range of frequency coverage.

Non-communication type sensors can also be mounted in the buoy. Several system configurations are available to suit any size and type of submarine and can offer a full range of communication/navigation capabilities.

The buoys are tethered to the submarine by a multiconductor tow cable, and are deployed and retrieved using either an inboard hydraulic winch, or an outboard palletised submersible electric winch.

Operational status
Sippican manufactures all of the towed buoy systems used by the US Navy submarine fleet.

Contractor
Sippican Inc, Marion, Massachusetts.

VERIFIED

ELECTRO-OPTICAL SENSORS

Introduction

Although the sonar suite is the submarine's main sensor system, the periscope, and its successor the electro-optic mast, will remain major sensors for some time to come. These sensors provide amplifying information to that already gathered by the sonar suite and, for this reason, will remain important for the foreseeable future.

The modern periscope is highly sensitive and sophisticated, generally integrating image intensifier, infra-red detection and ranging, camera recording equipment, together with gyrostabilised fixed lines of sight and so on. Other features common to modern periscopes are split beam binocular viewing, heated windows, alphanumeric data display in the ocular, data transmission to the combat information system, power drive and other optional extras which all help to improve the effectiveness of the system. In addition, the mast often carries various other sensors such as ESM and communications antenna. With the advent of new command systems, multifunction consoles and new software technologies including Windows®, operators are able to display both tactical data and visual images from the periscope/electro-optic mast on a single console display. This enhances considerably the command team's ability to assess a tactical situation.

Periscopes are either of the hull-penetrating or non-penetrating type. Non-penetrating masts have the advantage that they leave the control room deck clear of obstruction and offer much improved positioning for the operator. In this arrangement the ocular remains in a fixed position, overcoming the need for the operator to follow the periscope lens round. Non-penetrating masts are now a standard fit on all new submarine designs and may begin to replace hull-penetrating systems on older boats as they become due for mid-life update programmes. Hull-penetrating masts, on the other hand, require the operator to follow the periscope lens round, which takes up more space. Modern hull-penetrating periscopes no longer require the operator to adopt awkward crouching positions when using the ocular at the base of the mast. This problem has been overcome by mounting the periscope inside a large rotating tube to which is fixed the ocular, which remains at a constant level irrespective of the position of the periscope. The latter slides up and down as normal inside the outer tube. The field of view is reflected off a prism mounted in the lower part of the tube, up to the ocular sited at eye level, affording the operator a continuous view during the full vertical movement of the periscope.

There are at present two main types of periscope, each with its own particular ocular arrangement. The main periscope is the search periscope with a large (in relative terms) lens designed to gather the maximum amount of light to provide the best possible means of detection, even in conditions of low light. These periscopes incorporate extra optical systems for use at night and often include a tilt mechanism which allows zenith observation for navigation. The much smaller attack periscope is designed to create minimum disturbance of the water and present the minimum radar cross-section to reduce the possibility of detection.

As soon as a mast penetrates the water surface it is subject to enormous forces which, when it is a certain height above the surface and moving above a certain speed, cause vibration in the mast. Vibrations occur due to the resonance between the natural bending frequency of that part of the periscope submerged in the water and the frequency of the vortex shedding from that part of the periscope above the water as it passes through the water. The vibration can seriously affect the clarity of the image viewed in the ocular. This vibration is overcome by the use of hydrodynamically designed fairings around the mast, by corrective optical lenses and through stabilisation of the line of sight. Careful design enables periscopes to provide accurate vibration-free viewing at speeds up to 12 kt.

Periscopes are now undergoing a revolutionary change. This has been made possible by the latest developments in electro-optic, fibre optics and allied technologies. The direct optical channel is being made redundant, to be replaced by high-resolution, broadband Electro-Optical (EO) sensors which will have a major impact on the operational capabilities of the platform. These new technologies will enable the periscope view to be displayed on a large screen in the control room, obviating the need for the operator to view the scene through the fixed ocular system.

Because the operator views the horizon from a fixed position, he has no immediate feel for the direction of view and bearings to objects will have to be displayed against a fixed scale presented on the screen.

These revolutionary developments will result in future submarine control room layouts which may well differ considerably from current designs.

VERIFIED

Table XII

Operational periscope systems as at August 2004*

System	Manufacturer	Country	Installed on	Navy	No units
APS	SAGEM AS	France	Scorpene	Chile	1
ASC 18 attack	Zeiss Optronic	Germany	Type 209/1200 (Salta)	Argentina	1
ASC 18 attack	Zeiss Optronic	Germany	Type 209/1200 (Pijao)	Colombia	2
ASC 18 attack	Zeiss Optronic	Germany	Type 209/1300 (Shyri)	Ecuador	2
ASC 18 attack	Zeiss Optronic	Germany	Type 209/1100 (Glavkos)	Greece	4
ASC 18 attack	Zeiss Optronic	Germany	Type 209/1200 (Islay)	Peru	2[1]
ASC 18 attack	Zeiss Optronic	Germany	Type 209/1200 (Atliay)	Turkey	6
BS 19 search	Zeiss Optronic	Germany	Type 209/1200 (Salta)	Argentina	1
BS 19 search	Zeiss Optronic	Germany	Type 209/1200 (Pijao)	Colombia	2
BS 19 search	Zeiss Optronic	Germany	Type 209/1300 (Shyri)	Ecuador	2
BS 19 search	Zeiss Optronic	Germany	Type 209/1100 (Glavkos)	Greece	4
BS 19 search	Zeiss Optronic	Germany	Type 209/1300 (Sabalo)	Venezuela	2
BS 19 search	Zeiss Optronic	Germany	Type 209/1200 (Islay)	Peru	2[1]
BS 19 search	Zeiss Optronic	Germany	Type 209/1200 (Atilay)	Turkey	6
BS 40 attack	Zeiss Optronic	Germany	Type 209/1300	Venezuela	2
CH 081 attack	Thales Optronics	UK	Sauro (Type 1081)	Italy	2
CH 083 attack	Thales Optronics	UK	Swiftsure	UK	4
CH 084 attack	Thales Optronics	UK	Trafalgar	UK	7
CH 085 attack	Thales Optronics	UK	Victoria	Canada	4
CH 091 attack	Thales Optronics	UK	Vanguard	UK	4
CH 093 attack	Thales Optronics	UK	Collins	Australia	6
CK 030 search	Thales Optronics	UK	Kobben (Type 207)	Poland	4
CK 031 search	Thales Optronics	UK	Sauro (Type 1081)	Italy	2
CK 033 search	Thales Optronics	UK	Swiftsure	UK	4
CK 034 search	Thales Optronics	UK	Type 207 (Tumleren)	Denmark	3
CK 034 search	Thales Optronics	UK	Trafalgar	UK	7
CK 035 search	Thales Optronics	UK	Victoria	Canada	4
CK 037 search	Thales Optronics	UK	Dolgorae	South Korea	2
CK 038 EO search	Thales Optronics	UK	Västergötland A 17	Sweden	4
CK 039 search	Thales Optronics	UK	MG 110	Pakistan	3
CK 041 search	Thales Optronics	UK	Dolphin (Midget)	South Korea	9
CK 043 search	Thales Optronics	UK	Collins	Australia	6
CK 051 search	Thales Optronics	UK	Vanguard	UK	4
CK 083	Thales Optronics	UK	Götland	Sweden	3
J	SAGEM AS	France	Agosta	Pakistan	2
J	SAGEM AS	France	Agosta	Spain	4
J	SAGEM AS	France	Agosta	Malaysia	1
J95 search	SAGEM	France	Khalid	Pakistan	2
M41 search	SAGEM AS	France	Daphne	Pakistan	4
M41 search	SAGEM AS	France	Daphne	Portugal	2
M41 search	SAGEM AS	France	Daphne	Spain	2
Model 76 search	Kollmorgen	USA	TR 1700	Argentina	2
Model 76 search	Kollmorgen	USA	Type 209/1400 (Tupi)	Brazil	4
Model 76 attack	Kollmorgen	USA	Type 209/1400 (Tupi)	Brazil	4
Model 76 attack	Kollmorgen	USA	Improved Romeo	Egypt	4
Model 76 search	Kollmorgen	USA	Type 209/1500	India	4
Model 76 attack	Kollmorgen	USA	Type 209/1500	India	4
Model 76 search	Kollmorgen	USA	Dolphin	Israel	3
Model 76 attack	Kollmorgen	USA	Dolphin	Israel	3
Model 76 search	Kollmorgen	USA	Improved Sauro	Italy	4
Model 76 attack	Kollmorgen	USA	Improved Sauro	Italy	4
Model 76 search	Kollmorgen	USA	Walrus	Netherlands	4
Model 76 attack	Kollmorgen	USA	Walrus	Netherlands	4
Model 76 search	Kollmorgen	USA	Näcken	Denmark	1
Model 76 attack	Kollmorgen	USA	Näcken	Denmark	1
Model 76 search	Kollmorgen	USA	Götland	Sweden	3
Model 76 search	Kollmorgen	USA	Type 209/1400 (Atilay)	Turkey	6
Model 76 attack	Kollmorgen	USA	Type 209/1400 (Atilay)	Turkey	6
Model 82	Kollmorgen	USA	Ohio	USA	18
Model 86 search	Kollmorgen	USA	Improved Romeo	Egypt	4
Model 86	Kollmorgen	USA	Los Angeles	USA	51
Model 152	Kollmorgen	USA	Ohio	USA	18
OMS	SAGEM AS	France	Le Triomphant	France	2
SERO 40 STAB	Zeiss Optronic	Germany	Type 209/1300 (Thomson)	Chile	2
SERO 40	Zeiss Optronic	Germany	Type 209/1200 (Poseidon)	Greece	4
SERO 40	Zeiss Optronic	Germany	Type 209/1300 (Cakra)	Indonesia	2
SERO 40	Zeiss Optronic	Germany	Type 209/1200 (Angamos)	Peru	4
SERO 40 STAB	Zeiss Optronic	Germany	Type 209/1200 (Chang Bogo)	South Korea	9
SERO 40 STAB	Zeiss Optronic	Germany	Hai Lung	Taiwan	2
SERO 40 STAB	Zeiss Optronic	Germany	Type 209/1400 (Preveze)	Turkey	4
SERO 40 STAB	Zeiss Optrnoic	Germany	Type 209/1300 (Sabalo)	Venezuela	2
SERO 14 search	Zeiss Optronic	Germany	Ula	Norway	6
SERO 15 attack	Zeiss Optronic	Germany	Ula	Norway	6
SMS	SAGEM AS	France	Scorpene	Chile	1
SPS	SAGEM AS	France	Le Triomphant	France	2
SPS	SAGEM AS	France	Rubis	France	6
ST3 attack	SAGEM AS	France	Daphne	Pakistan	4
ST3 attack	SAGEM AS	France	Daphne	Portugal	2
ST3 attack	SAGEM AS	France	Daphne	Spain	4

System	Manufacturer	Country	Installed on	Navy	No units
ST 5	SAGEM AS	France	Agosta	Malaysia	1
ST5 attack	SAGEM AS	France	Agosta	Pakistan	2
ST5 attack	SAGEM AS	France	Agosta	Spain	4
ST5-95	SAGEM AS	France	Khalid	Pakistan	2
Trident mast	Riva Calzoni	Italy	Ula (Type P 6071)	Norway	6

*Details are given for periscope fittings where known.
[1] *Islay* and *Arica* only

UPDATED

France

APS

Type
Small diameter attack periscope.

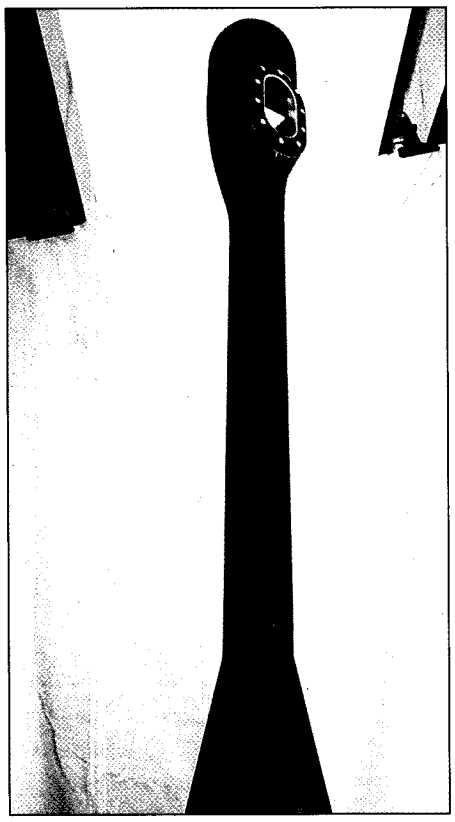
Description
The small diameter (140 mm) attack head includes a single-axis gyrostabilised line of sight for both optical and low-light level TV channels. Four magnifications (×1.5, ×3, ×6, ×12) and four fields of view (30°, 15°, 7.5° and 3.5°) are available for the optical channel. The LLTV colour CCD camera is mounted in the head. The head is covered with RAM for low RCS. The ocular can either be fixed (only the mast and head rotate) or rotating (mast, head and ocular rotate together).

Optional features include an IR camera replacing the LLTV camera, a built-in ESM antenna or GPS antenna on top of the mast, and control exercised from a combat system multifunction common console.

Operational status
Developed from periscopes operational on board French submarines. On order to equip the Scorpene type boats building for the Chilean Navy.

Contractor
SAGEM Optronic and Airland Systems, Paris.

UPDATED



Attack PeriScope (APS)

IMS

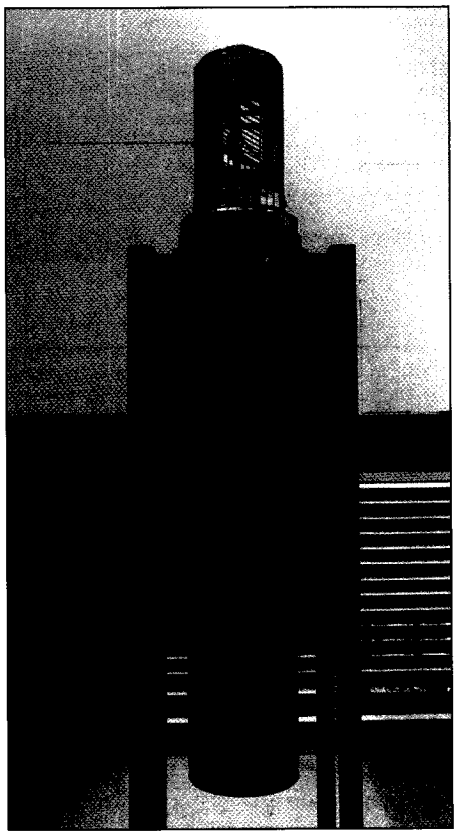
Type
Submarine infra-red non-penetrating mast.

Description
The infra-red mast combines the capabilities of SAGEM's non-hull-penetrating masts while including a single IR channel (8 to 12 µm). Reduced dimensions of the above water element improves discretion through careful design and the use of RAM while providing a real day and night capability. The head is 210 mm in diameter.

The infra-red mast includes:

- dual field of view thermal imaging system (conventional manual mode, auto look-around mode, panoramic search mode)
- two-axis gyrostabilisation of line of sight
- interface for ESM antenna and/or GPS antenna
- electrical rotation
- range estimation
- RAM coatings.

Passive range-finding is carried out on the controller's screen using stadiametric technique. As well as the direct view there are panoramic surveillance and 'look around' modes of operation.



IMS infra-red non-penetrating mast

The infra-red mast can be fitted on any type of non-hull-penetrating hoisting device. A remote-control and display console includes a 19 in CRT display, VCR, joystick and keyboard as well as electronic PCBs and power supply.

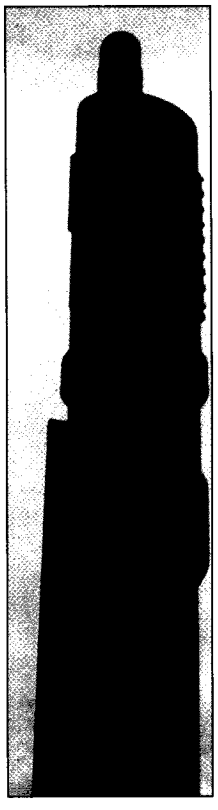
Operational status
In production for export customers. Installed in two Narhvalen class submarines of the Royal Danish Navy.

Contractor
SAGEM Optronics and Airland Systems Division, Paris.

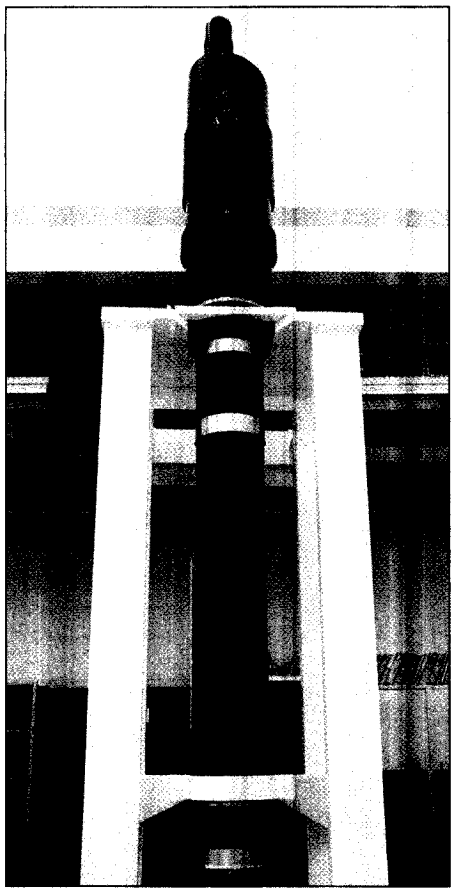
UPDATED

OMS

Type
Submarine optoradar non-penetrating mast.



The OMS mast as installed on the Le Triomphant class SSBNs of the French Navy
0007233



OMS non-penetrating optoradar mast

Description

The optoradar mast combines the capabilities of SAGEM's electro-optic mast and the integration of a navigation radar. The optoradar mast allows elimination of separate masts for these functions, thus improving the discretion of the submarine. The non-hull-penetrating system facilitates submarine retrofit upgrades. The head is 360 mm in diameter.

The optoradar mast includes:

- dual field of view thermal imaging system (conventional manual mode, auto look-around mode, panoramic search mode)
- high-resolution ×2 magnification TV system
- single-axis gyrostabilisation of line of sight
- X-band navigation radar
- electrical rotation
- interface for ESM antenna and/or GPS antenna
- range estimation
- RAM coatings.

Stabilised azimuth surveillance can be presented on one of four range scales between 4 and 32 km. Up to five targets can be tracked and automatic target acquisition is provided. Separate control and display consoles are provided to operate the radar and the electro-optic system. Passive range-finding is carried out on the operator's screen using stadiametric technique. As well as direct view there are panoramic surveillance and 'look around' modes of operation. The radar console includes PPI display, software keys and a trackerball. The electro-optics console includes a 19 in CRT display, VCR, joystick and keyboard as well as electronic PCBs and power supply.

Operational status

Entered service on board Le Triomphant class SSBNs of the French Navy in 1993.

Contractor

SAGEM Optronics and Airland Systems Division, Paris.

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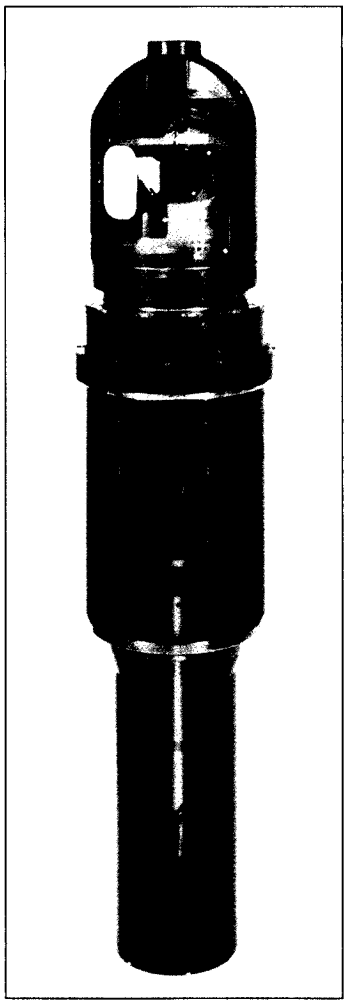
SMS

Type

Submarine non-penetrating mast.

Description

The electro-optic mast combines the advantages of SAGEM's electro-optic search periscopes with the advanced safety of non-penetrating masts. With the mast fully located outside the pressure hull, control room space is increased and more comfortable operating conditions are provided. The electro-optic non-penetrating mast is thus more easily accommodated in submarine designs and facilitates retrofit upgrades. The diameter of the head is 320 mm.



Search electro-optic mast

The search mast includes:

- dual field of view IRCCD thermal imaging system (IRIS) offering the 3 to 5 µm or 8 to 12 µm infra-red band, (conventional manual mode, auto look-around mode, panoramic search mode)
- high-resolution magnification (×1.5, ×3, ×6 and ×12) TV system
- two-axis gyrostabilisation of line of sight
- interface for ESM antenna and/or GPS antenna (optional)
- electrical rotation
- range estimation
- RAM coatings.

The SMS mast can be fitted on any type of non-penetrating hoisting device. A remote-control and display console includes one or two 19 in CRT displays, VCR, joystick and keyboard as well as electronic PCBs and power supply.

The mast can be controlled from a multifunction common console in the combat system.

Operational status

Developed 1990. Trials were undertaken on board a French Daphné class submarine *Psyché* (in 1992), the Swedish submarine *Västergötland* (in 1993), a South Korean Type 209/1200 (in 1995) and a Norwegian Kobben class *Svenner* (in 1995). In production for several export customers including the Chilean Navy Scorpene type.

Contractor

SAGEM Optronics and Airland Systems Division, Paris.

UPDATED

SPS

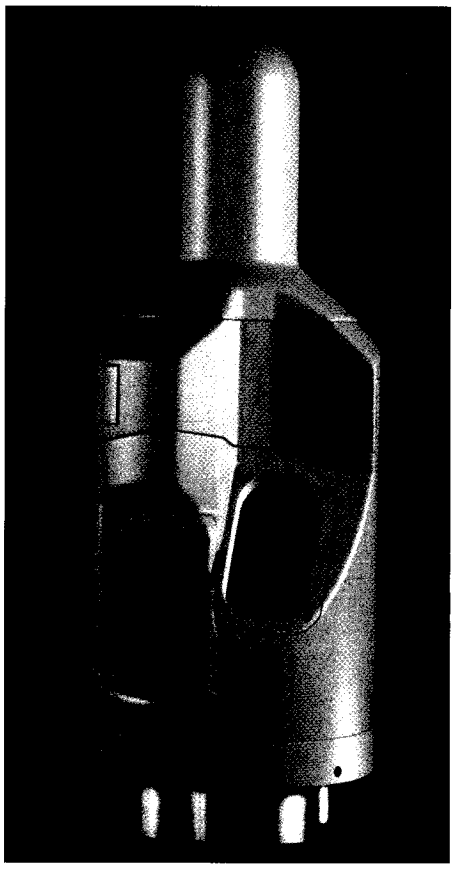
Type

Submarine visual and infra-red periscopes.

Description

The electro-optic search periscope SPS (Pivair) is built around three fundamental characteristics: two-axis gyrostabilisation of the line of sight, built-in vertical reference, and integration of infra-red vision and an optical channel. The head is 320 mm in diameter. The head and upper fairing are coated with RAM. The fairing is of new design optimised to reduce wake and head vibration which results from vortex shedding.

A two-axis gyroscope located in the head overcomes problems from head vibration and improves visual and IR observations by gyrostabilising the line of sight in elevation and bearing.



Search head

Associated with the built-in vertical reference, very accurate sextant measurements can be obtained, providing a reliable position fix.

The use of 8 to 12 µm band infra-red extends the operational capabilities to night operation. The periscope can be operated in an auto look-around mode for a quick panoramic view above the water and in a real panoramic IR search mode providing long-range airborne and surface detection.

A number of options is also available, including:

- choice of magnification (optical channel) ×1.5 to ×12
- range-finder
- built-in ESM antenna on top of the mast
- built-in GPS Navstar receiver antenna on top of the mast
- RAM coatings
- low-light level TV camera
- display and recording of video and infra-red images on remote console.

Operational status
Operational on board all French Navy nuclear submarines (SSBN and SSN).

Contractor
SAGEM Optronics and Airland Systems Division, Paris.

UPDATED

ST 5

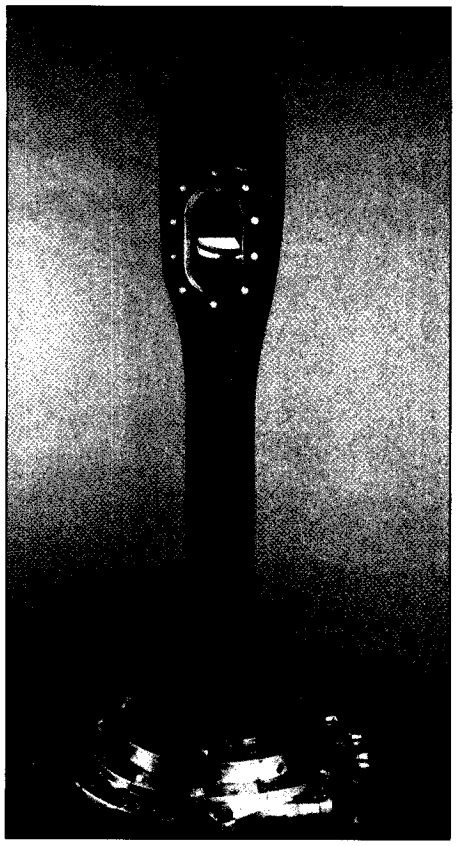
Type
ST 5 attack periscope.

Description
The ST 5 attack periscope has recently been upgraded to provide it with enhanced transparency, single-axis stabilisation, night vision capability with image intensification, improved stealth and a reduction in noise signature. The image intensifier camera is sufficiently compact to be mounted in the small head of the attack periscope. The fixed eyepiece provides magnifications of ×1.5, ×6 and ×12 with fields of view of 36° and 7° through an elevation area of −10 to +30°. To improve stealth the head is specially shaped and coated with RAM to reduce the radar cross-section (RCS).

Operational status
In service aboard French Navy SSNs. The ST5-95 variant is being installed on the Agosta 90B boats for Pakistan.

Contractor
SAGEM Optronics and Airland Systems Division, Paris.

UPDATED



ST 5 attack periscope head

Type J

Type
Modernised J-type search periscope.

Description
Upgrades to the J-type search periscope include magnification of ×1.5 and ×6, elevation arc of −10 to +90°, image intensification and improved stealth.

Operational status
Being delivered for the Agosta 90B boats for the Pakistan Navy.

Contractor
SAGEM Optronics and Airland Systems Division, Paris.

UPDATED

Germany

OMS 100

Type
Optronic mast system.

Description
The rotatable sensor head of the optronic mast system OMS 100 can be raised above the bridge fin of the submarine using a hoisting mast. The head section features a visual TV channel fitted with a B/W or colour HDTV camera with the field of view zoomed, and an IR channel having a third-generation IR camera operating in the far IR 8 to 12 µm band or, alternatively, in the mid-IR 3 to 5 µm band.

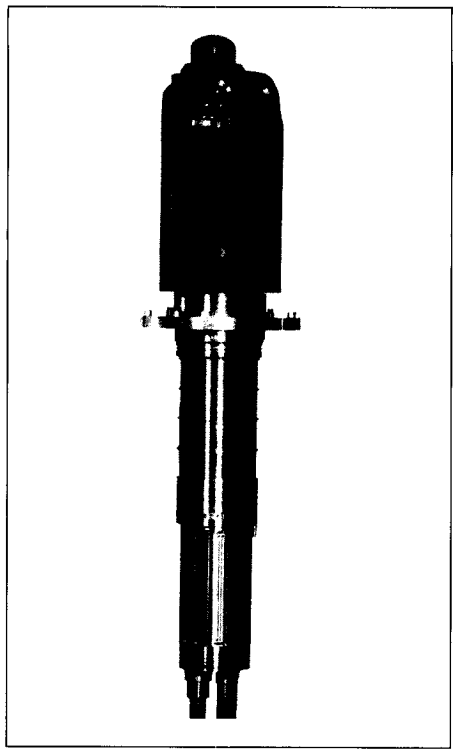
The elevation prism of the visual channel and the elevation mirror of the IR channel are coupled, range between −15° and +60°. The field of view of the visual channel varies between 23.6° × 13.4° (horizontal × vertical) to 3.0° × 1.7° (horizontal × vertical), and that of the IR channel between 12.4° × 9.3° (horizontal × vertical) or 4.1° × 3.1° (horizontal × vertical).

Digital interfaces allow data to be transmitted to the control console. The visual and thermal images can be displayed on monitors and/or recorded on videotape and/or digital storage medium.

The line of sight of both channels can be set continuously in azimuth using a brushless DC motor drive. The line-of-sight is stabilised in elevation and azimuth to ensure observation even under pronounced movements of the submarine.

The following options are available:

- Radar early warning antenna
- Navigation (GPS) and communication (UHF/VHF) antenna
- RAM coating.



Head of the OMS 100 (Zeiss Optronik)
NEW/1036698

Operational status
Currently in series production for new submarines of the South African Navy (Type 209), the Hellenic Navy (Type 214), the South Korean Navy (Type 214), and the Indian Navy (Type 209) in combination with the periscope SERO 400.

Contractor
Zeiss Optronik GmbH, Oberkochen.

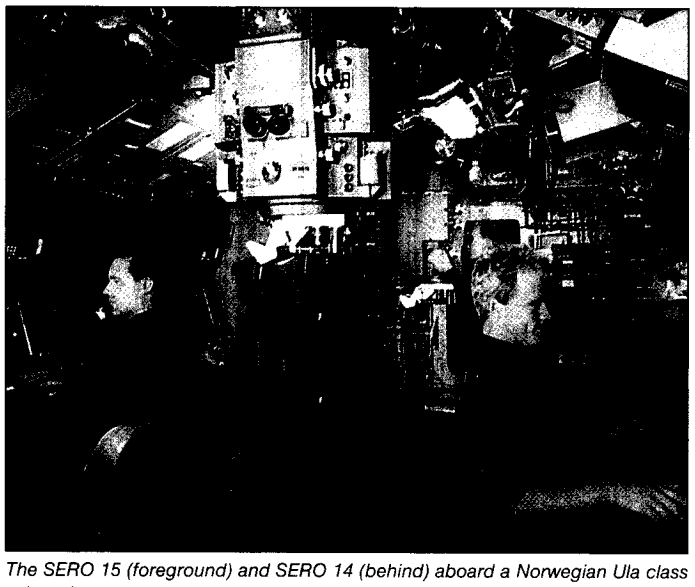
UPDATED

SERO 14

Type
Periscope system.

Description
The SERO 14 and SERO 15 periscopes (see entry on SERO 15) together comprise a modular system. In its basic configuration the SERO 14 features a two-axis line-of-sight stabilisation for both the visual and the IR channel, binocular viewing with geometrical beam splitting, continuous zoom of the visual image with click-stop magnifications at ×1.5, ×6 and ×12, efficient optical range-finding system (stadimeter), remote-control capabilities from a combat system console and integration facilities on top for a wide variety of antennas.

The IR channel is equipped with an Ophelios second generation thermal camera in the wavelength region of 7.5 to 10.5 µm. The CMT detector is of the IRCCD 96 × 4 type with 2:1 interlace (number of lines 576, pixels per line 768).



The SERO 15 (foreground) and SERO 14 (behind) aboard a Norwegian Ula class submarine 0007234

The elevation prism ranges between –15 and +75°. The field of view of the visual channel varies by continuous zooming from 34 × 28° (horizontal by vertical) at ×1.5 magnification to 4 × 3° (horizontal by vertical) at ×12 magnification.

The auxiliary eyepiece at the rear side of this periscope allows the attachment of different types of cameras. The eyepiece data display provides a digital readout of the true and relative bearing, line of sight elevation angle, target height and range.

The SERO 14 is installed into a hoisting mast with streamlined fairing.

The following options are available:
- Radar early warning antenna
- Navigation (GPS) and communication (UHF/VHF) antenna
- CCDTV camera, alternatively LLLTV camera, alternatively a digital and/or small film camera (35 mm)
- RAM coating.

Operational status
The SERO 14 periscope is operational in the Norwegian Ula class submarines and is in production for the German and Italian navies' new Type 212A submarines.

Contractor
Zeiss Optronik GmbH, Oberkochen.

UPDATED

SERO 15

Type
Periscope system.

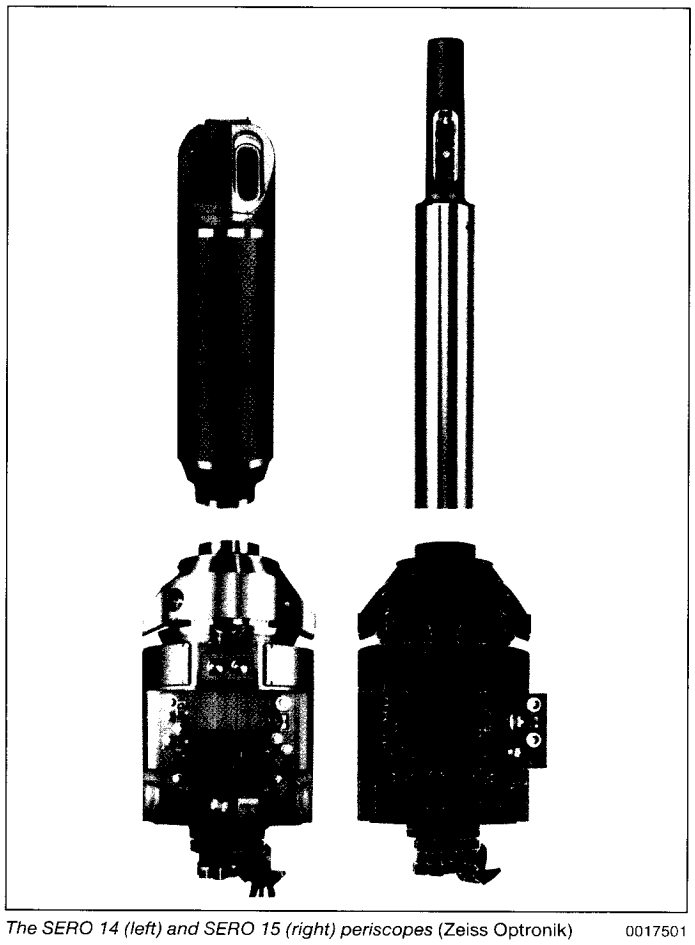
Description
The SERO 15 and SERO 14 (separate entry) periscopes together comprise a modular system. In its basic configuration the SERO 15 features an integrated eye-safe laser range-finder on top of the periscope, a two-axis line of sight stabilisation for both the visual and the laser channel, binocular viewing with geometrical beam splitting of the visual channel with magnifications at ×1.5 and ×6, efficient optical range-finding system (stadimeter) and remote-control capabilities from a combat system console.

The laser channel is equipped with an eye-safe Raman-shifted Nd:YAG laser. The maximum target range indicated amounts to 19,990 m.

The elevation prism ranges between –15 and +60°. The field of view of the visual channel amounts to 36 × 28° (horizontal by vertical) at ×1.5 magnification to 8.5 × 6.5° (horizontal by vertical) at ×6 magnification.

The auxiliary eyepiece at the rear side of this periscope allows the attachment of different types of cameras. The eyepiece data display provides a digital readout of the true and relative bearing, line-of-sight elevation angle, target height and range.

The SERO 15 is installed into a hoisting device with streamlined fairing.



The SERO 14 (left) and SERO 15 (right) periscopes (Zeiss Optronik) 0017501

The following options are available:
- CCDTV camera, alternatively LLLTV camera, alternatively a digital and/or small film camera (35 mm)
- RAM coating.

Operational status
The SERO 15 periscope is in service aboard Norwegian Ula class submarines and is in production for the German and Italian navies' new Type 212A submarines.

Contractor
Zeiss Optronik GmbH, Oberkochen.

VERIFIED

SERO 400

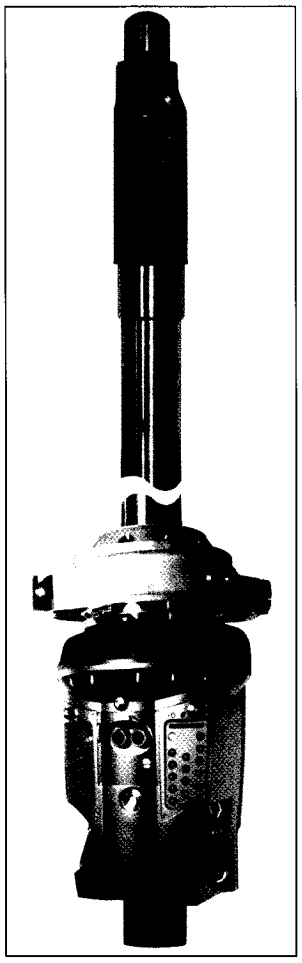
Type
Modular periscope system.

Description
The standard configuration of the SERO 400 190.5 mm periscope features two-axis line-of-sight stabilisation, binocular viewing, selectable magnification of ×1.5 and ×6 and ×12, highly efficient visual optical range-finding system (stadimeter), remote-control capabilities from a combat system console, and integration facilities for a wide variety of antennas and/or a laser range-finder (option). The eyepiece data display provides a digital readout of the true and relative bearing, line-of-sight elevation angle, target height and range.

The prism has an elevation range of –15 to +75° (restricted to +60° if an antenna and/or laser is fitted). There is a wide field of view at ×1.5 magnification (36° azimuth, 28° elevation) decreasing correspondingly at higher magnifications (8° azimuth, 6.5° elevation at ×6, and 4.2° azimuth, 3.4° elevation at ×12).

The installation of SERO 400 into hoisting devices with streamlined fairing is the preferred option.

The following options are currently available:
- Colour TV
- Low-light level CCD TV camera
- Radar early warning antenna
- Navigation (GPS) and communication (UHF/VHF) antenna
- Digital still camera
- Eye-safe laser range-finder (Raman-shifted Nd:YAG laser)
- RAM coating.



Head of the SERO 400
(Zeiss Optronik)
NEW/1036697

Operational status
Currently in series production for new submarines of the South African Navy (Type 209 mod), the Hellenic Navy (Type 214), the South Korean Navy (Type 214) and the Indian Navy (Type 209) in combination with the optronic mast system OMS 100.

Contractor
Zeiss Optronik GmbH, Oberkochen.

UPDATED

International

UMM

Type
Submarine Universal Modular Mast (UMM).

Development
August 2006 – final deliveries due.
July 2004 – The first two masts of latest contract delivered.
January 2003 – US$13.4 million contract from US Naval Sea Systems Command for 16 units. (Eight for fifth Virginia class and eight (four each) to first two Ohio class SSBNs being converted to SSGN.)
October 2002 – Order for 12 units.
2001 – Further eight units ordered.
1999 – Contract option for 14 units to complete first two Virginia class boats.
1995 – Programme initiated for application on Virginia class SSNs (bank of eight UMMs per boat). Development phase and three initial production units.

Description
The UMM (Universal Modular Mast) from Kollmorgen and its Italian subsidiary, Calzoni SrL, is a modular structure with a telescopic two-stage fairing, providing a hoisting mechanism for a variety of different sensors utilised by the US Navy.

The UMM consists of a cartridge assembly including a structural module, a mast fairing subassembly, a hoist cylinder and a closed-door mechanism. The use of standard interface allows integration of a variety of above-water sensors and communications antennas to be fitted to the mast system. The modularity of the design enables easy and quick installation and de-installation from the platform and the possibility, with minor changes, of using common subassemblies for different sensor payloads. The use of a cartridge concept in which the faired mast, bearings and hydraulic actuation are incorporated into a single unit, ameliorates alignment problems.

The two-stage design allows for higher sensor positioning and height adjustments at periscope depth. The mast features an operating speed of 12 kt, with survival assured at up to 16 kt.

The sensors and communication systems in the mast include electro-optic imaging, AN/BLQ-10 ESM, radio and satellite communications and radar. Integration is achieved via standard interface modules. Calzoni has proposed its integrated mast module, using the UMM, for the advanced submarine bridge fin being developed by the US Navy.

Operational status
In production for the US Navy's Virginia class and two of the four converted Ohio class SSGN submarines.

Contractors
Kollmorgen Corporation, Electro-Optical Division, Northampton, Massachusetts.
Calzoni SrL, Bologna, Italy.

UPDATED

Israel

Nite Eye

Type
Thermal imager for submarine periscopes.

Description
The Nite Eye thermal imaging system is designed to carry out surveillance and target detection at night and in adverse weather conditions. Operating in the 8 to 12 µm band, the system provides the operator with real-time visual images using a standard video output. The camera uses either a narrow (2.75 × 1.9°) or wide angle (10.5 × 6.5°) field of view and a separate focal attachment is available for further expansion of the field of view.

The miniaturised, modular Nite Eye can be fitted to a range of submarine periscopes.

Operational status
The thermal imaging system has been integrated into the Kollmorgen periscopes of the Israeli Navy Dolphin class submarines.

Contractor
Opgal Optronic Industries Ltd, Karmeil.

VERIFIED

United Kingdom

CK032, CK037, CK039, CK041 periscopes

Type
Compact periscopes for small submarines.

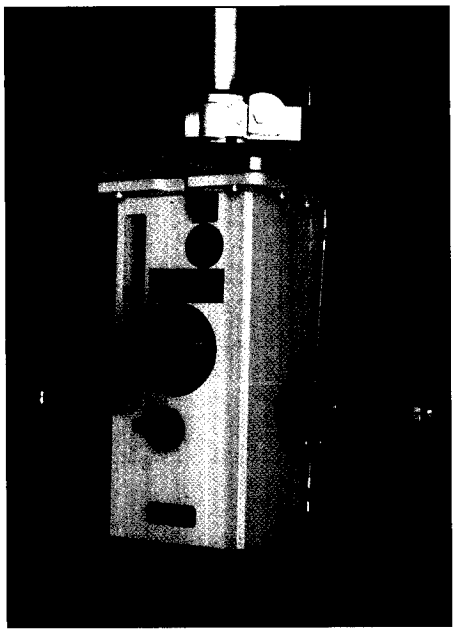
Description
This range of periscopes is optimised for small platforms of between 50 and 500 tonnes. With a range of four models (CK032, CK037, CK039, CK041) using modular designs and 127 mm diameter tubes, solutions are available to meet all requirements. Offering high-performance optics coupled with stadiametric range-finding, image intensification for night vision, stabilisation, electronics weapons system interface, still camera, elevation of line of sight facility (–15 to +60°) and dual magnification, the periscopes can be further enhanced by the addition of TV camera, ESM, communications sensor and GPS sensors.

Operational status
The CK032, CK037, CK039 and CK041 periscopes are in service with the Pakistan Navy (MG-110 midget submarines) and South Korea (Dolgorae and Dolphin class midget submarines).

Specifications
Tube diameter: 127 mm
Length: 3,500-5,400 mm
Weight: 150-250 kg
Magnification: ×1.5, ×6
Elevation: –15 to +60°

Contractor
Thales Optronics, Glasgow.

UPDATED



Compact search periscope
0006984

CK038 periscope

Type
Search and attack periscopes.

Description
The search periscope CK038 is fitted with 190 mm diameter tubes. It is compatible with medium-sized diesel-electric submarines for either new build or retrofit applications and can also be offered in search/attack or stand-alone configurations.

The CK038 is optimised for low susceptibility to visual counter-detection and has an optical system designed for maximum light gathering to accommodate watch-keeping, night viewing and use in poor visibility. The periscope features image intensification, thermal imaging, LLTV, video recording, stabilisation, torque drive or torque assist and an electronic weapons system interface. Optional features are ESM warning, GPS and communications sensors.

All functions on the periscopes are electronically controlled.

The CK038 periscopes on the Swedish 'Västergötland' class are to be upgraded with the addition of a thermal imaging camera and an improved image intensifier.

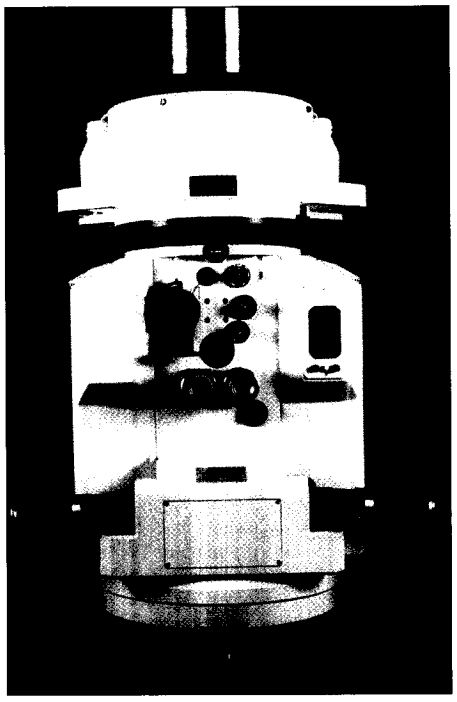
Data and images from the CK038 can be relayed to the CM010 advanced optronics mast.

Operational status
The CK038 periscope is in service on board the Swedish Västergötland class submarines.

Specifications
Diameter: 190 mm
Mechanical length: 10,990 mm
Optical length: 10,400 mm
Weight: 800 kg
Magnification: ×1.5, ×6 (with ×3, ×12 electronic optional)
Elevation (line of sight): –10 to +60°
Elevation (edge of field): –26 to +76°

Contractor
Thales Optronics, Glasgow.

UPDATED



190 mm electronic periscope
0006985

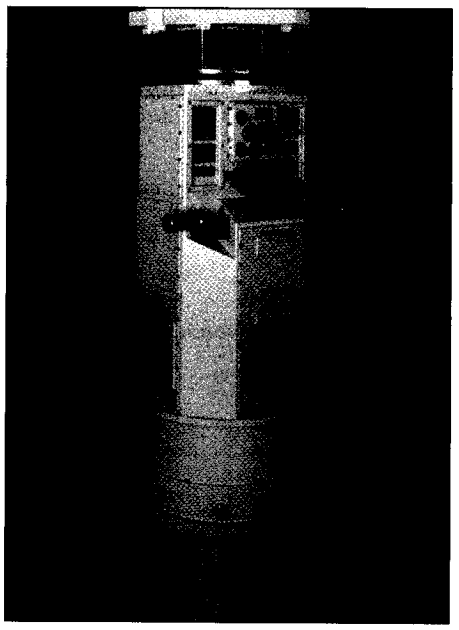
CK043/CH093 periscopes

Type
Search and attack periscopes.

Description
The most advanced periscope systems currently in service, the 254 mm CK043 search and CH093 attack periscopes offer the optimum combination of day and night vision and electronic surveillance sensors. Both periscopes have four fields of view. In addition to the optical path, CK043 has thermal imaging and low-light television sensors, while CH093 has image intensification and low-light television sensors. These can be viewed directly or at a multifunction, remote-control and viewing console and are designed to allow full integration with the platform's combat system.

Key tactical data can be viewed either on the consoles or by eyepiece injection. Other key operational features include line of sight stabilisation, optical and electro-optic range-finding, position fixing (sextant), still photography, internal communications (intercom) and support for a comprehensive ESM sensor suite.

Operational status
All versions of the electro-optic periscope are in service. The CK043 and CH093 are fitted in the Australian Collins class submarines and the CK051 and CH91 are in service aboard the Vanguard class SSBNs of the Royal Navy.



254 mm optronic periscope as fitted in the 'Collins' class submarines

Specifications
Tube diameter: 254 mm
Length: 14,300 mm
Weight: 1,500-1,900 kg
Magnification: ×1.5, ×3, ×6, ×12
Elevation: –15 to +60°

Contractor
Thales Optronics, Glasgow.

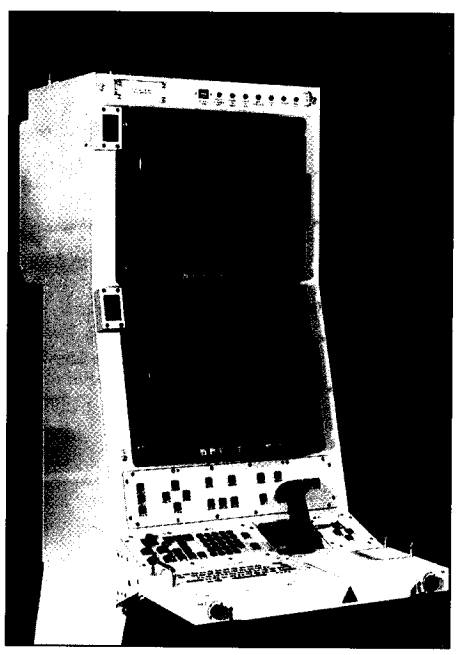
VERIFIED

CM010 series

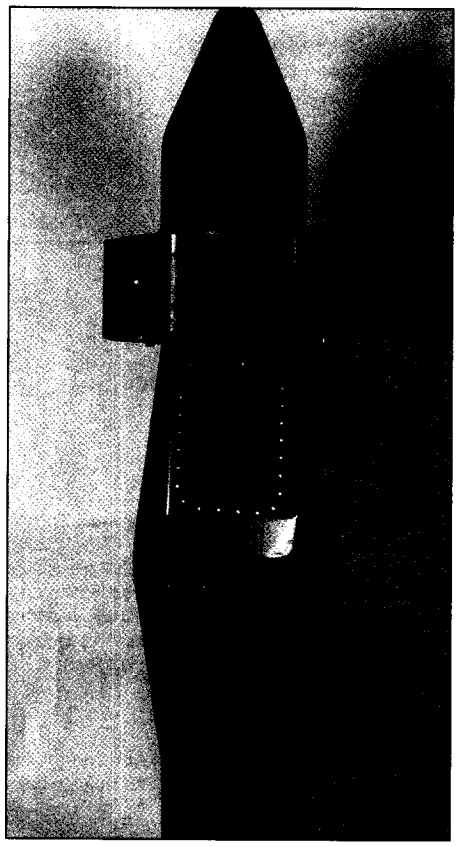
Type
Non-hull-penetrating electro-optic masts.

Description
The CM010 series of electro-optic masts combines innovative design with the latest proven technology to provide exceptional performance and operational advantage under all conditions. All CM010 masts are non-hull-penetrating and can be fitted with a wide range of modular sensor heads. Sensor technologies available include thermal imaging, image intensification, high-colour TV sensors and support for high-sensitivity broadband ESM, communications and GPS sensors. Images captured by the system are complemented by advanced image manipulation and image processing capabilities which further enhance the operational advantages of the system.

The 'stealth' mast also features a quick look round facility which allows full horizon coverage in just a few seconds. The data gathered can then be examined and analysed once the mast is lowered, keeping mast exposure to an absolute minimum. Radar cross-section reduction measures and streamlined shape further reduce the risk of detection.



Electro-optic mast console



Electro-optics mast sensor head fitted with AZE-2 ESM head
0006986

The electro-optic mast systems are controlled and operated from dedicated remote-control consoles equipped with high-resolution colour monitor displays, allowing the command team to obtain a complete above-water picture. Alternatively the system can be controlled from suitably equipped multifunction consoles. The common mast raising equipment facilitates integration with other payloads such as dedicated ESM, radar, Satcom and communications antenna packages.

The system selected for the three Royal Navy Astute class will include high-resolution, colour LLTV and a thermal imaging camera. The sensors are stabilised in three axes and the mast has a 360° quick look facility to minimise above water exposure.

Operational status
2004 - The CM010 electro-optic mast is in production.

Early 2002 - The first systems (CM010 and CM011) due for delivery for the Astute class.

May 1998-2000 - The UK Royal Navy Trafalgar class submarine *Trenchant* was fitted with a CM010 mast for trials. It temporarily replaced the CH084 attack periscope.

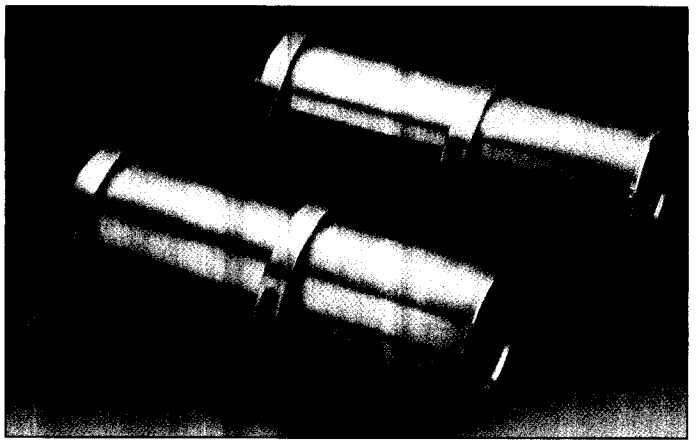
Contractor
Thales Optronics, Glasgow.

UPDATED

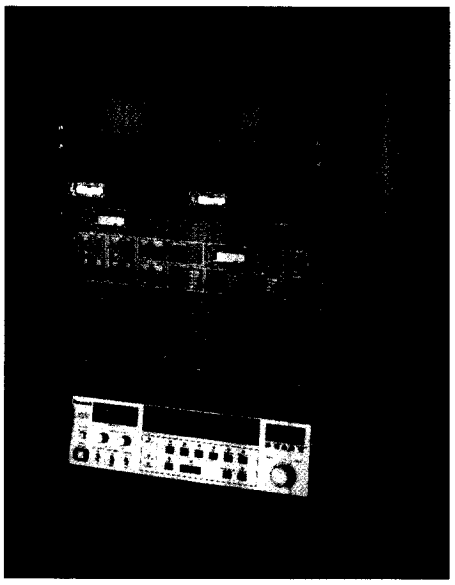
OE 0285

Type
Submarine ice operation camera.

Description
Developed for use aboard submarines operating in ice conditions, the OE 0285 is an ISIT camera capable of viewing objects in ultra-low light level conditions in the region of overcast starlight, enabling thinner patches of ice to be identified. This provides an important aid to submarines surfacing through ice when engaged on Arctic operations. The cameras, which are the first to be developed specifically for under ice operations where low-light levels present a major obstacle to obtaining well-defined images, are connected via suitable cabling and hull gland penetrators to the control equipment inside the submarine's hull. The control equipment comprises a dual-redundant camera power supply, data overlay generator, display monitor and high-quality video monitor. The cameras are housed in nickel aluminium bronze castings and are positioned on the submarine's fin, allowing both forward and overhead images to be obtained.



Model OE 0285 ice cameras in bronze housings



Model OE 0285 combined display monitor, video monitor, power supply and control unit

Operational status
In production and operational aboard Royal Navy submarines.

Contractor
Kongsberg Maritime Ltd, Aberdeen.

UPDATED

United States

AN/BVS-1

Type
Non-hull-penetrating electro-optic mast.

Description
The AN/BVS-1 photonics mast will provide US submarines with increased information gathering capacity and a greater ability to process, distribute and share information for improved battlespace awareness. The non-hull penetrating sensor subsystem performs surveillance, intelligence gathering and electronic warfare operations. The system affords the capability to readily upgrade existing sensors and to incorporate new state-of-the-art multispectral devices to ensure dominance of the submarine battle force.

The mast contains a multispectral suite of EO sensors (including two high-definition TV systems in colour and monochrome and a mid-wave staring IR sensor), an eye-safe laser range-finder, as well as ESM, microwave DF and other RF sensors. The system is integrated with and deployed using the hydraulically activated Universal Modular Mast (UMM). Operator control is exercised from an inboard workstation through the use of specific control devices while imagery and status information is presented on the workstation displays.

The photonics mast interfaces with other subsystems aboard the submarine through the software architecture. An onboard training capability is integrated with the system hardware and software to allow operator training either locally or as part of a team exercise.

Operational status
Trialled since 1999 on board the Los Angeles class submarine *Annapolis* and now in production for the US Navy Virginia class submarines. Each Virginia class boat will carry two AN/BVS-1 masts.

Contractor
Kollmorgen Corporation, Electro-Optical Division, Northampton, Massachusetts.

VERIFIED

Model 76

Type
Modular attack and search periscope.

Description
The Model 76 is a modular periscope system with common components for the attack and search versions. The basic difference is that the attack periscopes have a smaller profile head, while the search periscopes have a larger head to act as multipurpose reconnaissance platforms.

The system consists of a mast unit with optical train, a display and control unit including a split-beam binocular eyepiece, a 35 mm camera and training handles. In addition to the mast unit, there is a hoisting yoke, a control unit, and a junction box unit.

The basic Model 76 periscope incorporates numerous features in the basic configuration including: elevation line of sight stabilisation; integral electric torque drive with auto-torque assist; microphone; three magnifications; mechanical bearing dials; eyepiece data display for range, true/relative bearing and elevation displays; heated head window; 35 mm photo camera kit; optical stadimeter; fail-safe elevation line of sight; image intensification; and LLLTV or CCD TV cameras.

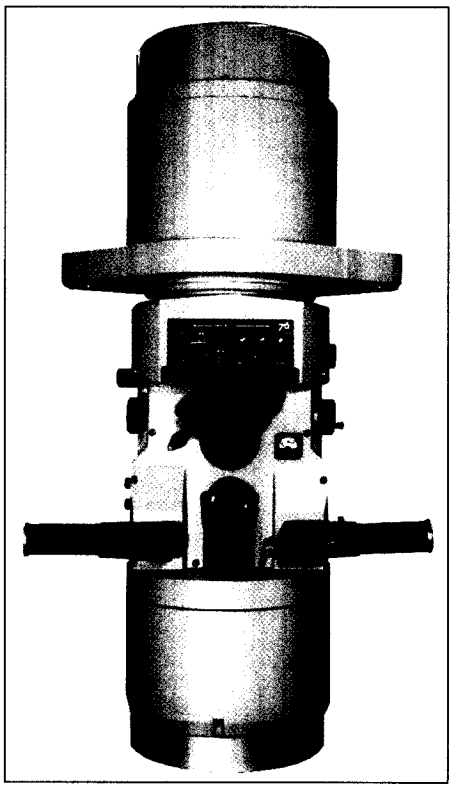
Features offered as options include RAM, ESM/DF antennas (2 to 18 GHz), video tape recorders, GPS antenna, voltage probe antenna, thermal imaging capability (3 to 5 μm or 8 to 12 μm), SATCOM antenna, remote-control console, sextant capability and laser range-finder.

Operational status
In production. The Model 76 is fitted in a number of submarines including: Argentina ('Santa Cruz'), Brazil (Type 209/1400), India ('Shishumar'), and Turkish Type 209 submarines, the Danish 'Kronborg' (ex-Swedish *Näcken*), the Egyptian Romeo class, the Italian Navy Sauro class (3rd and 4th series), the Netherlands (Walrus), and Swedish Gotland class (see Table XII).

Specifications
Diameter: 190.42 mm
Elevation: –10 to +74° (attack); –10 to +60° (search)
Magnification: ×1.5, ×6, ×12
Fields of view: 4°, 8°, 32°

Contractor
Kollmorgen Corporation, Electro-Optical Division, Northampton, Massachusetts.

UPDATED



Model 76 periscope

Model 86 series

Type
Submarine non-hull-penetrating electro-optic masts.

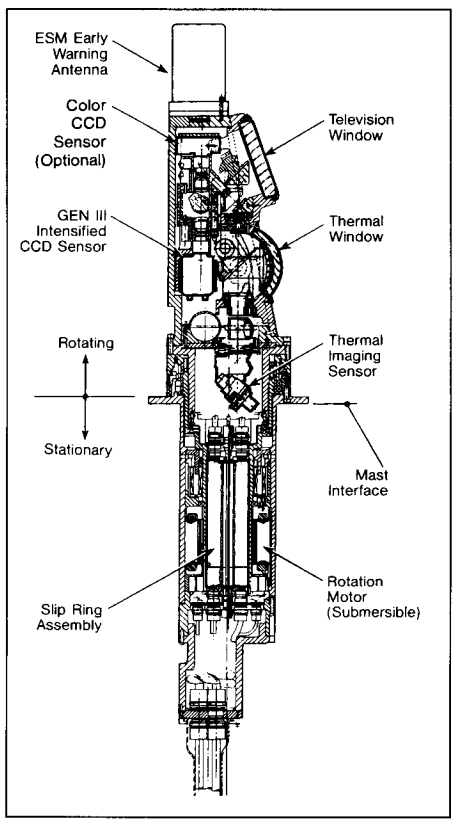
Description
Capabilities which previously required a hull-penetrating optical periscope can now be included in one of these sensor packages. The Model 86 universal modular optronic mast series includes a sensor unit, a hydraulically operated streamlined mast including connection cabling external to the hull, and electronic interface unit and a control/display console internal to the hull. Electronic processing and data transmission permit all sensor information to be processed and displayed in a dedicated operating console, or incorporated into the main combat consoles to further reduce space requirements and enhance operation.

Features of the optronic mast include:

- thermal imaging for day/night/adverse weather viewing without major hull penetration
- colour and black and white television for daylight, low-light level and 'quick-look' viewing
- two-axis line of sight stabilisation to eliminate ship's motion and mast vibrations
- ESM (2-18 GHz) warning to detect radar threats
- unique, rotating sensor package (sealed statically) with quick response and low power consumption
- automatic mast control with a 'quick-look' mode.



Model 86 electro-optic sensor head
(Kollmorgen)
0041423



Block schematic of Model 86 series periscope
(Kollmorgen)
0099761

Operational status
In production. The Model 86 has been installed in US Navy Los Angeles class submarines. The Model 86 is also on order for the Virginia class SSNs. A Model 86 is also fitted in the modernised Egyptian Romeo class boats.

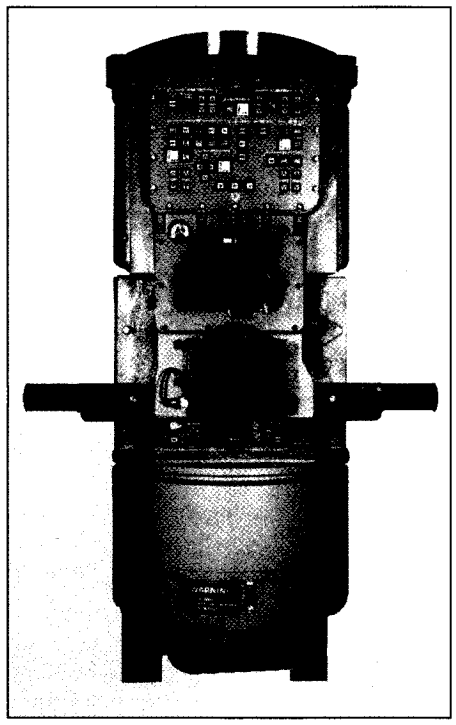
Specifications
Fields of view: 3°, 4°, 12°, 16° (visual); 3°, 4°, 6.75°, 9°(IR)
Elevation: -10 to +72° (visual); -10 to +55° (IR)
IR camera: 3-5 μm or 8-12 μm
Optional formats: mission critical camera, RAS/RAM, laser range-finder

Contractor
Kollmorgen Corporation, Electro-Optical Division, Northampton, Massachusetts.

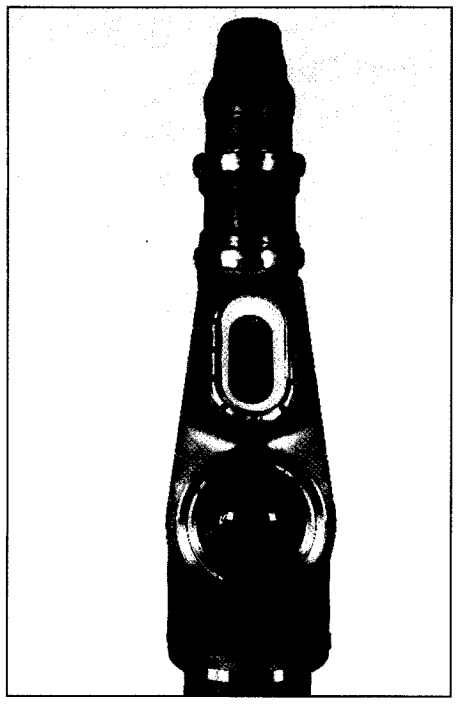
UPDATED

Model 90

Type
Submarine electro-optic system.



Model 90 electro-optic mast eyepiece unit



Model 90 electro-optic masthead unit

Description

This system has been developed to allow the operator to search the sea surface during day and night utilising a thermal imaging subsystem and, at the same time, to supply a direct viewing visual channel.

The system combines a wide range of sensors in one periscope: a thermal imaging camera; (3 to 5 μm or 8 to 12 μm) CCD TV camera; 35 mm photographic camera; laser range-finder as well as passive TV and visual stadimeter; omniradar early warning antenna; a radar direction-finding antenna; and GPS. The periscope provides high performance by utilising accurate stabilisation to compensate for induced vibrations and platform motion to the visual and thermal lines of sight. Additionally, in combination with this function, the operator is provided with a periscope rotation and line of sight elevation rate control which allows fast direction and target tracking. The operator has a direct view of the scene in addition to a video display and eyepiece data display of target range, target bearing and line of sight elevation angle.

A remote-control station is supplied as part of the periscope system, in addition to a complete control datalink to the submarine fire-control system.

Operational status

Sea trials completed 1992, delivery of first production systems 1995. The mast is operational aboard the Israeli Dolphin class.

Specifications

Periscope tube diameter: 190.42 mm
Line of sight elevation: –10 to +74° (visual and TV); –10 to +55° (thermal imaging)
Magnifications: ×1.5, ×6, ×12, ×18
Fields of view: 2.5°, 4°, 8°, 32° (visual) 4.4°, 10° (IR)

Contractor

Kollmorgen Corporation, Electro-Optical Division, Northampton, Massachusetts.

VERIFIED

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juws.janes.com

MAGNETIC ANOMALY DETECTION SYSTEMS

Canada

AN/ASQ-504(V)

Type
Magnetic Anomaly Detection (MAD) equipment.

Description
The AN/ASQ-504(V) Advanced Integrated MAD System (AIMS) is an inboard digital system designed to provide optimum performance when used on helicopters and fixed-wing aircraft. AIMS is a fully automatic Magnetic Anomaly Detection (MAD) system which improves detection efficiency while significantly reducing operator workload. For helicopter installation, the detecting head is mounted inside the aircraft. This provides true 'on-top' contact when over a target by eliminating the delay inherent in a towed detecting system.

The AN/ASQ-504(V) system combines sensitivity and accuracy with ease of operation, eliminates aircraft-generated interference fields and delivers continuous, automated feature recognition. Contact alert, both visual and audible, is provided. Slant range is displayed allowing the operator to determine if he is within target acquisition range.

AIMS eliminates hazards associated with towed systems and permits high-speed surveillance and manoeuvrability, thereby increasing patrol range, improving detectability and substantially reducing false alarms. When used with dipping sonar, transition from one system to the other can be performed quickly and effectively.

The AIMS package weighs 26.3 kg (49 lb) and consists of a 0.005 nanotesla optically pumped magnetometer, a vector magnetometer, an amplifier computer and an optional control indicator. The system operates from a single-phase, 115 V, 400 Hz power source. AIMS has the flexibility either to perform independently or to accept and execute commands from common control/display units via a 1553 databus.

Operational status
Production quantities have been delivered for requirements on the RAN Seahawk, Taiwanese Grumman Turbo-Tracker, RAF Nimrod MR Mk 2, MR Mk 4 and RN Sea King and to the Canadian Forces for their Sea Kings. CAE is under contract to deliver MAD systems to the Australian Air Force for its P-3C Update Programme. The system is also in service in the Republic of South Korea (Lynx helicopter) and Singapore (Maritime Enforcer).

Specifications
Detecting head: caesium, optically pumped, oriented
Sensitivity: 0.01 γ (in-flight)
Features: automatic target detection. Operator alert, visual and audible. Slant range estimate to 854 m (2,800 ft)

Outputs
Visual: contact alert and estimated slant range
Analogue: adaptive MAD signal
Digital: control and display interface to MIL-STD-1553B
Audio: ICS alert
Dimensions: 178 mm (diameter) × 813 mm (long) (detecting head); 193 × 257 × 559 mm (amplifier/computer); 152 × 152 × 152 mm (vector magnetometer); 190 × 145 × 145 mm (control indicator)
Weights: 6.1 kg (detecting head); 17.7 kg (amplifier/computer); 0.7 kg (vector magnetometer); 1.8 kg (control indicator)



A CAE MAD detector head being inserted into the tail of a CP-140 Aurora maritime aircraft

Contractor
CAE Electronics Ltd, Saint Laurent, Montreal, Quebec.

VERIFIED

France

Mk III detector

Type
Magnetic anomaly detection system.

Description
The MAD Mk III is specifically designed for inboard use on fixed-wing aircraft and helicopters to detect the presence of a submersible by measuring the disturbance to the earth's magnetic field. In the helicopter version the MAD body is towed at the end of a 70 m cable to eliminate disturbances. It is an integral, digital, solid-state airborne system which becomes operational at switch on without any warm-up time. Target parameters are automatically delivered in real time on a CRT control and display unit.

The basic equipment can be broken down into three separate units; a detection unit, a computer and a control/display unit. A 1553B databus interface card is included in the system. A graphic recorder is available as an option.

The sensor operates on the nuclear magnetic resonance principle and uses the precession of protons in a liquid, the frequency of which, measured by the pick-up coils, is proportional to the magnetic field to be measured. Compensation is employed to eliminate from the received signal all disturbances created by the magnetic element in the aircraft and their movement in the earth's field. The compensator uses a 16-term model, representing the magnetic components of the aircraft. The MAD Mk III includes rapid aircraft identification modes.

The target is detected and located automatically. This is a fundamental role, allowing the MAD system to give a high-detection probability with a very low false alarm rate in extracting the target signal from the background noise. The Thales Avionics MAD system is based on a mathematical comparison between the current MAD signal and an analytical model of the target signals, as opposed to the more conventional method using threshold detection in several frequency bands. All computing tasks are performed by the ALPHA 732 proprietary 1 MOPS digital computer operating in Pascal.

Operational status
In service with the French Navy Atlantique 2 and Lynx.

Specifications
Dimensions: 1,250 mm (long) × 125 mm (diameter) (detection element); ½ ATR (long) (computer); 190 mm (long) × 146 mm (wide) × 162 mm (high) (control/display unit)
Weights: 5.5 kg (detection element); 10 kg (computer); 3.5 kg (control/display unit)

Contractor
Thales Avionics, Meudon La Foret.

UPDATED

United States

AN/ASQ-81(V) ASW magnetometer

Type
Magnetic anomaly detection system.

Description
The AN/ASQ-81(V) Magnetic Anomaly Detector (MAD) system was developed for the USN for use in the detection of submarines from an airborne platform. The system operates on the atomic properties of optically pumped metastable helium atoms to detect variations in total magnetic field intensity. Changes in the Larmor frequency of the sensing elements are converted to an analogue voltage, which is processed by bandpass filters before it is displayed to the operator.

Four configurations of the AN/ASQ-81(V) are available: two each for installation within an airframe and for towing behind an aircraft. The USN uses the AN/ASQ-81(V)-1 inboard installation with carrier-based S-3 Viking aircraft as well as with the land-based P-3C ASW aircraft. In the S-3 Viking the MAD is deployed on an extendable tailboom. For towing, the configuration is the AN/ASQ-81(V)-2, which is employed by USN SH-3H and SH-2D helicopters. The towed AN/ASQ-81(V)4

version is fitted in the USN SH-60B Seahawk. The body is deployed from a 24 to 55 m long tow cable at speeds between 10 and 138 kt providing a maximum detection range of around 1 km. The AN/ASQ-81(V)1 and AN/ASQ-81(V)3 use a DT-323 magnetic detector and the AN/ASQ-81(V)2 and AN/ASQ-81(V)4 a TB-623 magnetic detector housed in the towed body.

The equipment has been upgraded with a form, fit and function replaceable digital implementation version, which incorporates microprocessor technology to achieve automatic aircraft compensation and to perform all signal processing and built-in test. The upgraded version features improved performance and can eliminate up to 13 Weapons Replaceable Assemblies (WRAs).

Operational status
The AN/ASQ-81(V) 1 is in service aboard USN P-3, and the AN/ASQ-81(V)3 S-3 and the AN/ASQ-81(V)4 on SH-60B/F and SH-2G aircraft and a variety of international platforms such as the Lynx, HSS-2, 500D and SH-60J. Among navies operating the system are Australia (Orion), Egypt (Seasprite), Japan (Orion), Netherlands (Orion and Lynx), Norway (Orion), Portugal (Orion), Spain (Orion and 500M), and Taiwan (Seasprite, Orion and MD-500).

Contractor
Raytheon Electronic Systems, Sensors & Electronic Systems, McKinney, Texas.

VERIFIED

AN/ASQ-208(V) MAD system

Type
Digital magnetic anomaly detection system.

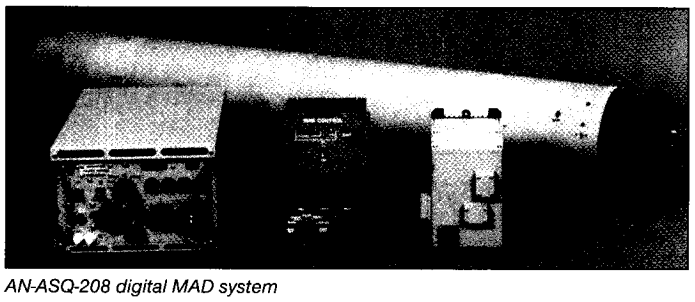
Description
The AN/ASQ-208(V) is a derivative of the AN/ASQ-81 magnetometer that operates on the same principle as the atomic properties of optically pumped metastable helium atoms to detect variations in total magnetic field intensity. The AN/ASQ-208(V) is a digital implementation which incorporates microprocessor technology to achieve aircraft compensation, multiple channel filtered display and threshold processing. The system uses a high-sensitivity helium detector unit with enhanced signal recognition provided by three-channel filtered data for optimum operator display and automatic detection. The display provides a range/confidence estimate as an operator aid. The system can be controlled either through an online 1553B digital interface, or offline through a control indicator unit. For ease of integration there is also an RS-232 interface which can be connected directly to a standard PC for displaying and/or archiving data. Two system configurations are available; one for inboard installations and one for towed installations. The system has been configured for ease of installation on either existing or new aircraft and uses current AN/ASQ-81(V) wiring where applicable.

This system is form, fit and function replaceable with the AN/ASQ-81(V) and eliminates up to 13 ancillary WRAs. Digital signal processing yields a 25 per cent improvement in open water detection range and a 50 per cent improvement in shallow water detection range compared to the AN/ASQ-81(V). The reduced number of WRAs has a significant advantage in initial price and has an even greater advantage in reduced maintenance costs.

Operational status
In service aboard USN P-3 aircraft and S-76N helicopters.

Contractor
Raytheon Systems Company, Sensors and Electronic Systems, McKinney, Texas.

VERIFIED



AN-ASQ-208 digital MAD system

Helium magnetometer

Type
Magnetic anomaly detectors.

Description
Currently under development these laser-pumped helium magnetometers are designed for the detection of small submarines in shallow water, being deployed from fixed wing, helicopters, and UAVs.

The low-noise sensor can be packaged into a buoy and is designed to detect ELF emissions and static dipole magnetic signatures. The manufacturers claim that this technology can offer 10 times the detection performance of conventional resonance magnetometers as well as being less expensive.

Operational status
Under development under a US Naval Air Warfare Center Aircraft Division contract.

Contractor
Polatomic.

VERIFIED

Stationary Helium-3 ASW magnetometer

Type
Magnetic anomaly detection system.

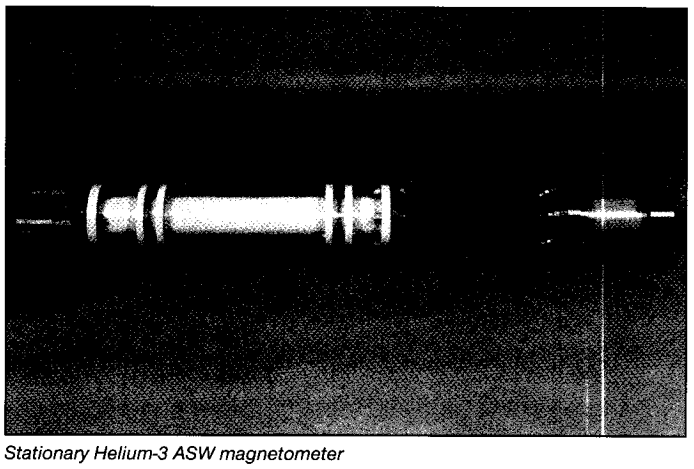
Description
The He^3 magnetic anomaly detection system was developed to have characteristics ideal for missions in which the sensor is stationary and the target is moving, such as MAD buoys, arctic ASW arrays, underwater arrays for shallow water or coastal surveillance and sensors for advanced mines. It derives its signal from the free precession of He^3 nuclei, polarised by an optical pumping process, and is therefore an absolute measure of magnetic field. This provides the stability required to detect the extremely low-frequency (1 to 50 mHz) signals generated at typical target speeds.

The 100 MW sensor has 1 $pT/\sqrt{H_3}$ sensitivity in the 1 to 10 MHz passband. Array processing techniques have achieved 80 dB background noise suppression in undersea and Arctic array tests. Each sensor unit consists of two subassemblies, the basic sensor, and the associated electronics package. The sensor is a 4 in diameter cylinder, 10 in long and the electronics telemetry package is a cylinder 5 in in diameter and 25 in long. The total weight of a sensor and the electronics package, with batteries installed, is 10 kg.

Operational status
The system has been used in sea tests at depths over 600 ft and on the Arctic ice cap to record the passage of submarines and surface vessels.

Contractor
Raytheon Systems Company, Sensors and Electronic Systems, McKinney, Texas.

VERIFIED



Stationary Helium-3 ASW magnetometer

UNDERWATER WEAPONS

Strategic and cruise missiles

Guided ASW/ASUW weapons

Torpedoes

Mines

ASW rockets and depth charges

STRATEGIC AND CRUISE MISSILES

Introduction

Although the overall numbers of Russian Federation and Associated States (CIS) and American strategic missiles are being reduced, the diversity and deployment of such weapons throughout the world is on the increase. The one category of system which remains static is the submarine-launched ballistic missile, with the RFAS, the United States, France, the United Kingdom and China currently being the only operators of such systems. Both the RFAS and the United States have unilaterally agreed to withdraw submarine-launched tactical nuclear cruise missiles and to scale down the numbers of operational strategic nuclear weapons.

While the RFAS and the United States have agreed to reduce their inventories of such weapons, France and the United Kingdom do not appear to be willing to reduce their stocks, and China is actively increasing its stock, albeit at a very slow rate. However, all three countries possess very few numbers of such weapons when compared to those held by the RFAS and the United States.

Of increasing concern is the developing capability among smaller nations to develop nuclear weapons. Although there does not seem to be any likelihood of either India or Pakistan deploying submarine-launched ballistic missiles in the very near future, this must, in the long term, remain a distinct possibility. India, especially, is devoting resources to develop nuclear weapons, probably including submarine-launched weapons and is said to have an SLBM.

Of greater concern must be the possibility that ballistic missiles might be armed with biological or chemical weapons, a much easier and in some ways more deadly threat to develop and deploy.

Another use for ballistic missiles, which is currently being studied in the United Kingdom, for instance, is the possibility of deploying conventional high-explosive warheads as an alternative to NBC warheads.

While the current situation concerning the SLBMs could be regarded as fairly static, the same cannot be said for cruise missiles. Current inventories are increasing and more sophisticated versions of existing systems are either under development or just entering service. In addition, a number of the world's smaller navies, now acquiring the latest generation of submarine, are seeking to acquire cruise missiles for deployment from their boats, either through purchases from abroad or through indigenous development.

VERIFIED

TABLE XIII

Submarine-launched strategic and cruise missiles

Weapon	Type	Country origin	Launch weight	No of RVs	Warhead/Payload	Range
Alfa	Cruise	RFAS	1,200 kg	–	300 kg	150 n miles
UGM-109 Tomahawk	Cruise	USA	1,452 kg	–	454 kg	250-1,400 n miles
JL-1	IRBM	China	14,700 kg	1	250 kT	1,160 n miles
JL-2	ICBM	China	52,000 kg	1	1,050 to 2,800 kg	4,300 n miles
M-4	IRBM	France	35,000 kg	6	100 kT ea	2,000 n miles
M-45	IRBM	France	35,000 kg	6	100 kT ea	3,500 n miles
M-51	ICBM	France	50,000 kg	6	100 kT ea	5,400 n miles
SS-N-8 Sawfly (Mod 2)	ICBM	RFAS	33,300 kg	1	800 kT	4,900 n miles
SS-N-18 Stingray	ICBM	RFAS	35,300 kg	3	500 kT ea	3,500 n miles
SS-N-19 Shipwreck	Cruise	RFAS	6,980 kg	–	500 kT	300 n miles
SS-N-20 Sturgeon	ICBM	RFAS	87,600 kg	10	200 kT ea	4,500 n miles
SS-N-21 Sampson	Cruise	RFAS	1,700 kg	1	200 kT	1,300 n miles
SS-N-23 Skiff	ICBM	RFAS	40,300 kg	4	100 kT ea	4,500 n miles
SS-NX-26	Cruise	RFAS	3,000 kg	1	250 kg SAP	160 n miles
SS-NX-27	Cruise	RFAS	1,920 kg	-	200 kg	120 n miles
Sagarika	Cruise	India	n/k	n/k	n/k	160 n miles
UGM-96 Trident C-4	ICBM	USA	32,850 kg	6	100 kT ea	4,000 n miles
UGM-133 Trident D-5	ICBM	USA	59,090 kg	1 to 8	100 or 475 Kt	6,500 n miles

VERIFIED

China

CSS-N-3 (JL-1)

Type
Intermediate-range, submarine-launched ballistic missile.

Development
Development of China's first submarine-launched ballistic missile, the Julang-1 (Giant Wave-1, JL-1), began in 1967. Designed for deployment from the Xia class submarine, the JL-1 is thought to embody some technology from the CSS-2 missile. Difficulties experienced in mastering the technologies associated with solid propellant fuels, together with delays in the nuclear warhead and submarine programmes, resulted in an extended development time for the missile. Initial test firings were carried out in 1982, reportedly from a submarine pontoon, and subsequently from a modified Golf class submarine. The first launch took place on 30 April 1982 and the second from the 'Golf' submarine on 12 October 1982.

The basic missile is currently being used as a test vehicle for the follow-on JL-2 missile.

Description
The missile is a two-stage, solid-propellant, ballistic missile employing inertial guidance. The first stage is ignited after the missile has emerged from the water. The warhead separates from the second stage when the motor burns out.

Operational status
The missile became operational in 1983 and featured in the October 1984 parade in Beijing. The missile is deployed in the Xia class submarine which has 12 missile launch tubes. A successful submerged launch of the missile from the *Xia* was accomplished on 27 September 1988. Sources indicate that 15 to 20 missiles remain in service.

Specifications
Length: 10.70 m
Diameter: 1.40 m
Launch weight: 14,700 kg
Warhead: 600 kg
Charge: 1 × 250 kT nuclear
Range: 1,160 n miles
Accuracy: c 700 m CEP

Contractor
Not known.

VERIFIED



The CSS-N-3 submarine-launched missile

CSS-NX-5 (JL-2)

Type
Intercontinental, submarine-launched ballistic missile.

Development
This missile, believed to have the Chinese designation Julang-2 (Giant Wave-2), is a second-generation missile with a longer range than the JL-1. Development began around 1970. A new submarine class designated Type 094 is under development to deploy the JL-2. Four boats are to be built, each carrying 16 missiles.

Description
JL-2 is a three-stage solid-propellant missile which may carry some form of accurate delivery system within a 700 kg payload. The payload weight would seem to indicate a single warhead, probably with a 1 MT yield. However, nuclear tests in 1994-95 could indicate the capability to deploy a 3/8 MIRV type warhead with selectable yields of 20, 90 or 150 kT and decoys and penetration aids. A range of 4,300 n miles has been reported. The warhead will separate from the third stage after motor burnout. Guidance may incorporate a stellar inertial tracking system or GPS.

Operational status
The first underwater launch was reported in 1985. A new class of submarine, Type 094, is under design and will deploy 16 or 18 of the new missile vertically stored. Anticipated date of entry into service is around 2005. Some reports indicate that the refitted submarine *Xia* may deploy the CSS-NX-5 missile.

Specifications
Length: 13 m
Diameter: 2 m
Launch weight: 52,000 kg
Warhead: 1,050/2,800 kg
Charge: 1 × 1 MT nuclear or 3/8 MIRV
Range: 4,300 n miles
Accuracy: 300 m CEP

Contractor
China Aerospace Industry Corporation, Beijing.

UPDATED

France

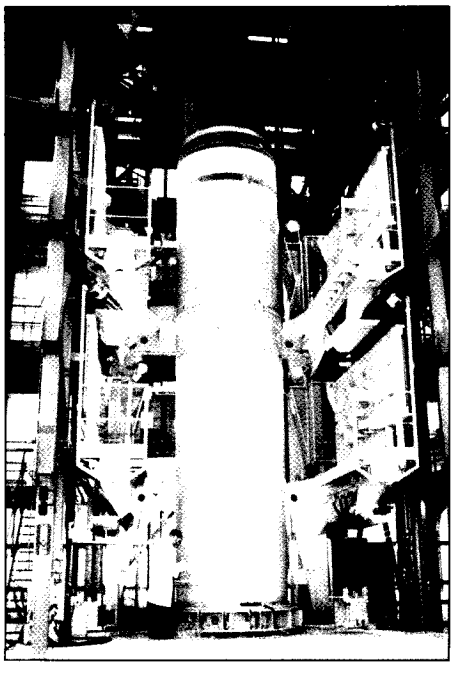
M-4

Type
Intermediate-range, submarine-launched ballistic missile.

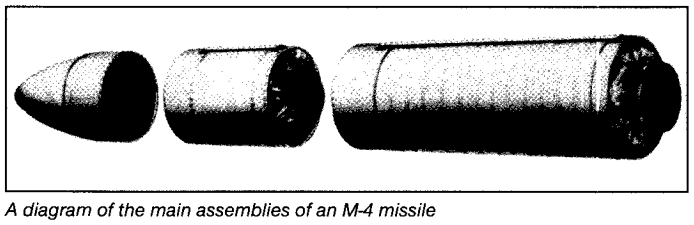
Development
Developed in the 1970s, the M-4 is the fourth in the MSBS (Mer-Sol-Balistique-Stratégique) family of submarine-launched missile systems and is similar in form to the US Polaris and Poseidon systems. Initial development work for the M-4 was carried out using the submarine *Le Gymnote,* using twin tubes for the tests. The first test launch took place in November 1980 from the Landes land-test range and the final test firing from the submarine was conducted on 24 February 1984. The first operational launch, from *Le Tonnant*, was carried out on 15 September 1987.

The M-4 was developed to carry multiple re-entry vehicles, and two versions are reported, the M-4A with a range of 4,000 km and the M-4B with a range of 5,000 km. An improved version, the M-45, has been developed with a range of 6,000 km.

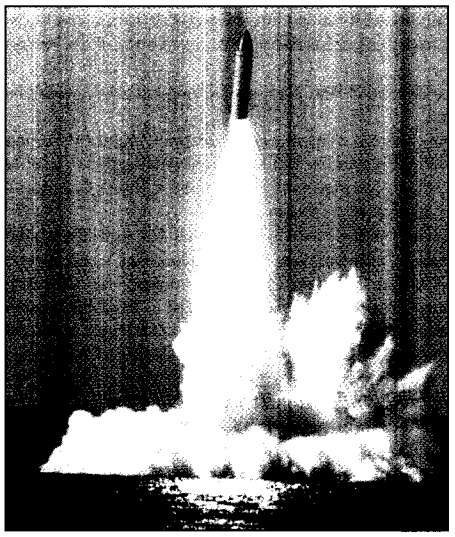
Description
The M-4 missile is a three-stage, intermediate-range missile using inertial guidance. The first stage burns for 62 seconds, the second for 71 seconds and the third for 43 seconds. The three-stage solid-propellant motors contain 20,000 kg, 8,015 kg and 1,500 kg of propellant respectively. Each motor has a single flexible nozzle for control. The missile carries six thermonuclear MRV (Multiple Re-entry Vehicles) which are believed to have some independent targeting capability. This implies that there is some additional guidance system incorporated within the delivery system.



M-4 missile
(EADS SPACE Transportation)
0113529



A diagram of the main assemblies of an M-4 missile



M-4 missile broaching the surface after launch
(EADS SPACE Transportation)
0113530

The TN-71 warheads have a yield of 150 kT and each re-entry vehicle is believed to weigh about 250 kg. This would suggest a total payload capability of approximately 1,700 kg. An estimated accuracy of the M-4 missile system is 500 m CEP.

The M45 carries a new TN 75 warhead with improved stealth and penetration aides. Control is exercised through a single flexible nozzle in each stage.

Operational status

The M-4 entered service in 1986 and is now only operational aboard the *L'Indomptable* – which is fitted with 16 missile launch tubes. It is believed that there are 96 M-4B missiles in service of which 16 are operational.

Test firings to qualify the M45 variant were successfully conducted by the new SSBN *Le Triomphant* in February 1995. The missile is now operational aboard the submarines *Téméraire*, *Le Triomphant* and *L'Inflexible*. A successful test firing of an M 45 missile was conducted by *L'Inflexible* on 18 April 2001. Currently 48 missiles are operational and reports indicate that a total of 192 missiles may be acquired.

Specifications

Length: 11.05 m
Diameter: 1.93 m
Launch weight: 35,000 kg
Payload: 6 re-entry vehicles in MRV configuration
Warhead: 150 kT per vehicle (TN 75 in M45)
Range: 2,000 n miles (M-4A), 2,700 n miles (M-4B), 3,200 n miles (M-45)
Accuracy: 500 m CEP

Contractor

EADS SPACE Transportation, Les Mureaux (prime contractor).

UPDATED

M-51

Type

Intercontinental-range submarine-launched ballistic missile.

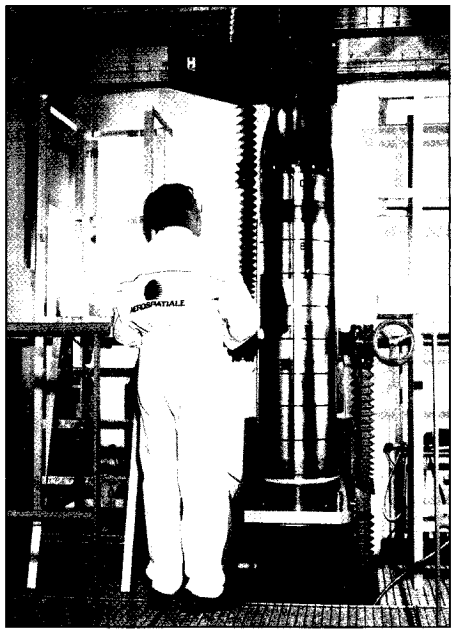
Development

Under development since 1992, the M-51 is the latest of the MSBS family and is planned to become operational in the SNLE-NG boats in 2008. Full-scale development of the M5 began in December 1992. In February 1996, the President of France confirmed the programme would continue with some changes in specifications to conform with budgetary constraints (a decrease of 20 per cent in funding). The missile was renamed M-51, but retains the essential characteristics laid down for the M-5.

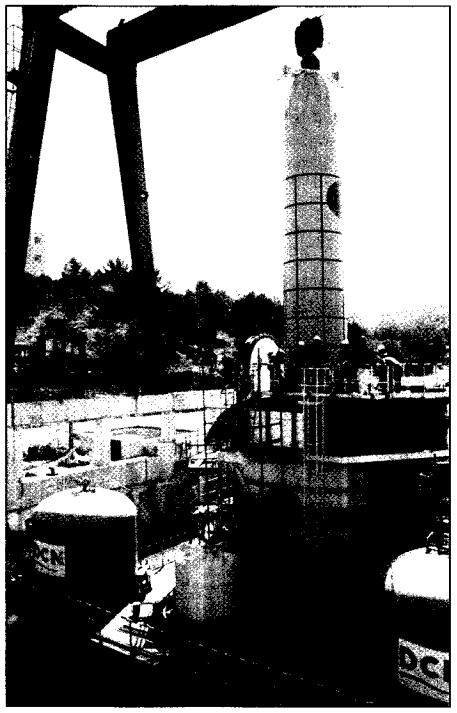
Description

The three-stage solid-propellant M-51 missile is equipped with modern penetration aides capable of matching the perceived upgrades to the Russian anti-ballistic missile system. Guidance is by inertial system. The solid-propellant Butalane-stages are equipped with flexible nozzles made by filament winding of carbon fibre/epoxy material. To improve the flexibility in deploying the MIRVs a liquid-propelled post-boost stage is under development. The volume and weight available for payloads is significantly greater than for the M-4. Range is also much greater than the M-4.

The payload has been reported as being up to six MIRV armed with the TN 75 nuclear warhead with an expected yield of 100 kT. However, a funding dispute in 2000 may have resulted in the number of warheads being reduced to four with a reduction in range. The initial version of the M-51 will become operational in 2010.



A mock-up of the M-51 being prepared for testing from a submerged submarine launch tube by the DGA
(EADS Space Transportation)
0089207



MSBS M-51 – Jonas Mockup in CETACE test system
(EADS Space and Transportation)
NEW/1097468

The second variant will be armed with a new warhead (TN 0) and enter service in 2015.

Operational status

The missile is planned to enter service in 2010 aboard *Le Terrible* as a replacement for the M-4 and M-45 SLBM. *Le Triomphant* will then be modified to deploy the M-51 in place of the M-45 missile they currently deploy, the fourth new-generation SNLE, *Le Temeraire*, will be built directly to the M-51 standard. A total build of 57 missiles is planned.

During November 2001 EADS Launch Vehicles carried out two successful validation tests of major components for the full scale M-51 model. This model will be used for cold launch studies testing the ejection and hydrodynamic effects of underwater launches and the resistance of the afterbody to ejection. It will also check interfaces with the submarine. Components for the M-51 were tested aboard an M-45 missile fired from *L'Inflexible* on 18 April 2001. The first full flight test is planned for 2005.

Specifications

Length: 13.00 m
Diameter: 2.35 m
Launch weight: >50,000 kg
Payload: 6-10 MIRV
Warhead: 150 kT per vehicle
Range: >5,000 n miles

Contractor

EADS SPACE Transportation, Les Mureaux (prime contractor).

UPDATED

India

Sagarika

Type
Submarine-launched land attack cruise missile.

Development
Reports from India have indicated that a submarine-launched cruise missile, Sagarika (Oceanic), is under development by the DRDO with the Aeronautical Defence Establishment at Bangalore, southern India to arm the new nuclear-powered submarine (ATV) that India is developing. Development of the missile began around 1991 and was originally based on the Prithvi I SSM.

It would appear that work on developing the missile in its original form was halted sometime in the mid-1990s, when India initiated plans to purchase Russian SS-NX-27 Club missiles and to jointly develop the PJ-10 Brahmos missile with a Russian company. However, reports indicate that work on the Sagarika resumed around the end of the decade to a highly modified design with range quadrupled to around 646 n miles. The upgraded design has been reported as being based on the Russian Club missile.

The Sagarika is also reported as being based on the joint Russo-Indian PJ-10 anti-ship/land attack missile under development by BrahMos (Brahmaputra-Moscow) Pvt, which uses an airframe and engine manufactured by Machinostroyeniye of Russia.

Description
The missile is said to be powered by a turbojet engine with high subsonic speed and may have a nuclear capability. Sagarika is reported to have a dual high/low altitude (100/15 m) cruise trajectory using UAV data to update its flight trajectory. High altitude range at cruise speed is reported to be 160 n miles. The guidance system is based on INS and GPS and includes terrain contour matching.

Sagarika will be trialled from the P78 underwater missile launcher.

Operational status
In service date is indicated from reports as being around 2005.

Specifications
(Estimated and based on reported figures for PJ-10)

Length: 8.1 m
Diameter: 0.67 m
Weight: 3,000 kg
Warhead: c 200 - 250 kg
Range: 1,000 km

Contractor
Defence Research and Development Laboratories, Hyderabad.

UPDATED

International

PJ-10

Type
Medium range anti-ship missile.

Development
In February 1998, BrahMos, a joint venture between NPO Mashinostroenia and DRDO of India in co-operation with Bharat Electronics, was formed to carry out development of the Yakhont missile for the Indian forces.

The agreement was signed in July 1999 and development of the PJ-10 missile began in August 2001, focussing on a universal launcher-container for surface ships, submarines and even aircraft.

Description
The PJ-10 missile is very similar to the SS-NX-26 (see separate entry SS-NX-26) with the nose having a circular air inlet for the ramjet motor, with a terminal seeker inside the intake bullet. However, the PJ-10 version differs from the SS-NX-26 in that it has an additional nose mounted turnover assembly, located in the ramjet air inlet. This is used to turn the missile onto the required azimuth trajectory following a vertical launch.

Externally the missile consists of a slim cylinder that tapers at the front to a circular air inlet for the ramjet motor. The missile body is fitted with four fixed clipped-tip delta wings aft of the mid-body, and four moving delta control fins at the rear for flight control, all in cruciform arrangement. The wings and fins are folded when the missile is in its launcher container. The missile canister is installed in a slant (15°) TPK (transportno-puskoviy konteiner), or vertical-launcher for submarine launch, as it is clearly too large for installation in a torpedo tube. This pressurised canister is 9.0 m long, has a diameter of 0.71 m and weighs 900 kg when empty. The missile is cold launched from the canister using a gas cartridge, which is ignited to eject the missile up to around 25 m altitude. The turnover assembly has small rocket thrusters, and is jettisoned after use. An integral solid propellant boost motor ignites after turnover, and after accelerating the missile the main ramjet motor takes over.

It is possible that submarine-launched, and perhaps surface-launched, versions will have a protective nose cap.

Although internal design can only be conjectured, it probably conforms to the normal arrangement of a terminal phase Granit dual-channel active-passive radar seeker (range 40 n miles in the passive mode and 13 n miles in the active mode) and its planar antenna in the radome within the air intake.

Behind this is the warhead, which in the PJ-10 is the smaller 200 kg HE warhead developed for the air-launched missile version. There have been unconfirmed reports from India that PJ-10 will be modified to carry a nuclear warhead. The Siberian Devices and Systems Production Association ShYu 80-066B Inertial Navigation System (INS) fitted for the cruise or mid-course guidance phase, a digital computer, radar altimeter and batteries are sited in the middle of the missile together with the actuation system, which is probably electric.

At the rear is the propulsion section consisting of a kerosene fuel tank and a 200 kg Plamya ramjet, with an integral solid-propellant boost motor located in the ramjet nozzle section for launching. The ramjet motor has a maximum thrust at sea level of 4,000 kg.

The onboard command subsystem is probably configured to receive target data from off-board as well as on-board sensors. It is expected that India will use Kamov Ka-31 helicopters for target location, passing back target data to the launch ship to pre-program the missile's on-board command system. The missile's electronics have been developed by Bharat Electronics of India.

From a cold start, it will take four minutes to be activated, accept data, select missile or missiles and to program the INS. The missile has two operating modes: a long range hi-lo; or shorter-range lo-lo. On vertical ejection from the TPK the missile rises to an altitude of around 25 to 30 m above sea level where the turnover system is activated. The turnover system comprises a series of small rocket thrusters and a computer-based command unit located in a barrel shaped unit covering the air intake. The thrusters are fired to turn the missile to the correct azimuth and bring it to the optimal angle for the main propulsion system to be activated. At this point the turnover system is jettisoned to uncover the air intake. The integral solid-propellant rocket booster is then ignited to increase speed to the point at which the main ramjet engine can be started up.

The seeker requires two minutes to warm up and reportedly initially enters passive mode to make a stealthy approach to the target, although Russian reports indicate the seeker acquires the target at long range, locks on, passes the details to the inertial guidance system and switches off. The antenna covers ±45° and can detect targets at a range of at least 27 n miles, with cruiser-sized ships detectable at ranges of up to 40.5 n miles in conditions up to Sea State 7. For the terminal phase, which might be up to 21 n miles range, the missile descends to an altitude of 5 to 15 m to avoid detection and carries out pre-programmed evasive manoeuvres near to the target to overcome any ship's defences. According to Russian sources, at around 10 n miles from the target the radar is switched on to confirm the target's location. The missile can select an individual ship target from a group, even in a jamming environment.

A land attack version with INS/GPS guidance may possibly be developed later.

It is conceivable that the PJ-10 is the missile referred to as Sagarika (see entry on Sagarika).

Operational status
The joint Russian/Indian PJ-10 version was first flight tested at Orissa in India on 12 June 2001, and production was planned to start in 2003. Reports indicate that the PJ-10 will enter service with the Indian Navy in 2004. According to reports from Russia the missile might also be offered for export for equipping Kilo class submarines. It is possible that the missile may equip the nuclear submarines that India is negotiating to loan from Russia.

Specifications
Length: 8.9 m
Body diameter: 0.67 m
Launch weight: 3,900 kg
Warhead: 200 kg HE SAP
Range: 160 n miles

Contractors
NPO Strela, Orenburg (Russia).
NPO Mashinostroenia, Reutov, Moscow (Russia).

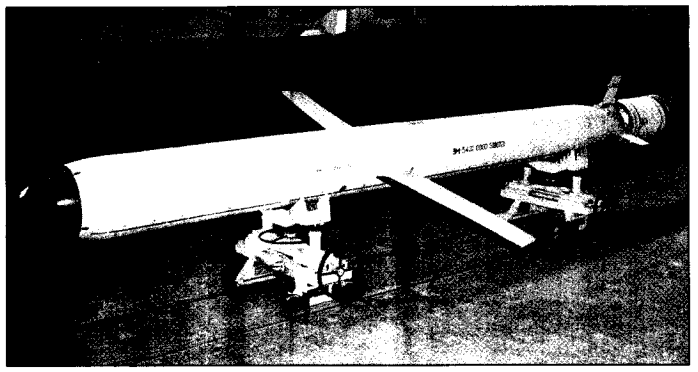
UPDATED

Russian Federation

3M-54E Klub S (SS-N-27)

Type
Submarine-launched anti-ship cruise missile.

Description
The 3M-54E Klub S submarine-launched anti-ship cruise missile forms part of the Klub family of anti-ship cruise missiles. The missile exhibits close design similarities to the 3M-10 Granat missile (SS-N-21 Sampson).



The 3M-54E1 anti-ship missile (Novator Design Bureau) 0048879

The 3M-54E is a three-stage missile with the first stage being an initial solid-propellant boost motor that separates from the rest of missile after broaching the surface and reaching an altitude of about 150 m. The scooped air intake of the second stage turbofan sustainer motor is then extended under the fuselage for the cruise phase powering the missile at a subsonic speed of between 0.6 to 0.8 Mach. Simultaneously two straight-chord rectangular wings and four small moving tail control surfaces are extended and the missile descends to its cruise altitude of about 10 to 15 m on a trajectory controlled by mid-course inertial guidance.

At about 30 to 40 km (12 miles) from its target the missile performs a pop-up manoeuvre and the ARGS-54 active radar homing seeker is activated. The radar has a maximum operational range of 60 km. During this manoeuvre the seeker sweeps a 90° sector across its bearing with a –20 to +10° elevation. After seeker lock-on the third stage rocket motor separates and ignites, four flip-out control fins are extended. The warhead and active radar seeker are now boosted to a speed of Mach 3 on a zigzag trajectory through the terminal phase at an altitude of about 3 to 5 m.

The missile is fired from a standard 533 mm torpedo tube with the submarine submerged.

Operational status

Being supplied as part of the standard weapons fit of the latest version Kilo class 977EKM of the Indian Navy which carry four missiles each. Final launch trials of the missile were conducted in the Baltic in June 2000. Earlier variants of the Kilo in service with the Indian Navy are gradually being refitted in Russia where they are being modified to accept the Klub S missile. The missile will also arm India's ATV (Advanced Technology Vehicle) submarine. A total of 84 missiles have been sold to India, but not all are for deployment from the Kilo class.

It is reported that the 3M-54E1 has been offered to China.

Specifications

Length: 8.22 m
Diameter: 533 mm
Span: 2.1 m
Weight: 2,300 kg (with booster)
Warhead: 200 kg
Speed: M0.6-0.8 (cruise); M3 (terminal phase)
Altitude: 3-5 m (terminal phase)
Range: 120 n miles

Contractor

Novator Experimental Machine-Design Bureau, Ekaterinburg.

UPDATED

RK-55 Granat/3M10 (SS-N-21 Sampson)

Type

Submarine-launched land-attack cruise missile.

Development

Development began around 1975 and it is believed that the SS-N-21 was first test flown in 1982 and was operational by 1985.

Description

Very little is known about the SS-N-21, but it is assumed that it is similar to the SSC-X-4 ground-launched cruise missile which was destroyed under the 1987 INF Treaty. Details of the latter were disclosed at the time of the exchange of data in connection with the INF Treaty.

Inertial guidance is used during the cruise phase of the trajectory, with some form of terrain matching for updates and terminal guidance. The missile has a radar altimeter and flies at around 200 m altitude. The missile is launched from a standard 533 mm torpedo tube and the wings unfold on leaving the water.

It is reported that the missile uses a tandem rear-mounted, expendable, solid-propellant booster to achieve cruise speed, while cruise speed is maintained by a turbofan engine whose air inlet is mounted underneath the after body of the missile being lowered into the airstream as the missile leaves the water.



An artist's impression of the SS-N-21 'Sampson' submarine-launched cruise missile

Operational status

The missile is believed to have become operational around 1984/5 and is deployed from the five Victor III, eight Akula and one Sierra II class SSNs and one Yankee Notch converted SSBN (from six additional 533 mm torpedo tubes with 35 missiles). In 1992, as part of the START 2 agreement, the RFAS indicated that the SS-N-21 would be removed from service and production terminated. However, extensive use of cruise missiles in the Gulf in 1991 may have caused the Russians to rework the missile to deploy a 410 kg conventional HE warhead.

Specifications

(approx)
Length: 8.09 m
Diameter: 0.51 m
Wing span: 3.3 m
Launch weight: 1,700 kg
Payload: single warhead
Warhead: 410 kg HE or submunition warhead
Range: 150 n miles
Accuracy: 150 m CEP
Speed: M0.7

Contractor

Novator NPO, Ekaterinburgor
or Raduga NPO

UPDATED

SS-N-8 Sawfly (RSM-40 Vyosta)

Type

Intercontinental, submarine-launched, ballistic missile.

Development

Development of the SS-N-8 began in 1961 and was considered to be a new generation because it was the first Russian SLBM to use stellar sensing techniques to enhance its accuracy. In addition, its increased length required a new submarine design for deployment.

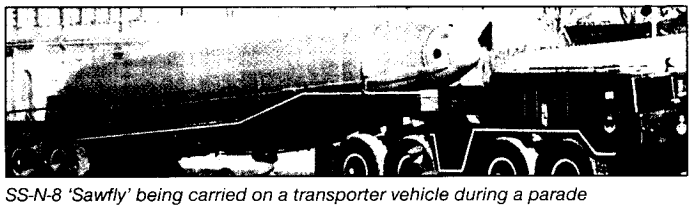
Description

The two-stage SS-N-8 liquid-propelled intercontinental missile has been developed in two versions, the first carrying a single 1 MT nuclear warhead and the Mod 2 carrying an 800 kT nuclear warhead.

The use of stellar inertial guidance greatly improved the accuracy over the previous generation of missiles. The missile uses unsymmetrical dimethyl hydrazine and nitrogen tetroxide liquids with a maximum first-stage burn time of 150 seconds and a second-stage burn time of 80 seconds.

Operational status

The SS-N-8 became operational in 1973 and the last remaining 12 missiles are deployed aboard the last remaining 'Delta I' SSBN, fitted with 12 missile launch



SS-N-8 'Sawfly' being carried on a transporter vehicle during a parade

tubes. To comply with the START 1 and START 2 agreements the RFAS has decommissioned the SS-N-8 and all Mod 2 missiles. The status of these decommissioned missiles is unknown. They were out of service by the end of 1999.

Specifications
Length: 13.9 m
Diameter: 1.80 m
Launch weight: 33,300 kg
Payload: single warhead
Warhead: Mod 1 - 1 MT nuclear; Mod 2 - 1 × 800 kT nuclear
Range: Mod 1 - 4,200 n miles; Mod 2 - 4,900 n miles
Accuracy: Mod 1 - 1,500 m CEP, Mod 2 - 900 m CEP

Contractor
Makeyev Design Bureau (design).

UPDATED

SS-N-18 Stingray (RSM-50 Volna)

Type
Intercontinental submarine-launched ballistic missile.

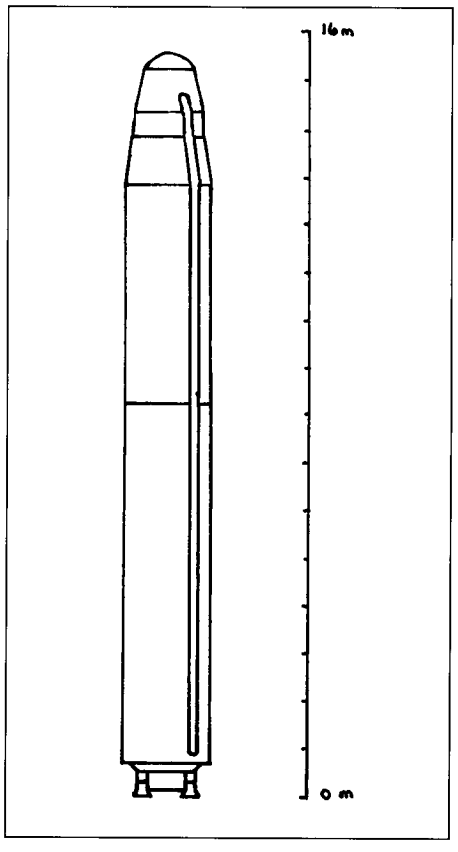
Development
Development of the SS-N-18 began in 1968 and was first tested from land-based launch sites in 1975 and from a submarine in November 1976. Long-range tests were carried out in the Pacific in late 1978.

The missile has many similarities with the SS-N-8, from which it may be derived; it does, however, have a more sophisticated guidance system and a MIRV warhead dispensing system.

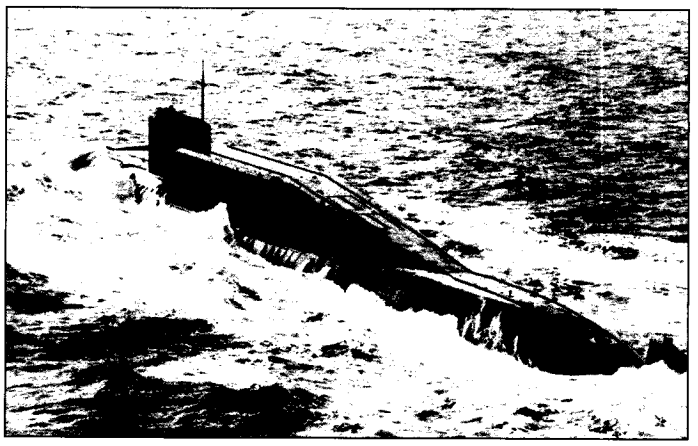
Description
The SS-N-18 is a two-stage, liquid-propellant, intercontinental ballistic missile fitted with a Post Boost Vehicle (PBV). Range is 6,500 km for the MIRV variants and 8,000 km for the single RV version. The Mod 1 carries a payload of three RVs in MIRV configuration, the Mod 2 a single RV and the Mod 3 up to seven RVs again in an MIRV configuration. The provisional START agreement allocated seven RVs to the SS-N-18, but in 1991, the Russians announced that they would download all missiles to three RVs in MIRV configuration.

The accuracy of the MIRV versions is around 900 m, indicating continuing use of the stellar inertial guidance system used in the SS-N-8.

Operational status
The SS-N-18 Mod 1 entered service in 1977, the Mod 2 in 1978 and the Mod 3 in 1979. The missile is deployed aboard seven Delta III class SSBNs, each fitted with 16 launch tubes. All missiles were downgraded to the Mod 1 version in the early 1990s. The number of missiles now thought to remain in the inventory is estimated at 70. Only Mod 1 version remains in service. Units of the 'Delta III' type are starting to decommission.



A diagram of the SS-N-18 missile



A Delta III class submarine, which carries 16 SS-N-18 'Stingray' missiles

Specifications
Length: 14.60 m
Diameter: 1.80 m
Launch weight: 35,300 kg
Payload: Mod 1 - 3 RVs in MIRV configuration; Mod 2 - single RV; Mod 3 - 7 RVs in MIRV configuration
Warhead: Mod 1 - 3 × 500 kT nuclear; Mod 2 - single 450 kT nuclear; Mod 3 - 7 × 100 kT nuclear
Range: Mods 1/3 - 3,500 n miles; Mod 2 - 4,300 n miles
Accuracy: 900 m CEP

Contractor
Makeyev Design Bureau.

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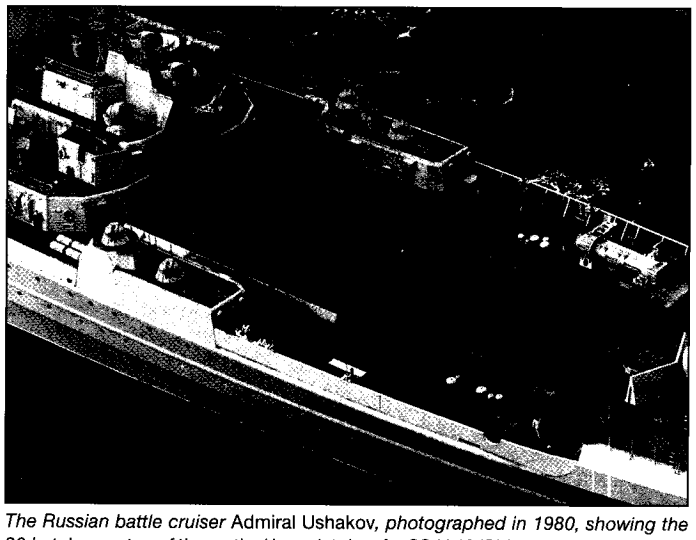
SS-N-19 Shipwreck (P-500 Granit)

Type
Submarine-launched anti-ship cruise missile.

Development
The SS-N-19 is the third-generation cruise missile and follows on the SS-N-3 Shaddock and SS-N-12 Sandbox missiles. It was developed in the early 1970s and was Russia's first vertically-launched ship- or submarine-deployed cruise missile.

Description
Very little detail is available concerning the missile, but it is believed to be similar, but much smaller than, the SS-N-12 with a lower flight profile. Mid-course guidance is inertial, with command update provided by aircraft or helicopter mounted Front Door C radar, or from satellite downlink from the launch platform. Terminal homing is provided by an active S/X-band radar system with an IR option as an interchangeable terminal seeker.

Vertical launch thrust is provided by a tandem solid-propellant boost motor, which is probably jettisoned after use, after which a turbojet engine with nose mounted air intake takes over to provide power for the cruise phase of the trajectory. Missile flight attitude is controlled by two mid-fuselage mounted delta wings which extend as the missile emerges from the water, and tail and fin surfaces at the rear of the fuselage. The missile is reported to have a high-altitude cruise phase of around 24,000 m, which is followed by a steep dive on to the target. The



The Russian battle cruiser Admiral Ushakov, *photographed in 1980, showing the 20 hatches on top of the vertical launch tubes for SS-N-19 'Shipwreck' missiles, with the smaller 12 hatches on the right of the picture for the SA-N-6 'Grumble'*

missile can also cruise at low altitude (approximately 10 m) which reduces the range to around 108 n miles. The payload is either nuclear or conventional HE. It is also believed that Russia could have developed a fuel-air explosive warhead, which is thought to be particularly effective against ship targets.

The launch tubes in Oscar class submarines are inclined at 40° and mounted in six sets of pairs on either beam outside the pressure hull, each pair of tubes being sealed with a single hatch.

Operational status

The SS-N-19 is thought to have entered service in 1983, and is currently operational on board the seven Oscar II class attack submarines equipped with 24 launch tubes.

It is estimated that a total of around 300 missiles will remain in service, possibly until around 2010, although they may be given a life extension upgrade and remain in service until 2020. There have also been reports that some SS-N-19 missiles are operational in the Ukraine.

Specifications

(approx)
Length: 10.00 m
Diameter: 0.85 m
Launch weight: 6,980 kg
Payload: Single warhead
Warhead: 500 kT nuclear or 750 kg conventional HE
Range: 300 n miles
Speed: M2.5

Contractor

KBM, Kolomna.

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SS-N-20 Sturgeon (RSM-52)

Type

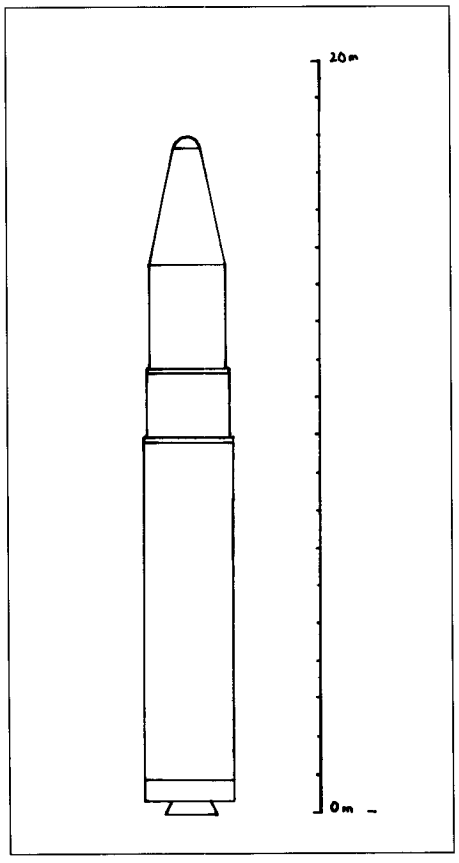
Intercontinental, submarine-launched ballistic missile.

Development

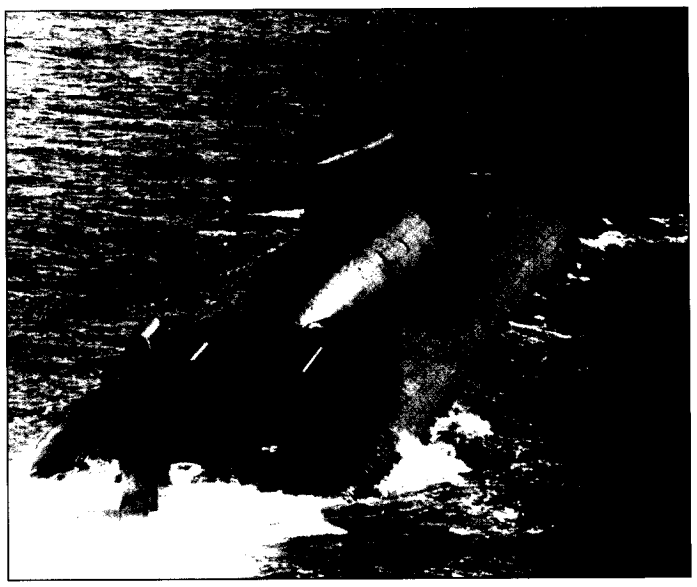
Development of the three-stage solid-propellant SS-N-20 began in 1972, the first test flight taking place in January 1980. Following a long run of failures, successful tests were finally conducted in 1981 and, in October 1982, a simultaneous launch of four missiles was reported.

Description

The SS-N-20 three-stage solid-propellant ballistic missile carries 10 re-entry vehicles in an MIRV configuration. US reports suggest that an early version only carried six vehicles, but this was not confirmed in START 1 information supplied by the RFAS in 1991. The first stage is 9.5 m long and houses a single 3D65 solid



A diagram of the SS-N-20 missile



A Typhoon class submarine, platform for the SS-N-20 'Sturgeon'

propellant motor. The third stage motor is carried inside the post-boost bus that carries the re-entry vehicles. Guidance is inertial with stellar reference update. Two missiles can be launched within 15 seconds.

Operational status

The SS-N-20 entered service in 1983 and is currently deployed in the three operational Typhoon class submarines, each of which is fitted with 20 launch tubes located forward of the boat's sail. This is the first SSBN to carry its ballistic missiles in such a configuration. It is reported that the RFAS was proposing to download SS-N-20 missiles to six or four RVs under the START 2 agreements, but this may not be undertaken as the Typhoon class is being decommissioned, and with it presumably also the missiles.

A total of about 60 missiles remain operational or in storage.

As the Typhoon class boats are being decommissioned it is probable that the SS-N-20 will be withdrawn from service. Only three 'Typhoon' boats remain in service.

Specifications

Length: 16.10 m
Diameter: 1st stage - 2.40 m; 2nd stage - 2.30 m
Launch weight: 84,000 kg
Payload: 10 RVs in MIRV configuration
Warhead: 10 × 20 kT nuclear
Range: 4,500 n miles
Accuracy: 500 m CEP

Contractor

Makeyev Design Bureau.

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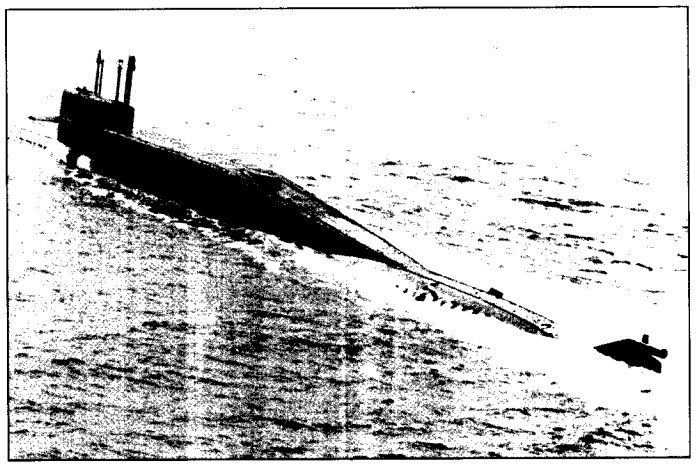
SS-N-23 Skiff (RSM-54 Sineva)

Type

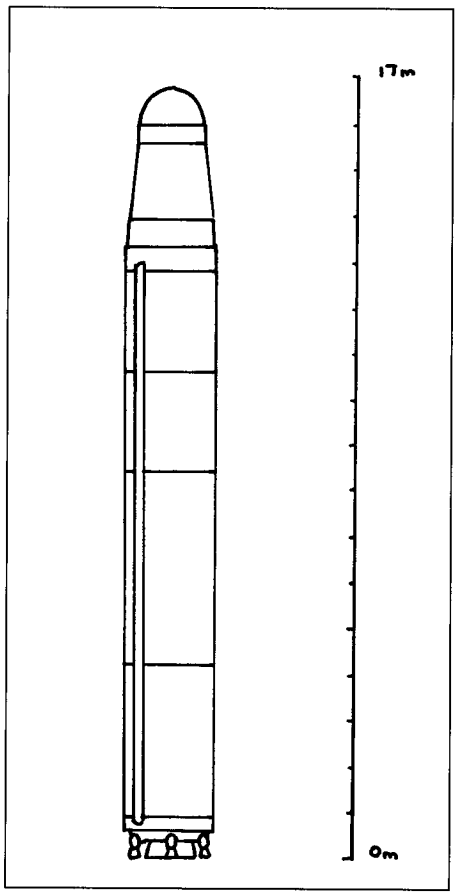
Intercontinental, submarine-launched, ballistic missile.

Development

Development of the SS-N-23, as the successor to the SS-N-18, began in the mid to late 1970s with testing commencing in 1983. Development of this missile indicates



The Delta IV submarine. Platform for the SS-N-23, the newest of the Russian SLBMs



A diagram of the SS-N-23 missile

that the Russian Federation continue to prefer liquid-propelled missiles over solid-fuelled ones, perhaps on the grounds of extensive experience and confidence in their safety. This may be the result of disappointing past experiences with the solid-propelled SS-N-17 and 20.

Description

The three-stage, liquid fuelled SS-N-23 MIRV-capable missile, like the Russian Federation's other ballistic missiles, uses inertial guidance with stellar reference for correcting in-flight trajectory. The missile is Russia's first three-stage liquid-propelled SLBM.

The missile carries between four and 10 warheads in an MIRV configuration, but the START agreement only allocates four RVs and hence it is assumed that the 10 RV version has never been tested.

Operational status

The SS-N-23 entered operational service in 1986 and is deployed aboard the six Delta IV class SSBNs fitted with 16 launch tubes. Manufacture of the SS-N-23 ceased in 1996. Manufacture of the SS-N-23 resumed in 2001 to maintain missile stocks due to the termination of the SS-NX-28 programme.

A total of 95 missiles remain in service with about 30 in reserve.

Specifications

Length: 14.8 m
Diameter: 1st stage – 1.90 m; 2nd stage – 1.85 m
Launch weight: 40,300 kg
Payload: 4 RVs in MIRV configuration
Warhead: 100 kT nuclear each
Range: 4,500 n miles
Accuracy: 500 m CEP

Contractor

Krasnoyarsk Machine Building Plant, Krasmash.
Makeyev State Rocket Centre (Design authority), Miass.

UPDATED

SS-NX-26 Yakhont

Type

Medium-range anti-ship missile.

Development

The original requirement for this missile is somewhat obscure and development has been somewhat protracted and indeterminate.

It appears that protracted development of another missile, SS-N-22 Moskit (Sunburn), led the Chelomei OKB organisation to propose an alternative supersonic missile. The influence of the company was such that it was allowed to begin design work in 1983 with official approval for development finally being given in 1985, but only under low priority, as the SS-N-22 was the favoured design. The aim, it has been said, was to provide a lighter weight, more compact follow-on system to the SS-N-9, SS-N-19 and SS-N-22 surface-to-surface missile systems, although this is disputed by Russian sources. Subsequent development has been further complicated by the collapse of the Soviet Union and limited financial support. As a result, the project has been developed largely as a private venture, by the NPO Mashinostroenia (formerly the Chelomei OKB) for the export market, as the Russian Navy has no requirement for this system.

The family of systems (air, surface ship, submarine launched and coastal defence) was given the designation 3M55 Oniks (Onyx) which has the NATO designation SS-NX-26. The Russians have subsequently changed their designation to Yakhont – Gem.

By March 1997, around 25 ballistic firing trials had been conducted with the 'Nanuchka IV' corvette trials ship *Nakat* being used for guided firing trials. By 1997 it was claimed that 10 such trials had been conducted. In October 1999, it was stated that series production of Yakhont would begin in 2001, although this did not materialise.

Russian sources claim that the Project 670M Skat-M (Charlie II class) nuclear attack submarine *Berkut* was converted to operate Oniks, but it would appear that she was scrapped before underwater trials began.

It appears that a submarine-launched version has been proposed, and an unconfirmed report indicated that the missile had been tested on a Charlie class submarine. The name Yashma (Jaspar) has been associated with this submarine launched variant. This variant may be fitted to Yasen class (Type 885) attack submarines, and could be launched from a new design vertical launch system with eight launchers per boat, and with each boat carrying up to 24 missiles.

In 2002, it was reported that an improved active radar seeker was being developed for greater accuracy.

Description

The SS-NX-26 comprises the 3K55 missile, a launcher-container, and a fire direction sub-system. Externally the missile consists of a slim cylinder that tapers at the front to a circular air inlet for the ramjet motor. The missile body is fitted with four fixed clipped-tip delta wings aft of the mid-body, and four moving delta control fins at the rear for flight control, all in cruciform arrangement. The wings and fins are folded when the missile is in its launcher container (transportno-puskoviy konteiner or TPK). This pressurised canister is 9.0 m long, has a diameter of 0.71 m and weighs 900 kg when empty. This appears to be a 'cold-launch' unit, in which a gas cartridge is ignited to eject the missile. The TPK can be installed in slant (15°) or vertical-launchers for submarine launch, as it is clearly too large for installation in a torpedo tube. It is possible that submarine-launched, and perhaps surface-launched, versions will have a protective nose cap.

Although internal design can only be conjectured, it probably conform to the normal arrangement of a terminal phase Granit dual channel, active-passive radar seeker (range 40 n miles in the passive mode and 13 n miles in the active mode) and its planar antenna in the radome within the air intake.

Behind this is the warhead mounted in the tail of the inlet's central body. The Siberian Devices and Systems Production Association ShYu 80-066B Inertial Navigation System (INS) for the cruise or mid-course guidance phase, a digital computer, radar altimeter and batteries are sited in the middle of the missile together with the actuation system, which will probably be electric.

At the rear is the propulsion section consisting of a kerosene fuel tank and a 200 kg Plamya ramjet, with an integral solid-propellant boost motor located in the ramjet nozzle section for launching. The ramjet motor has a maximum thrust at sea level of 4,000 kg.

The onboard command subsystem is probably configured to receive target data from off-board as well as onboard sensors. From a 'cold' start, it will take four minutes to be activated, accept data, select missile or missiles and to programme the INS. The missile has two operating modes: a long range hi-lo; or shorter-range lo-lo. On ejection from the TPK the booster carries the missile to the cruise altitude. The seeker requires two minutes to warm up and reportedly initially enters passive mode to make a stealthy approach to the target, although Russian reports indicate the seeker acquires the target at long range, locks on, passes the details to the inertial guidance system and switches off. The antenna covers ±45° and can detect targets at a range of at least 27 n miles, with cruiser-sized ships detectable at ranges of up to 40.5 n miles in conditions up to Sea State 7. For the terminal phase, which might be up to 21 n miles range, the missile descends to an altitude of 5 to 15 m to avoid detection and carries out pre-programmed evasive manoeuvres near to the target to overcome any ship's defences. According to Russian sources, at around 10 n miles from the target the radar is switched on to confirm the target's location. The missile can select an individual ship target from a group, even in a jamming environment.

According to unconfirmed reports, Yakhont does not require mid-course guidance data from the launch platform, thus making it suitable for submarine launch.

A land attack version with INS/GPS guidance may possibly be developed later.

Operational status

Several countries were approached for joint development programmes in 1997, and probably included China, India and Iran. An unconfirmed report has suggested that China may buy some SS-NX-26 (Yakhont) missiles to fit to two later 'Sovremenny class destroyers instead of the SS-N-22 'Sunburn'.

The joint Russian/Indian PJ-10 version was first flight tested in India in June 2001, and production was planned to start in 2003 with a joint programme between Russia and India (see entry on PJ-10).

Development of SS-N-26 continues with production scheduled to begin in 2003, and an in-service date of around 2005.

Some sources suggest that the new Russian 'Yasen class nuclear-powered attack submarines will have SS-NX-26 rather than SS-N-27 Alfa.

Specifications
Length: 8.9 m
Diameter: 0.67 m
Span: n/k
Launch weight: 3,000 kg
Warhead: 250 kg HE SAP
Speed: M2.6 (at 15,250 m); M2.0 (at 5 to 15 m)
Range: 160 n miles (at 15,250 m); 65 n miles (at 5 to 15 m)

Contractor
NPO Mashinostroyenia, Reutov.

VERIFIED

SS-NX-30 Bulava

Type
Submarine launched ballistic missile.

Development
In 2001 a new SLBM programme was reported in Russia, possibly with the NATO designator SS-NX-30, but with the Russian name Bulava. This project replaces the cancelled SS-NX-28 solid propellant SLBM, and is being developed jointly between the Makeyev Design Bureau and MIT.

The Bulava is believed to be a three-stage solid propellant SLBM, with a range of 10,000 km. The missile will be fitted to the *Yuri Dolgoruky* ('Borey') Type 955 class submarines, and a converted Type 941 Akula ('Typhoon') submarine is expected to be used for the trials programme.

Contractor
Makeyev Design Bureau, MIT.

VERIFIED

United States

UGM-96 Trident C-4

Type
Intercontinental submarine-launched ballistic missile.

Development
The Trident C-4 missile was designed to succeed the Poseidon system, being lighter and smaller than Poseidon and with improved range capability, which allows SSBNs more ocean in which to manoeuvre.

Two basic fire-control systems are used: the Mk 88 Mod 2 for retrofitting to Poseidon-converted boats and the Mk 98 Mod 0 for the new Ohio class SSBNs. A new digital fire-control computer has also been developed to handle the increased information flow in providing presetting on the larger submarines. A new Mk 4 re-entry vehicle was developed for the C-4 and a Mk 500 Evader, manoeuvre capable (MARV) system was put in development. The C-4 uses the full volume of the Poseidon missile tube and extends the range without penalty in payload.

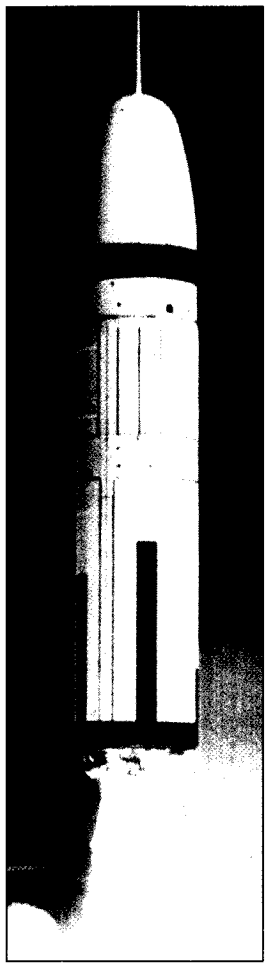
Description
The three-stage solid-propellant C-4 MIRV-capable missile carries eight Mk 4 RVs fitted with W76 nuclear warheads. It features an optional MARV package for ABM penetration, in keeping with its second strike retaliatory role. A feature of note is the use of an extendable spike' which is deployed from the missile's nose after launch to reduce aerodynamic drag during the early phases of flight.

The missile can be launched from either a submerged or surfaced submarine. It is ejected from the launch tube using a gas generator, and once the missile is clear of the surface the first stage ignites. Guidance is inertial with stellar reference update.

The fire-control system for the C-4 on the Ohio class submarine is the Mk 98.

Operational status
The missile entered service in 1979 and was deployed from Benjamin Franklin, La Fayette and Madison class SSBNs each fitted with 16 launch tubes and latterly from the first eight Ohio class fitted with 24 launch tubes. The C-4 missile is being phased out of service and the second four of the first eight Ohio class deploying the C-4 are refitting the D-5 which is to be completed by 2005, while the remaining four are being converted into the SSGN role. Currently two 'Ohio class boats remain in service deploying 48 C-4 missiles which will remain in service until around 2005.

Specifications
Length: 10.39 m
Diameter: 1.88 m
Launch weight: 33,106 kg



The first test launch of a Trident C-4 missile, at Cape Canaveral

Payload: 8 (max) × Mk 4 RVs in MIRV configuration
Warhead: W76 100 kT nuclear each
Range: 4,000 n miles
Accuracy: 450 m CEP

Contractor
Lockheed Martin Space Systems, Missiles & Space Operations, Sunnyvale, California (prime contractor).

UPDATED

UGM-109 Tomahawk

Type
Intermediate-range submarine-launched cruise missile.

Development
Development of surface-launched cruise missiles began in 1972 and the US Navy programme was planned to provide both surface ship and submarine-launched variants for attacking ships and land targets. In the early days it was planned that the weapon would have a nuclear warhead to provide an additional survivable nuclear force. The first underwater test firing was conducted in 1976 and General Dynamics was awarded the development contract.

Originally there were three versions of the ship- and submarine-launched cruise missile:

- the UGM-109A TLAM-N (Tomahawk Land Attack Missile-Nuclear)
- the UGM-109B TASM (Tomahawk Anti-Ship Missile) with a conventional HE warhead
- the UGM-109C TLAM-C (Tomahawk Land Attack Missile-Conventional) with a conventional HE warhead.

A fourth version, UGM-109D, a conventional submunition warhead land-attack missile, TLAM-D, entered service in 1989.

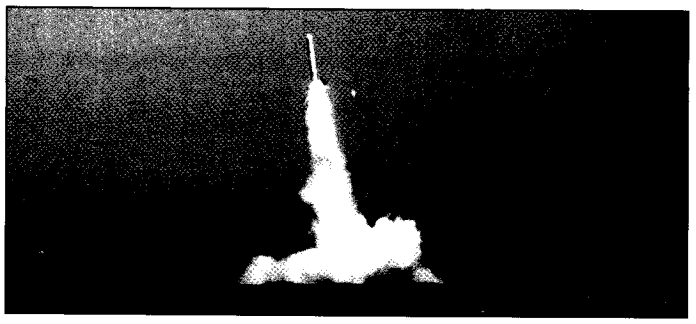
Several developments and improvements are funded for the SLCM programme including:

- laser radar guidance
- ability to select the most important target from a group of ships
- updates to the Digital Scene Matching Area Correlation (DSMAC) terminal guidance system
- time of arrival control
- new warheads
- GPS updates to improve mid-course guidance
- improved performance turbofan engines
- mission planning resource improvements to reduce reaction times and possibly provide mission planning aboard ships.

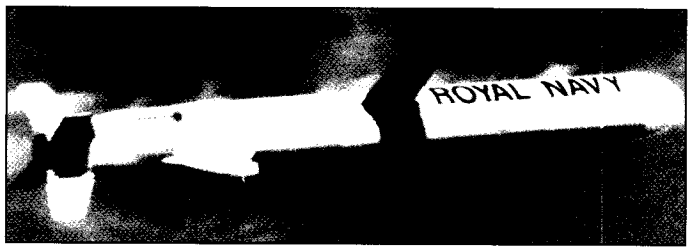
Specifications

	UGM-109A (TLAM-N)	UGM-109B (TASM)	UGM-109C (TLAM-C) Formerly Block IIA	UGM-109D (TLAM-D) Formerly Block IIB
Length**	6.25 m	6.25 m	6.25 m	6.25 m
Diameter	0.52 m	0.52 m	0.52 m	0.52 m
Wing span	2.76 m	2.67 m	2.67 m	2.67 m
Launch weight	1,452 kg	1,452 kg	1,452 kg	1,452 kg
Payload	1 warhead	1 warhead	1 warhead	1 warhead
Warheads	W80 200 kT	454 kg HE	454 kg HE*	166 bomblets
Range	1,400 n miles	250 n miles	500 n miles	500 n miles
Accuracy	80 m CEP	30-185 m CEP	10 m CEP	10 m CEP

* 318 kg shaped charge and range of 620 n miles in Block 3.
** With booster



A Royal Navy Tomahawk broaches the surface after a submerged launch (Royal Navy) 0524686



A Royal Navy TLAM-C Tomahawk missile in flight in 1998 (US Navy) 0062322

The Tomahawk Block 3 upgrade programme (which has only been applied to the land-attack versions UGM-109A/C/D) includes a GPS receiver, time of arrival control, and improved guidance computer, warhead and propulsion systems. The first test flight was completed in February 1991. Range in this variant has been increased by more than 30 per cent to 620 n miles. Some earlier missiles will be retrofitted with these improvements. Test flights of the Block 3 began in 1991 and production commenced in early 1992.

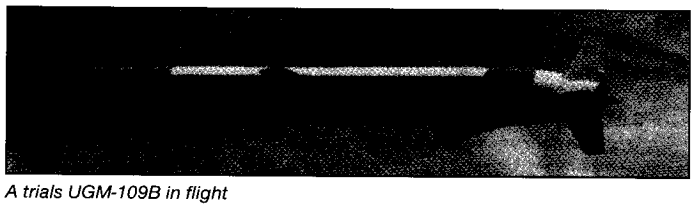
A Block 4 upgrade which began in 1994 was terminated in June 1998. Funding was switched to the Tactical Tomahawk Block 4 development programme which began development in 1998. Tactical Tomahawk is a completely redesigned missile with increased range.

Description

The missile carries a single warhead. Initial launch thrust to take the missile up to cruise speed from its steel/composite launch container which remains in the torpedo or missile tube is provided by a Mk III boost motor weighing 250 kg, which on burnout after around 12 seconds, is succeeded by a Williams International 65 kg F107-WR-402 turbofan producing about 272 kg thrust. The CSD/ARC boost motor, which is ignited after the missile leaves the submarine, is jettisoned on burnout and the wings extended and air intake dropped into flight position as the turbofan engine is started. The missile then flies in cruise mode to the first preplanned waypoint, after which it follows a preplanned route to the target using on-board autonomous navigation systems to check positional accuracy. Missiles are ejected vertically from the Northrop Grumman Mk 36 steel launch tubes or from torpedo tubes. Development programmes are in progress which will result in the canisters being built of lightweight composite materials, rather than steel.

Guidance varies between the various versions. The UGM-109A uses inertial navigation with terrain contour matching (Tercom). The UGM-109B uses inertial plus active radar/anti-radiation homing. The UGM-109C/D versions have inertial and Tercom mid-course guidance (TAINS – Tercom Aided Inertial Navigation) used with DSMAC (digital scene matching area correlation) for terminal guidance. Tercom is achieved by storing digital terrain profile map information in the missile before launch and comparing this with radar altimeter measurements of ground elevations below the missile during a set number of sections en route to the target. The Block 3 upgrade programme will include a GPS receiver linked to 24 satellites circling the earth to supplement or replace the Tercom system. The terminal phase DSMAC system uses a stored digital representation of the target area and compares this with the scene viewed below the missile by a TV camera. This latter system is claimed to be extremely accurate for attacking land targets, with a CEP of 10 m being reported.

The UGM-109A is fitted with a W80 135 kg nuclear warhead, the UGM-109B/C with old Bullpup B 454 kg B61 unitary HE warheads and the UGM-109D with 166 combined effects bomblets BLU-97B each weighing 1.5 kg and with shaped charges, fragmentation and incendiary capabilities. These submunitions can be dispensed in groups against up to four separate targets. The UGM-109C Block 3 missiles have a smaller WDU-36B 318 kg warhead carrying a unitary HE charge with a selectable fuze delay to increase warhead penetration before detonation. Both the UGM-109C and D versions have a programmable terminal dive attack mode option.



A trials UGM-109B in flight

There have been unconfirmed reports that some Tomahawk missiles used during the 1990-91 Gulf War were fitted with high-power microwave (EMP) generators in place of warheads to disrupt electronic circuits. Others are reported to have unrolled spools of carbon fibre to cause shorting between electrical power supply cables.

Range capabilities between the various versions differ because of the weight of the guidance systems and the warheads used. The range of the Block 3 missiles will be increased by at least 30 per cent due to increased fuel capacity and more efficient turbofan engines.

Tactical Tomahawk Block 4 features forward swept thin rectangular wings, new turbojet engine and new boost mortar with three control fins. The missile can be preprogrammed with several targets prior to launch and has a 2 hour loiter capability at a range of 242.5 n miles. New targets can be assigned during its flight profile using an onboard TV camera and an UHF satellite link for carrying out battle damage assessment. The tactical missile can be programmed to strike any of 15 preprogrammed alternative targets, or be redirected to any GPS target co-ordinates. It will also be able to loiter over a target area for some hours, and using its onboard TV camera, provide commanders with pictures of the target area for battle damage assessment. A variety of warheads may be fitted.

Operational status

The UGM-109 Tomahawk entered service in 1983 and it was planned to acquire nearly 4,000 missiles consisting of 637 UGM-109A, 593 UGM-109B, 1,486 UGM-109C and 1,157 UGM-109D.

By July 2000, it was estimated that the US inventory included 350 TLAM-N, 320 TASM and 2,900 TLAM-C/D. Raytheon was awarded an engineering and development contract for Tactical Tomahawk Block 4 in June 1998 with operational evaluation due in 2001 and initial production of 45 missiles due in 2002. The US requirement is for 1,343 Block 4 missiles.

In 1982, a second source contract was placed with McDonnell Douglas (now the Boeing Company), which has competed with General Dynamics (now Hughes Missile Systems) since FY85, and with Teledyne CAE competing with Williams International from FY89 for the engine.

Most submarines carry reloads of Tomahawk, up to eight missiles being carried in a Sturgeon class submarine and 45 (TLAM-N) in a Seawolf class SSN.

The UGM-109D entered service in 1989 and the Block 3 upgrade versions first went to sea in 1993.

During the 1990-91 Gulf War (Operation Desert Storm), a total of 264 TLAM-C and 27 TLAM-D variants was fired, 15 of them from two submarines. This was the first operational use of the missile. Further firings against targets in Iraq and Bosnia took place in 1993, 1995, 1996, 1998 (against Sudan), 1998 and 1999 (Serbia and Kosovo). RN submarines fired a total of 20 Tomahawks against targets in Serbia.

Following the START 2 agreement it is expected that all UGM-109A nuclear warhead missiles will be removed from service.

In 1995 the UK government signed a FMS Agreement for the procurement of 65 109C/D Block 3 Tomahawk Land Attack Missiles (TLAM) for the Trafalgar class SSNs. It has been reported that up to 200 missiles may be acquired.

Following a launch and live warhead test in November 1998, the UK declared the weapon operational. A successful test launch was conducted from HMS *Trafalgar* in the Gulf of Mexico in Summer 2001. *Trafalgar* was the third Royal Navy submarine to be equipped with Tomahawk. This was the first firing of Tomahawk using the SMCS command system and the first use of a joint US/UK version of the Advanced Tomahawk Weapon Control System software offering commonality and interoperability between the Royal Navy and US Navy.

As the Tomahawk Block III missile is no longer in production, the UK is now studying the possibility of purchasing the Tomahawk Block IV missile (TACTOM —

Tactical Tomahawk) should it be needed in the future. Raytheon has been awarded a contract to modify a Block IV Tactical Tomahawk for horizontal torpedo launch capability (as opposed to its current vertical launch capability), qualify a torpedo tube launch capsule and modify missile software to create a torpedo tube launch-capable all-up-round universally usable by both the United States and United Kingdom's SSNs.

In February 2002, Raytheon Systems was awarded a fixed price contract to remanufacture 22 Tomahawk missiles to the Block IIIC configuration for the UK government under the FMS Programme. A total of 434 Tomahawks are to be remanufactured to Block IIIC configuration by April 2004 for the US. Tomahawk achieved fleet weapon acceptance with the Royal Navy at the end of 2001.

Royal Navy submarines equipped to fire Block III TLAM are *Spartan, Splendid* (decommissioned in late 2003), *Trafalgar*, *Trenchant*, *Triumph* and *Turbulent*. TLAM is launched through existing torpedo tubes but TACTOM is deployed from VLS tubes at periscope depth. The UK/US have drawn up a study, which has examined the feasibility of an encapsulated version of TACTOM suitable for torpedo tube launch and design work is continuing.

A TACTOM carried out its first submerged launch on 10 November 2002. The missile simulated a conventional submerged vertical launch firing at nominal periscope depth to test the weapon's watertight integrity and demonstrate the sensor and rocket motor's ability to withstand the pressure and shock of an underwater launch. TACTOM is due to become operational during 2004. As of April 2003 the funded buy of TACTOM amounted to 2,396 missiles. Raytheon Missile Systems was awarded a combined contract for the production of 225 TACTOM missiles for the US and UK on 4 March 2004.

The Royal Navy fired a number of missiles against targets in Serbia during the Kosovo campaign in 1999, against Afghanistan in 2001 and also against Iraq in 2003.

According to unconfirmed reports, the Royal Navy expended most of its stock of Tomahawk missiles against Iraq and the United States has seriously depleted its stock of missiles. Considerable emphasis will now be placed on rebuilding those stocks.

Contractor
Raytheon Electronic Systems, Tucson, Arizona.

UPDATED

UGM-133 Trident D-5

Type
Intercontinental submarine-launched ballistic missile.

Development
The D-5 Trident has been developed together with the Ohio class SSBNs to provide the US Navy with a capability that extends range, payload and inventory of its missile force and to introduce a hard target capability in the submarine-based missile. The high accuracy is achieved through sophisticated improvements to the boat's navigation system and to the missile. A wide variety of mid-course updating techniques and terminal guidance systems are being considered to further enhance accuracy. The use of the Global Positioning System (GPS) satellite navigation system is an example of the former and there is a number of terminal guidance techniques that might be applied. It is reported that an earth penetrator warhead is being developed for the missile to attack underground hardened command centres and initial tests were conducted in 1993.

The first D-5 was launched from a land-based test site in January 1987 and the first sea launch, which proved to be a failure, in March 1989. The first successful submerged launch took place from the USS *Tennessee* in December 1989 and the missile was first deployed operationally in March 1990. The full test programme has now been completed with a total of 49 firings recorded by 1993.

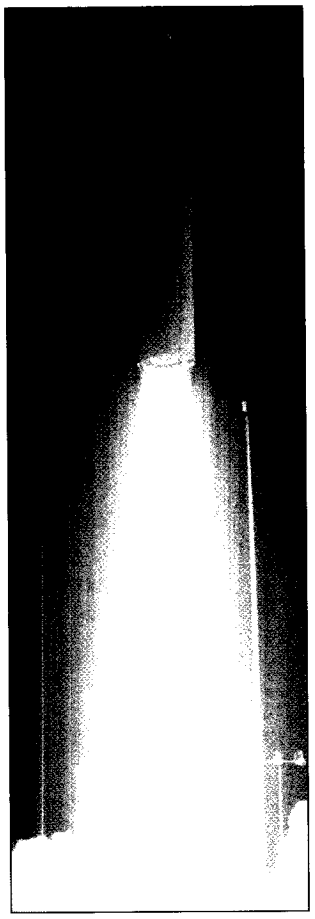
Description
The three-stage solid-fuelled D-5 MIRV-capable ballistic missile uses an inertial guidance system with stellar sensor update. The missile uses the AN/BQN-25 navigation sonar system as an aid to inertial navigation. During long patrols the INS of the SSBN requires external position resets to correct errors. The AN/BQN-25 provides a position correction using a bathymetric fix. This is a map-matching process in which previously surveyed areas referred to as precise bathymetric navigation zones are transmitted while the sonar covertly 'pings' the bottom. Like the C-4, the D-5 is fitted with an aerodynamic 'spike' which deploys from the nose early in flight to improve the drag characteristics of the missile.

The missile's payload is from eight to 12 MIRVs which are either the Mk 4 RV with W76 nuclear warhead, or the Mk 5 RV with W88 nuclear warhead. Production of the Mk 4 RV ended in mid-July 2000 after 23 years.

The Mk 4 provides thermal protection for the W 76 warhead from the harsh re-entry environment while ensuring accurate delivery of the payload to its intended target. The Mk 4 and W 76 warhead will remain in service until 2040.

The vehicle and warhead will be upgraded under a life extension programme beginning this decade and due to complete by 2020.

The propulsion system is manufactured under a joint venture by the former Alliant Techsystems and the Thiokol Corporation using filament wound motor cases and high-energy solid propellants.



Launch of the second development test Trident D-5 missile from Cape Canaveral in March 1987

Operational status
The D-5 became operational in 1990 and is successively equipping the Ohio class SSBNs from the ninth boat onwards. Currently some 12 missiles are being built each year, with a full production total of 453 missiles The plan is to build up an inventory sufficient to support a force of 14 Ohio class SSBNs all armed with the D-5 missile. Since initial production began in 1987, the US has purchased a total of 396 D-5 missiles. As of December 2001, the US Navy had conducted 94 successful launches and test flights of D-5 missiles, which began in December 1989. In mid-2000 a follow-on production order for 12 D5 missiles was placed with Lockheed Martin to retrofit four Ohio class SSBNs in place of their current C-4 missiles. The boats involved are: *Henry M Jackson, Alabama*, *Alaska* and *Nevada*. Delivery was due to complete in 2004. Current production of the D-5 is running at about 12 missiles per year, and it is anticipated that 568 missiles will have been manufactured by 2013.

In 1980, an agreement was reached with the UK for the sale of Trident D-5 missiles. The missile will be fitted with the US-designed MIRV capability with US Mk 4 RVs, but with UK-built warheads believed to be similar to the US-designed W76 warhead. The UK missiles are able to carry up to eight warheads each, but it is expected that most missiles will only carry between one and four warheads. The UK proposes to deploy some D-5 missiles in a sub-strategic role. The UK version is to be carried by the four boats of the Vanguard class.

The first UK missile was successfully launched from HMS *Vanguard* on 26 May 1994 and its first operational patrol undertaken early in 1995. On 24 July 1995, the second Vanguard class SSBN, HMS *Victorious*, successfully launched a D-5 missile. The third boat *Vigilant* has also successfully launched two D-5 missiles.

In October 1997, it was announced that the UK would buy an additional seven missiles, making a total of 58 D-5 missiles held in the UK inventory.

In January 2002 Lockheed Martin Space Systems was awarded a contract by the US Navy to start a D-5 Service Life Extension Program (SLEP). It has been reported that some 300 missiles will be upgraded to the D-5A version by 2020, and that these missiles will remain in service until 2042.

Specifications
Length: 13.42 m
Diameter: 2.11 m
Launch weight: 59,090 kg
Payload: 8 × Mk 4 or Mk 5 RVs in MIRV configuration
Warheads: 8 × W76 at 100 kT nuclear or 8 × W88 at 475 kT nuclear
Range: 6,500 n miles
Accuracy: 90 m CEP

Contractor
Lockheed Martin Space Systems, Missiles & Space Operations, Sunnyvale, California (prime contractor).

UPDATED

GUIDED ASW/ASUW WEAPONS

Introduction

In the Western world submarine-launched anti-ship guided weapons tend to be variants of existing surface-launched anti-ship missiles such as Exocet and Harpoon. To some extent the same is true of submarine-launched anti-ship missiles developed by Russia under the Communist regime. However, they have also developed a number of anti-ship weapons designed specifically for submarine launch.

The latest country understood to be developing an indigenous submarine-launched cruise missile is India. Under development by the Defence Research and Development Organisation, the missile called Sagarika is in the early development phase and may possibly arm the nuclear-powered submarine under development by India.

In addition to anti-ship weapons, a number of guided weapons has been developed for deployment in the anti-submarine role. These are long-range ASW weapons designed primarily to deploy lightweight, homing torpedoes.

The latest type of guided missile to be developed for deployment from submarines are weapons designed to counter the air threat — especially helicopters. With the increasing threat from ASW helicopters deploying a new generation of lightweight ASW torpedoes, it is now becoming essential for submarines to deploy some form of active defence measure against this threat. As submarines are increasingly being asked to operate in littoral waters anti-helicopter defence measures must be considered to be an essential element in a submarine's armoury. These weapons will be increasingly fitted to non-nuclear submarines in the coming years.

VERIFIED

Table XIV

Operational Guided ASW/ASuW Weapons

Weapon	Type	Country origin	Length	Diameter	Wing Span	Launch weight	Warhead/Payload	Charge	Speed	Range	Operating depth
CSS-N-4 Sardine (YJ-1/C-801)	anti-ship	China	5.81 m	0.36 m	1.18 m	815 kg	165 kg	HE SAP	M 0.9	20 n miles	
CY-1 (YJ-8)	ASW	China	5.50 m			700 kg	34 kg/torpedo	HE		8 n miles	300 m
YJ-82	anti-ship	China		0.53 m							
SM 39 Exocet	anti-ship	France	4.69 m*	0.35 m	1.13 m	655 kg	165 kg	HE	M 0.9	27 n miles	
Milas	ASW	International	6.00 m	0.46 m	1.06 m	800 kg	59 kg/MU90 homing torpedo	HE	M 0.9	32 n miles	
SS-N-14 Silex	ASW	Russia	7.20 m	0.55 m		3,700 kg	185 kg/E53-72 homing torpedo	HE	M 0.9	30 n miles	400 m
							5 kt	nuclear			
SS-N-15 Starfish	ASW	Russia	6.90 m	0.53 m		1,800 kg	300 kg/depth charge	HE		21 n miles	
							200 kt	nuclear			
SS-N-16 Stallion	ASW	Russia	8.17 m	0.65 m		2,850 kg	60 kg/ET-80 torpedo	HE		65 n miles	500 m
							200 kt	nuclear			
RUM-139A VLA	ASW	United States	5.08 m	0.35 m	0.69 m	635 kg	45 kg Mk 46/50/ torpedo	HE	M 0.9	9 n miles	
RUR-5A ASROC	ASW	United States	4.57 m	0.325 m		435 kg	45 kg Mk 46/50/ torpedo	HE		5.5 n miles	
SLWM	anti-ship	United States									
UGM-84 Sub Harpoon	anti-ship	United States	4.64 m	0.34 m		682 kg	222 kg	HE		70 n miles	

NOTES: *missile. Length of canister 5.80 m

NEW ENTRY

China

CSS-N-4 Sardine (YJ-1/C-801)

Type
Submarine-launched SSM.

Development
Development of the Ying-Ji (Eagle Strike) is believed to have started in the early 1970s, but it was not until 1984 that the missile was first revealed by the Chinese. Initially the design was developed for surface ship deployment, but the weapon can also be launched from surfaced submarines.

Description
Similar in appearance to the French Exocet, the missile features four clipped delta wings at the mid-point of the body and four small clipped-tip triangular moving control fins at the rear. Propulsion is by a tandem-mounted, solid-propellant boost motor that is jettisoned after use. An encapsulated version (YJ-8-2) for submerged torpedo tube launch may be under development for deployment from Chinese and Iranian Kilo class submarines and the new type 093 Song class.

Mid-course guidance is inertial, with a monopulse active radar (probably operating in the J-band) in the terminal homing phase. Cruise altitude is believed to be around 20 m, followed by a terminal homing phase altitude of around 5 to 7 m. Altitude is controlled by a radio altimeter.

Operational status
In production, entering service about 1984. Operational on board a Chinese modified Romeo class submarine with six external launchers, and on Han and Song class boats.

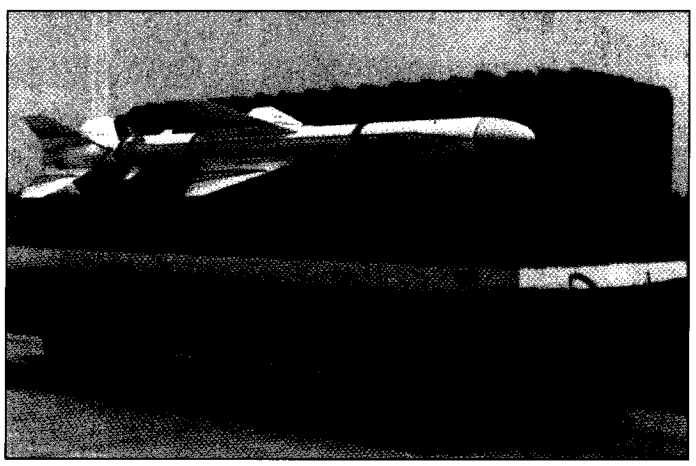
Specifications
Length: 5.81 m
Diameter: 0.36 m
Wing span: 1.18 m
Launch weight: 815 kg
Warhead: 165 kg
Charge: HE SAP
Speed: M 0.9
Range: 20 n miles

Contractors
CPMIEC, Beijing (marketing).
Chinese State Factories (manufacturer).

UPDATED



A launch of a Ying-Ji-1 missile from a modified Chinese-built Romeo class submarine



Ying-Ji-1 (C-801 export version) surface-to-surface missile mounted beside its container, showing the jettisonable tandem boost motor assembly at the left-hand (rear) end

CY-1 (YJ-8)

Type
ASW surface-launched missile.

Description
The CY-1 single-stage ASW missile was first revealed in 1986. It would appear to be similar to the American RUR-5 ASROC system. Designed to be deployed by surface ships from multicelled launchers, CY-1 has been seen mounted on a Luda III class destroyer in four inclined twin-launcher canisters. It is estimated that the missile has a range of about 18 km and is armed with a torpedo. The torpedo is said to be similar to the Italian A244 with a length of 2.7 m, diameter of 324 mm, weight 220 kg, warhead 34 kg and a speed of 30 kt and range of about 3.5 n miles.

The weapon is designed to engage submarines at depths down to 300 m travelling at speeds up to 30 kt.

There have been reports that the weapon has been encapsulated for deployment from China's Song and Kilo class submarines.

Operational status
Believed to be operational on board Luda III class destroyers.

Specifications
Length: 5.50 m
Launch weight: 700 kg
Warhead: 34 kg
Payload: Torpedo
Charge: HE
Range: 8 n miles
Operating depth: 300 m

Contractor
China Precision Machinery Import & Export Corporation (CPMIEC), Beijing.

UPDATED

YJ-82

Type
Submarine launched anti-ship missile.

Description
Unconfirmed reports indicate that a missile designated YJ-8-2 has been developed from reverse engineered Exocet SM39 data/technology. Iran may be carrying out research in co-operation with China to develop such a missile for deployment from Kilo class submarines through standard 533 mm torpedo tubes. A report in 1997 indicated that such a missile might have undergone firing trials from a Song class submarine. However, other reports have stated that the YJ-8-2 is a modified encapsulated YJ-1 missile, which itself looks similar to the Exocet SM-39.

Operational status
Undergoing trials but unconfirmed. It is believed that 'Han', 'Song' and Kilo classes now have the capability to launch an encapsulated anti-ship missile of this type.

Specifications
Diameter: 0.53 m

UPDATED

France

SM 39 Exocet

Type
Subsurface-to-surface anti-ship missile.

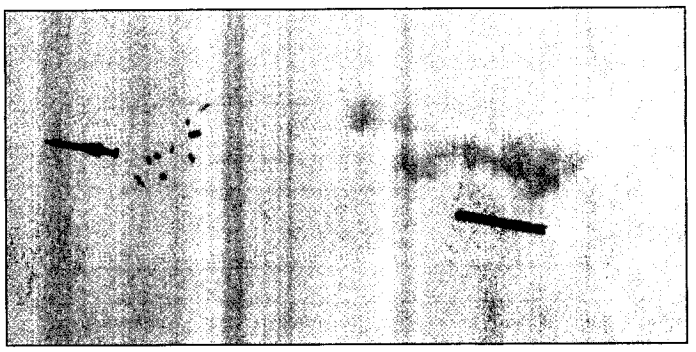
Development
Work on SM 39 began in 1979 and was completed in 1984.

Description
The French Navy deploys a submarine-launched version of Exocet, known as the SM 39.

Like the other Exocet missiles, with which it has many components in common, the SM 39 is an all-weather, fire-and-forget, sea-skimming weapon. Target acquisition and tracking is carried out by an active electromagnetic homing head.

The SM 39 missile consists of a watertight, highly resistant, powered and controlled underwater capsule, housing an aerial missile before the latter's ejection following surface broach.

Known as the VSM *(Véhicule Sous-Marin)*, the capsule can be discharged from a submarine's 533 mm standard torpedo tube at any speed, course and depth. The 5.8 m capsule weighs 1,350 kg and is pressurised to 300 millibar. At a safe distance from the submarine, the solid-propellant motor of the VSM is ignited and



The submarine-launched SM 39 Exocet missile, shortly after broaching the water and leaving the launch capsule (VSM) after a submerged firing

the VSM is piloted up to ejection of the aerial missile by jet deviation of gases; this deviation is performed by four interceptors actuated by electromagnets placed to the rear of the nozzle outlet section.

The guidance orders for pitch and yaw, which slave the VSM to a preset bearing and attitude depending on the launch depth and offset angle, are elaborated by the inertial system and guidance computer in the aerial missile.

The missile breaks the surface at an angle of 45° in the direction of the target, whatever the sea state. The nosecone is jettisoned. Jet interceptors enable the VSM attitude to be stepped down to limit the culmination altitude (30 m). After unlatching, the aerial missile is ejected, its wings and control surfaces are deployed, the boost motor is ignited and then it flies towards impact with the target like all other Exocets. All VSM's components sink rapidly to avoid detection. The missile is powered by the SNPE Narval composite case-bonded sustainer and the SNPE Condor composite propellant booster.

Target position is fed to the missile immediately prior to launch. Mid-course guidance is inertial, using one axial and two vertical gyroscopes operating in conjunction with three accelerometers. Coupled with the radio altimeter, the inertial system allows the missile to follow a sea-skimming trajectory to the target before the active radar takes over for the terminal phase of the flight. The active radar has an operating range of 27 n miles at a speed of 0.9 Mach. The radar seeker is the Thomson-CSF Detexis ADAC (Auto Directeur Anti-Clutter) I-band (8-10 GHz) single-axis active monopulse system. The warhead is a Luchaire GPIA fragmentation charge activated by a SERAT delayed impact fuze and an autopilot-controlled proximity fuze.

Operational status

The Exocet missile entered production in 1972 and the SM 39 entered service in 1985 and remains in production. SM 39 is operational in the French 'Le Triomphant', 'L'Inflexible', and Rubis class submarines and has also been exported to Pakistan for its Agosta class submarines. It is stated that a total of 130 SM 39 Exocet missiles have been manufactured.

Specifications

Length: 4.69 m*
Diameter: 0.35 m
Wing span: 1.13 m
Launch weight: 655 kg
Warhead: 165 kg
Charge: HE
Speed: M 0.9
Range: 27 n miles

*Launch vehicle: 5.80 m

Contractor

MBDA, Chatillon.

VERIFIED



A trials firing of a Milas anti-submarine missile, launched at San Lorenzo in Sardinia in 1989

vehicle which will be carried by frigates and be capable of carrying a lightweight anti-submarine torpedo.

The first two development firing trials of Milas were conducted at the San Lorenzo range in Sardinia on 21 and 27 June 1989. The successful firings validated the separation of the torpedo from the carrier.

Description

Milas is derived from the Otomat missile, but with the warhead and terminal seeker replaced by a lightweight torpedo. Attached to the missile's body are four folding delta-shaped wings which are mounted mid-way along the length of the body. The command receiver is mounted at the wingtip. At the rear of the missile are four small clipped triangular moving control fins.

The missile is launched using two 75 kg jettisonable boost motors and on reaching cruise speed the missile is powered by a 400 kg thrust turbojet engine. Cruise altitude is 200 m.

Target co-ordinates are preprogrammed into the missile's inertial navigation system before launch and several in-flight mid-course updates are passed by datalink either from the launch vessel or from rotary- or fixed-wing aircraft using dipping sonar or sonobuoy data. The missile also features an automatic in-flight retargeting capability. During the terminal flight phase, the turbojet is shut down and the torpedo separates from the missile's body and descends to the water by parachute. On entering the water the torpedo's motor is activated and the active sonar homes the weapon onto the target. Milas is designed to carry the new MU90 Impact lightweight torpedo and design studies have been carried out to examine the possibility of mounting other lightweight torpedoes such as the US Mk 46, Stingray and Mk 50. The time between launching and torpedo release at 32 n miles is 3 minutes.

The modular system can handle four to 12 missiles from a single control console. The launchers are organised in modules, each holding four missile containers.

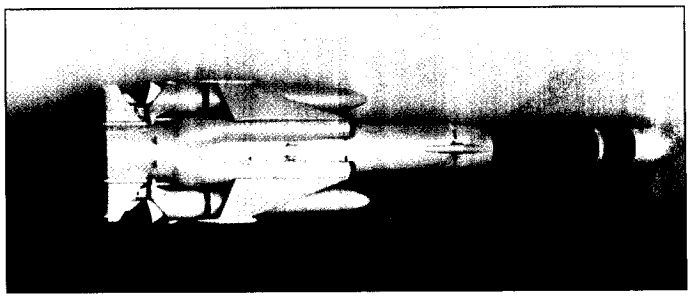
Operational status

Under development with first production delivery now taking place. Early in 1993 successful launch trials were carried out with a dummy Impact torpedo. A test launch was carried out from the Italian trials ship *Carabiniere* in April 1994.

The missile turned through 180° and launched the torpedo at the correct speed and angle at a range in excess of 10 km.

Although originally planned to equip the three French Tourville class destroyers and the Georges Leygues class, the programme was dropped by the French government. Development continued however, for the Italian Navy, and Milas will equip Italian Navy anti-submarine frigates. The final development test firing took place in September 1999 from the French Navy's trials ship *Ile d'Oléron*. During the test the entire weapon system was validated, the missile using an MU90 torpedo against a real submarine target. The system is now entering production for the Italian Navy.

In November 2000 the Italian Navy decided to equip the De La Penne class destroyers with four launchers each, production delivery was scheduled for 2003.



The Milas ASW missile under development by MBDA

International

Milas

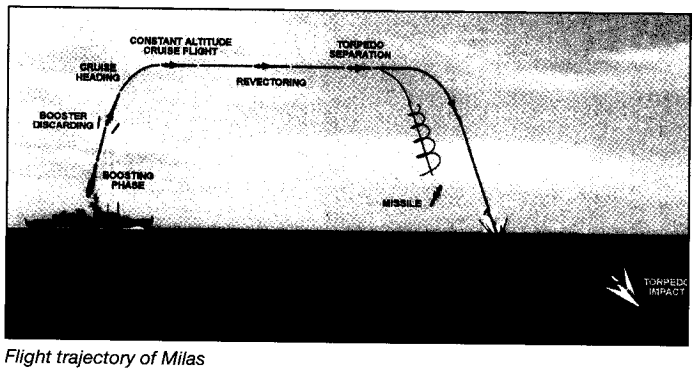
Type

Surface-launched ASW torpedo-carrying missile system.

Development

Milas, first revealed at the Le Bourget Naval exhibition in 1986, is being developed by MBDA to meet a joint French and Italian naval requirement for an air flight

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
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Flight trajectory of Milas

Specifications
Length: 6.00 m
Diameter: 0.46 m
Wing span: 1.06 m
Launch weight: 800 kg
Warhead: 59 kg
Payload: MU90 torpedo
Charge: HE
Speed: M 0.9
Range: 32 n miles

Contractors
MBDA , Velizy-Villacoublay, France.
MBDA, Rome, Italy.

UPDATED

Russian Federation

SS-N-14 Silex

Type
Ship-launched anti-submarine missile.

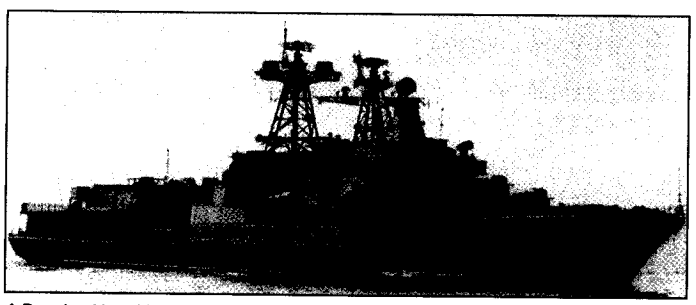
Description
The SS-N-14 'Silex' is thought to be somewhat similar in concept to the French Malafon anti-submarine weapon in which a subsonic winged vehicle carries a homing torpedo to the position of the target submarine. It can have its course corrected using command guidance techniques during flight to allow for submarine movements before making an accurate drop. The SS-N-14 deploys a 400 mm parachute-retarded homing torpedo or, alternatively, can carry a nuclear warhead with a weight of about 150 kg and a yield in the low kiloton range. Weapons deployed by the SS-N-14 include the E45-70A, and E53-72 torpedoes.

It is also believed that the SS-N-14 has an anti-ship capability and may be able to drop a homing torpedo outside a ship's normal defensive cover. Control of the weapon is exercised through a Head Light or Eye Bowl radar director.

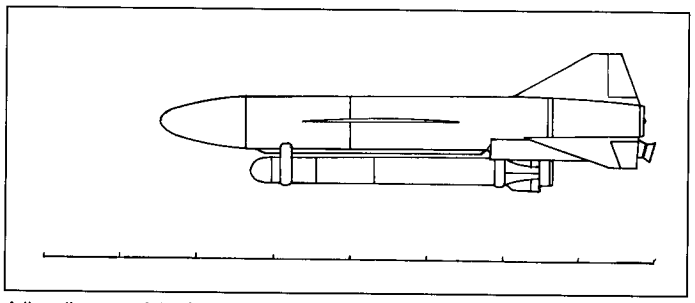
The missile is powered by a solid-propellant motor. The trajectory follows a programmed/radio command flight to target area under autopilot control with command override capability. Speed is about M0.95 at 400 m above sea level.

Operational status
Operational since 1968 but no longer in production. The SS-N-14 is carried by Krivak I/II (15 units) and Udaloy class (9 units) anti-submarine destroyers that are fitted with two quadruple launchers. The total number of missiles in service is considered to be about 100. The weapon is also in service with the Ukrainian Navy.

Specifications
Length: 7.20 m
Diameter: 0.55 m
Launch weight: 3,700 kg
Warhead: 185 kg
Payload: E53-72 torpedo
Charge: HE or 5 kt nuclear



A Russian Navy Udaloy class destroyer with the starboard quadruple SS-N-14 'Silex' launcher just forward of the bridge (US Navy)



A line diagram of the SS-N-14 missile, with a torpedo attached underneath

Speed: M 0.9
Range: 30 n miles
Operating depth: 400 m

Contractor
Smolensk Aircraft Plant.

UPDATED

SS-N-15 Starfish

Type
Submarine and surface ship-launched ASW missile.

Development
Developed in the late 1950s, the SS-N-15 is reported to be of the same general type as the US SUBROC.

Description
The missile is horizontally launched from a standard 533 mm torpedo tube at depths down to 50 m. It follows a short underwater path before broaching the surface to follow an airborne trajectory with inertial guidance for the major part of the flight to the target area. On reaching the target area, a depth charge is released to continue on a ballistic trajectory until entering the water near the target and sinking to the optimum depth before detonation. This type of weapon relies upon accurate localisation of the target in the first instance, followed by rapid launch and flight to the target area before the target has time to travel far from its last known position. The weapon is associated with the Shark Teeth LF active/passive sonar system.

It was originally estimated that the solid-propellant motor gave the missile a range of about 18 n miles, but later official US reports have credited the missile with a range of between 24 and 27 n miles.

Operational status
The missile is reported to have entered service around 1969. It is currently operational aboard Typhoon (three units), Delta IV (six units), Oscar II (seven units), Victor III (four units), Sierra I/II (two units) and Akula (eight units) class submarines as well as a Neustrashimy class frigate, two 'Kirov class battlecruisers and one 'Udaloy II' destroyer. It is also understood that the missile will arm the new submarine *Severodvinsk* of the Yasen class, currently under construction. It has been estimated that about 190 missiles remained in service at the end of 1998.

Specifications
Length: 6.90 m
Diameter: 0.53 m
Launch weight: 1,800 kg
Warhead: 300 kg
Payload: depth charge
Charge: HE or 200 kt nuclear
Range: 21 n miles

Contractor
Novator NPO, Ekaterinburg.

UPDATED

SS-N-16 'Stallion'

Type
Submarine and surface ship-launched ASW missile.

Development
Believed to be a further development of the SS-N-15 to provide a delivery vehicle for a torpedo instead of a depth charge. Considered to be similar to the US ASROC in concept.

Description
The SS-N-16 is believed to carry a Type 65 or E45-75A torpedo, although a nuclear-tipped torpedo could be fitted in place of the conventional weapon.

The missile is horizontally launched from a standard 650 mm torpedo tube to follow a short underwater path before broaching the surface to follow an airborne trajectory with inertial guidance for the major part of the flight to the target area. On reaching the target area the solid-propellant motor is jettisoned and the torpedo descends to the water by parachute. On entering the water the torpedo's motor is activated together with its active sonar homing head to carry out a preprogrammed search and attack pattern. This type of weapon relies upon accurate localisation of the target in the first instance, followed by rapid launch and flight to the target area before the target has time to travel far from its last known position.

A later variant of the missile (88R) carries an ET-80 torpedo and can only be launched through a 650 mm torpedo tube while a third variant has a range of 107.8 n miles.

Operational status
The missile is reported to have entered service in 1981 and may still be in limited production. The SS-N-16 is deployed in 'Oscar II' (seven units), 'Victor III' (four units), 'Sierra II' (two units), 'Akula' (eight units) class submarines. It has been estimated that each submarine carries, on average, four ASW nuclear weapons, either SS-N-15 or SS-N-16. The number of missiles remaining in service has been estimated at around 120 at the end of 2002.

Specifications (88R)
Length: 8.17 m
Diameter: 0.65 m
Launch weight: 2,850 kg
Warhead: 60 kg
Payload: ET-80 torpedo
Charge: HE or 200 kt nuclear
Range: 65 n miles
Operating depth: 500 m

Contractor
Novator NPO, Ekaterinburg (design).

UPDATED

United States

RUM-139A Vertical Launch ASROC (VLA)

Type
Short-range vertical launch ASW rocket.

Development
Initially, plans were developed to provide separate ASW standoff capabilities for surface ships and submarines. These were subsequently suspended on the grounds of cost and a requirement to merge the project with the ASW-SOW standoff weapon programme. However, changes in the USN's overall ASW policy led to a reversal of this decision in 1982 and development of the RUM-139 Vertical Launch ASROC (VLA) began in 1984. It is deployed from the Mk 41 vertical launch system using the Mk 116 Mods 6.7/8 ASW combat systems.

Description
The rocket-propelled three-stage VLA features a boost motor fitted with thrust vector controls which are used to turn the missile over through 40° then 29° on to a ballistic trajectory after its vertical launch phase. The flight path is determined using digital autopilot control. The booster is jettisoned at a predetermined time, and the payload and sustainer motor flies on a ballistic path to the point where the torpedo separates from the sustainer motor. A parachute is deployed to slow the descent of the Mk 46 torpedo and ensures that it enters the water at the correct angle after which the parachute is discarded, and the torpedo's boiler fired and its search initiated. All VLA systems (including export models to Japan) will be armed with the Mk 46 Mod 5 Neartip torpedo.

The increased range of the VLA enables it to capitalise on the increased range of the SQS-53 sonar over the SQS-23 along the direct path.

Integration testing with the Mk 54 lightweight hybrid torpedo was initiated earlier in 2000.

Operational status
VLA was initially deployed in 1995. In US service, VLA arms the Ticonderoga class cruisers and Arleigh Burke and Spruance class destroyers. In the Japanese MSDF, VLA equips the Kongo and Murasame class destroyers and will equip the improved Kongo class. The final 30 RUM-139B vehicles have been delivered and about 400 missiles remain in inventory.

Specifications
Length: 5.08 m
Diameter: 0.35 m
Wing span: 0.69 m
Launch weight: 635 kg
Warhead: 45 kg
Payload: Mk 46/Mk 50 torpedo
Charge: HE
Range: 9 n miles

Contractor
Lockheed Martin Naval Electronics and Surveillance Systems, Akron, Ohio.

VERIFIED

RUR-5A ASROC

Type
Short-range ASW rocket.

Development
Development of ASROC began in 1956 to meet a USN requirement for a quick reaction ASW system. Since the original design entered service in 1961, it has undergone several upgrades, with five major variants (5A, 5B, 5C, 5D and 5E) entering service. The latest variant to be developed is a vertical launch version to equip both surface ships and submarines (see RUM-139A entry).

Description
The RUR-5 is basically an all-weather unguided rocket system powered by a solid-propellant motor and armed with a Mk 46 acoustic homing torpedo. The warhead is enclosed in a split shell flared into the front end of the rocket. The rocket motor and the front end shell are fitted with four stabilising fins at their rear ends.

After launch, the missile follows a ballistic trajectory before the solid-propellant rocket booster motor is jettisoned at a predetermined point and the missile follows a ballistic flight to the point of airframe separation. At this point, the steel band that holds the front shells together is split by an explosive charge, after which the payload continues towards the target. A parachute is deployed which affords the torpedo a certain degree of control during its descent and allows it to enter the water at the correct angle where its protective dome-shaped frangible plastic nose cap is shattered, the parachute discarded, the weapon's motor ignited and its seeker head activated.

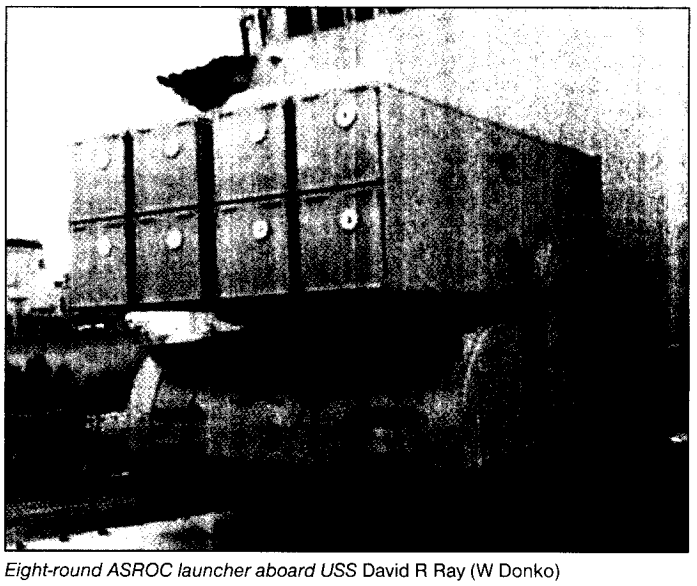
The rocket is fired from the Mk 112 eight-cell trainable launcher (which is also used to fire Harpoon), at a fixed elevation of 45° the Mk 26 launching system, or from the Mk 10 Terrier (SAM) missile launcher system. Other major components of the system include a fire-control computer and an underwater sonar detector.

Operational status
Although no longer in production, ASROC is still in operational service with many countries including Brazil, Canada, Egypt, Germany, Greece, Italy, Japan, South Korea, Mexico, Pakistan, Spain, Taiwan, Thailand and Turkey. It is expected that the RUR-5 variant will be phased out of service, although limited numbers of spares are still being manufactured to support missiles still in service.

Specifications
Length: 4.57 m
Diameter: 0.325 m
Launch weight: 435 kg
Warhead: 45 kg
Payload: Mk 46/50 torpedo
Charge: HE
Range: 5.5 n miles

Contractor
Honeywell Training & Control Systems, West Covina, California.

VERIFIED



Eight-round ASROC launcher aboard USS David R Ray (W Donko)

SLWM

Type
Submarine-launched short-range anti-ship missile.

Development
The Electric Boat Division of General Dynamics is offering the SLWM (Submarine Littoral Warfare Missile) as part of the design improvement process for the Virginia class SSN. The US Navy has not yet funded the concept, although it has been approved. It does not, therefore, appear to have a high priority at present, although this may change as US submarines are tasked to operate closer to shore.

Description
The SLWM has been designed to provide the Virginia class with the ability to defend itself against small surface vessels and other potential threats when operating at periscope depth or on the surface in coastal waters. The fibre optic guided missile would be integrated into the modular mast of the SSN and the missile-targeting systems on board the submarine.

Operational status
Waiting Navy funding.

Contractor
General Dynamics Electric Boat Division, Groton, Connecticut.

UPDATED

UGM-84 Sub Harpoon

Type
Short-range submarine-launched anti-ship missile.

Development
The USN commenced studies for an anti-ship missile in 1965, at about the same time as McDonnell Douglas was carrying out private studies to meet a similar requirement. In July 1971, McDonnell Douglas won the development contract and in May 1973, the US Navy selected the Harpoon as its prime anti-ship missile system for deployment from aircraft, submarines and surface ships. All these versions entered service in 1977, since when various improvement programmes have been initiated. Block 1B was introduced in 1982 and featured ECCM improvements, while 1C featured an improved seeker and increased range, and entered service in 1985. Block 1G, which incorporates re-attack and other guidance improvements entered service in 1997.

Description
Harpoon has four clipped-tip triangular wings sited midway along the body and four similar in-line clipped triangular moving control fins at the rear. Initial thrust is provided by a jettisonable tandem boost motor with in-line tail fins attached, with a turbofan sustainer motor (the Teledyne CAE J402 turbojet) maintaining cruise speed. Maximum range is 70 n miles.

The missile receives target data manually or automatically via the fire-control system, either the Mk113 or the Mk117. The operator selects both the seeker search pattern mode and the source for the target data, allowing the seeker to select one of three search modes.

The missile is carried in a special, unpowered, buoyant capsule, which is launched from the torpedo tube. The capsules consist of a nose cap, the main body and the aft body. The nose cap consists of a broach pressure sensor, explosive bolts and a nose removal rocket. The main body is a tube with shock isolation rails, which also guide the missile out during the exit phase. The missile is fitted with a sabot assembly at the nose to provide further support and shock protection. The sabot straps are cut and the sabot falls away during the exit phase. The aft body mates with the rear of the missile by means of pyrotechnic bolts and consists of a folding control fin and planes. It links the capsule system sequencing controls to the submarine through an umbilical cord. As the capsule leaves the torpedo tube at a velocity of some 15.25 m/s, stabilising fins and hydroplanes unfold to establish a proper glide angle to enable the weapon to reach the surface. Initially the planes assist buoyancy movement, the angle depending upon the angle of the torpedo tubes, but when the optimum glide angle of 45° is reached they neutralise this movement. A sensor detects when the missile is near the surface it initiates the sequence in which both the nose cap and the aft body are jettisoned and the booster is ignited. The booster burns for 3 seconds and takes the missile out of the water to near cruise velocity at which point the turbojet operates. As the missile exits the capsule, its wings and fins unfold and the weapon is propelled into a flight trajectory similar to that of surface launches.

After booster separation, the missile descends to a low-cruise altitude determined by its altimeter and flies towards the target by heading reference guidance, under the power of its turbofan engine. The Block 1C and 1G versions can execute mid-course waypoints based on preset data to avoid obstacles in the trajectory, approach the target from a desired direction or provide multiple-missile simultaneous arrival on target. At a point preset by the launch platform the J-band, frequency-agile, two-axis active radar seeker is activated into its search and acquisition mode. The missile is usually launched in this preset range and bearing launch mode, turning on the radar seeker at the last moment to acquire the target. The radar can be set for large, medium or small acquisition windows that determine the range-to-target at which the seeker is activated. The smaller the window, the more precise the initial target data must be, and the less chance that the missile will succumb to ECM. An alternative launch technique is the bearing-only launch in which the missile is fired along the target bearing and seeker is activated early in the trajectory to scan a 45° search sector either side of the missile's course. If no target is acquired after a suitable time on the initial bearing then the missile switches to a preset search pattern, and if it then fails to acquire the target will self destruct. In either launch mode, once the target is detected and the seeker is locked on its tracking mode the Block 1A missile climbs rapidly at about 1,800 m from the target in a pop-up manoeuvre before diving down onto the target at an angle of about 30°. The later Block 1B, 1C and 1G missiles have a sea-skimming terminal attack profile. The Block 1C and 1G have an optimal shallow 'pop-up' manoeuvre. The Block 1G, instead of self-destructing at the end of the search phase, will turn and execute a reattack manoeuvre if it missed the target on its first pass.

The UGM-84B variant for the UK Royal Navy (RN designation GWS 60) is in service aboard Swiftsure and Trafalgar class submarines where it is launched from the torpedo tubes. US submarines also launch Harpoon through their torpedo tubes.

The UGM-84J Block 2 is being developed for land attack as well as anti-ship use. This variant may incorporate SLAM software with a ring laser gyro inertial measurement unit and GPS receiver.

Submarines carry between six and eight missiles, depending on the class of submarine.

Operational status
The missile entered service in 1977 and is operational in the submarine forces of a number of navies including Australia, Egypt, Greece, Israel, Japan, Netherlands, Pakistan, Turkey, UK and US.

Country	Class	Missile
Australia*	'Collins'	UGM 84C
Egypt*	'Romeo'	UGM 84C
Greece	Type 209/1100	UGM 84C
	Type 214	UGM 84C
Israel	'Dolphin'	UGM 84C
Japan	'Oyashio'	UGM 84C
	'Harushio'	UGM 84C
	'Yuushio'	UGM 84C
Netherlands	'Walrus'	UGM 84C
Pakistan	'Agosta'	UGM 84A
	'Daphne'	UGM 84A
Turkey	Type 209/1400	UGM 84C
UK**	'Trafalgar'	UGM 84D
	'Astute'	UGM 84D
	'Swiftsure'	UGM 84D
US	'Sturgeon'	UGM 84C
	'Los Angeles'	UGM 84C

Notes:
* Harpoon II customers.
** The Royal Navy plans to withdraw Sub-Harpoon from its inventory between 2003 and 2005. However, Block II might be acquired for the Astute class.

Specifications
Length: 4.64 m
Diameter: 0.34 m
Launch weight: 682 kg
Warhead: 222 kg
Charge: HE blast penetration
Range: 70 n miles

Contractor
The Boeing Company, Military Aircraft and Missile Systems Group, St Louis, Missouri.

VERIFIED

TORPEDOES

Introduction

The torpedo is the primary ASW weapon used by surface ships, aircraft and submarines. The weapon dates back to 1866 when Robert Whitehead developed the first real torpedo in his factory at Fiume, Italy. Driven by cold compressed air at a speed of about 7 kt, it was successfully demonstrated to a number of interested countries and by the early 1880s had been developed to run at speeds of up to 30 kt for distances of about 1 km. This method of propulsion continued to be developed until the early part of this century when experiments with heated air in the UK produced a dramatic increase in performance. In this system, paraffin, water and air were mixed, the result being a steam-air mix driving a radial engine. In the US a turbine-powered weapon was developed using alcohol as the fuel.

By the middle of the First World War, the torpedo had become a much more effective weapon, despite problems with the fuzing. Indeed, the British Mk 4 torpedo could run at distances of around 9 n miles at speeds of up to 40 kt, figures that with the exception of a Japanese torpedo in 1942 were not exceeded until a few years ago.

Between the First and Second World Wars a great deal of development continued in the field of warhead, fuzing and propulsion systems. One of the most remarkable and certainly the most long-lived products of this period was the British Mk 8 which was developed in the early 1930s and remained in service with the Royal Navy until 1986, more than 50 years of service. It was Germany which revolutionised the torpedo by introducing an electronically propelled weapon in 1939. Powered by lead/acid batteries this weapon could travel at 27 kt over ranges up to around 15 n miles. The German Navy also produced the first acoustic homing torpedo in 1943, another major milestone in torpedo development, as well as the wire guidance system that is used on all modern heavyweight torpedoes, and also wake following techniques. Post-war the latter had primarily been developed in the former Soviet Union, but other countries are now increasingly developing this technology.

By this time it had also been realised that not only were torpedoes essential for use against surface shipping, but they were even more necessary to combat hostile submarines. Indeed, this latter capability has now become the main requirement for the modern torpedo.

After the end of the Second World War, development continued apace, mainly in the field of electrically propelled weapons with acoustic homing systems, until the increasing speed and depth capabilities of submarines necessitated the return to a thermally powered torpedo. The two latest torpedoes are the thermally powered US Mk 50, which has now reached its end of nearly 20 years of development, and the Swedish Torpedo 2000. Torpedo development takes a very long time.

In the present economic climate, it is proving increasingly difficult to justify funds for development of a weapon which may take years to perfect. It is not, therefore, surprising to find increasing interest in international collaboration. One such venture is that between France and Italy to develop a new lightweight weapon based on experience with national programmes involving the Murene and A290 weapons.

Post-war advances in submarine design have laid down the most important requirements for ASW torpedoes as:

- stealth
- speed (sufficient to chase and overtake high-speed underwater targets)
- range and endurance (sufficient to carry out search, attack and, if required, re-attack procedures)
- onboard homing
- depth
- guidance.

In addition to these features, the modern torpedo must be able to distinguish between real and false targets and to disregard countermeasures. It must also be effective in shallow water as well as at the maximum operating depth of submarines. This requirement is now even more important as focus shifts towards littoral operations in regions of high ambient noise.

Finally, the submarine-launched torpedo must have a dual capacity to operate effectively against both surface targets as well as submarines. Space on board submarines is too precious for two types of torpedo with different roles to be carried.

Torpedoes have undergone a major transformation over the last two decades. Today's torpedo is a highly sophisticated, guided, homing missile. To achieve the features outlined above, a vast span of technologies have had to be encompassed covering such diverse disciplines as hydrodynamics; mechanical; electrical; thermal propulsion; electro-acoustic transducer design; signal processing and correlation; beam-steering; self-generated noise suppression; computers employing very advanced algorithms and incorporating signature libraries used for comparison; computer architecture; flow noise techniques; simulation and warhead design. The shift in emphasis from deep to shallow water is now driving further technology developments and in the coming years many torpedoes, both lightweight and heavyweight, will undergo further upgrades to meet the demanding requirements of changing scenarios.

With weapons embodying such sophisticated technologies, it is no longer necessary to employ salvo firing to attain a high-hit probability. A single wire-guided or fully autonomous torpedo in the hands of expert operators is sufficient to assure at least a 95 per cent hit probability. The problem is being able to place the weapon in exactly the right position to ensure a 100 per cent kill probability. This in turn demands that the weapon carries ever more sophistication and computation capabilities, combined with even more effective warhead charges, in many cases of the shaped directed type. While deploying torpedoes in salvoes is a tactic of the past, two modern sophisticated weapons can be deployed in certain circumstances against a target which is using highly sophisticated evasive manoeuvres. Using this tactic, the target can be attacked from different directions, both weapons homing on to the target at its most vulnerable spot to strike simultaneously. Used in this way the modern torpedo can enable a submarine to increase considerably the number of targets it can effectively attack.

An area which has been the subject of considerable development in recent years has been propulsion. Today, new and powerful thermal propulsion systems using mono-propellant and chemical reaction to produce steam to drive turbine engines have been developed. This has allowed weapons to achieve greater ranges and higher speeds and enables high-speed manoeuvring targets to be attacked and re-attacked until either the target is destroyed or eventually the weapon runs out of fuel. Preciously such systems have not been favoured because of the high radiated noise that they have produced. Modern technology, however, combined with quiet pump-jet propulsors has overcome this problem, and the noise generated by torpedoes powered by thermal systems is now comparable to that developed by battery-driven torpedoes at equivalent speeds. The standard electric propulsion system based on silver-zinc (Ag-Zn) or magnesium silver chloride (Mg-AgCl) is being replaced as the primary power source by more efficient and powerful silver-oxide aluminium (Al-AgO) batteries.

The development of effective torpedo warning capabilities in the latest generation of sonars, linked with the development of sophisticated countermeasures, is beginning to pose a major problem for the torpedo. To remain effective and achieve a high-hit/kill probability, torpedoes must now incorporate an increasingly sophisticated degree of stealth technology combined with a much more effective onboard sonar and processing capability. Together these will enable the next generation of weapons to 'burn through' the countermeasures, detect the real target behind them and effectively home on to it. New generations of torpedo will have to incorporate a high level of ECCM technology to counter anti-torpedo countermeasures currently under development.

Guidance involves the resolution of the fire-control equation by the combat information system and control of the weapon until its own onboard sensor can take over and home the weapon on to the target. Because of size constraints, torpedoes can only be fitted with small transducer arrays, which limits them to operating in the L-band with only a relatively short detection range capability. Hence the need to guide the torpedo to the vicinity of the target before its own onboard sonar can take over and complete the terminal homing phase.

Initial control of the weapon from the submarine command system is achieved using a very fine wire, some tens of kilometres in length. This fine wire is paid out from both submarine and torpedo. This ensures that the wire remains stationary in the water and unaffected by any strain resulting from manoeuvres by either the submarine or torpedo. The wire is used to carry commands from the submarine to the weapon and for response signals from the weapon to be fed back to the launch platform's combat information system.

The possibility of using fibre optics in the future with even finer connections between submarine and torpedo will permit the weapon to be guided for much longer periods and out to greater ranges than hitherto. It will also help to overcome ECM jamming techniques used to counter the torpedo. Furthermore, the much wider bandwidth will allow a much greater volume of data to be passed between weapon and launch platform. Linked to the use of fibre optics are developments designed to give the torpedo much greater tactical autonomy. However, improved operator control could be an advantage when the torpedo is used in an ASV role.

The need outlined above for higher speed creates severe problems at the front end of the weapon where the sonar transducers are mounted. To be effective, the weapon must be able to 'hear' its target, but the target must not be able to 'hear' the torpedo. The torpedo must, therefore, be a very silent weapon, employing the latest stealth technologies. This requires very careful design with detailed attention being paid to noise reducing techniques. To achieve detection at the maximum possible range the torpedo uses an LF sonar system. For terminal homing, torpedoes are fitted with an onboard signal processor and sophisticated algorithms which are capable of detecting the correct target, ignoring false contacts and countermeasures, and steering the weapon to the exact position and inclination of the target for the warhead to detonate with the maximum effect.

Modern software enables the weapon to operate effectively at high speed, the enormous signal processing capacity being able to sort out any problems arising from adverse hydrodynamic and self-generated noise. This enables the weapon to overcome any acoustic degradation at high speeds. To achieve this, fast Fourier transform is used for spectral analysis, together with correlation techniques, which are used to cancel out false returns and other ambiguities.

The problem is further aggravated in shallow water by the modern ultra quiet SSK. The torpedo's homing head must now also discriminate the real target against high background noise, bottom and surface reverberations as well as torpedo countermeasures. Against this noise the homing head must be able to detect and classify the low-Doppler real target. Whilst multibeam technology has done much to overcome these problems, the future must lie with advanced signal processing techniques such as pulse coding of individual beams and so on.

One area of development which has not been addressed to any major degree, except by the RFAS, is wake homing. Wake homing, when it can be effectively conducted, is immune to current countermeasures. Wake homing torpedoes are fitted with a single, upward-looking sensor which is used to detect and localise a ship's wake which may extend for some miles behind the vessel. The weapon is fired at an angle which anticipates crossing the wake and after registering the initial disturbance, and the exit from it, the weapon then continues to execute a zig-zag pattern across the wake following the narrowing width of the wake as it gets closer

to the ship. This homing method offers a number of advantages. It is almost impossible to replicate with a decoy, by using an upward looking sensor it overcomes to a large degree the self-generated noise of the torpedo. Finally, the wake sensor can also be used to detonate the torpedo when it senses the disappearance of the wake. The tactics can be further enhanced by the integration of satellite sensors used initially to detect a ship's wake, thus ensuring better positioning of the torpedo. Wake following technology will become really effective with the introduction of high-speed, long-range thermal torpedoes, for the weapons currently suffer generally from too low a speed – the speed of advance of the weapon being considerably reduced due to its zig-zag movement across the wake and hence the extended time required to reach the target, currently limited by the weapon's endurance. Wire-guidance and satellite information used by the launching platform's command system can, to some extent, overcome this disadvantage.

The torpedo tube has now become a general delivery system for missiles and mines as well as the torpedo, and most boats today ship a mix of missiles and torpedoes. As a general rule two or three mines can be substituted for each torpedo and submarine mines are available from numerous international sources. A feature now available for submarines is an external add-on container for mine stowage so that there is no reduction in the number of missiles/torpedoes carried.

Owing to the increased space demanded by bow sonars, there is a tendency to resite torpedo tubes from their traditional bow position to a position slightly further aft, and angled out from the centreline.

The type of torpedo carried depends, to some extent, on the boat's mission. In the past torpedoes were optimised for anti-submarine or anti-surface vessel missions. However, it is both a restriction on mission capability and a waste of valuable space for a submarine to carry two types of torpedo. Modern torpedoes are thus optimised for use against both surface and submerged targets.

Weapons stowage is an area of considerable importance and shock requirements, position of tubes, shape of compartment, size of weapon and handling arrangements all dictate the number and availability of weapon reloads that can be carried.

Two prime methods of discharge have been developed: positive discharge and swimout. In the swimout tube the weapon is discharged using its own propulsive system. It is thus entirely passive and relatively simple in construction. The positive discharge system is designed for use with weapons which have no means of self-propulsion, or which are specifically designed for positive discharge and can in fact handle all types of weapon with greater flexibility. In the positive discharge system energy is imparted to the weapon by an external source to push it out of the tube either by pneumatic water pulse (using air or hydraulic pressure as the prime mover), or mechanical means. Positive discharge systems allow a submarine to deploy tube-launched weapons at a wide range of speeds and depths. Both methods of discharge require that the torpedo tube be first flooded and vented to expel all air, then the tube pressure is equalised with sea pressure. After that the weapon can then be discharged.

In the swimout tube, the diameter of the tube is greater than the weapon in order to allow water to flow aft in the void caused by the weapon exiting the tube. This provides the weapon's propulsor an element against which to turn and provide the necessary thrust for discharge. To achieve successful launch the submarine's speed has to be limited, and changes of course avoided in order to prevent the weapon being damaged or jamming in the tube. One of the limitations of the swimout tube is that the energy required to achieve swimout by the weapon inevitably reduces the weapon's capability after launch. While the swimout tube requires less space it does require large volumes of water to be transferred during weapon loading, which requires large capacity tanks. The swimout system is low weight and does not require great energy. It does suffer from a disadvantage in that the torpedo propulsion makes a small noise which modern sonars are capable of detecting. Likewise the opening of the torpedo tube doors can be detected by modern sonars.

Unlike the swimout system, the positive discharge system does not require a major consumption of energy by the weapon in order to achieve discharge. Four types of positive discharge are available. The compressed air type can be independent of depth, but at greater depths it requires greater energy to accomplish discharge. Such systems were widely used after the Second World War but have now been largely superseded, except in some instances where they are used to launch air flight missiles. The piston pump (water ram), turbine-driven rotary pump and direct acting telescopic ram methods are all independent of depth.

The turbine rotary driven pump system is perhaps the most effective for it requires less space than a piston pump, weighs less and the discharge cycle is quicker. It also features a much lower acoustic signature in operation. The system can also be adapted to suit various types of weapon (for example, mines, torpedoes and missiles). The air turbine pump uses high-pressure air to drive a pump operating in a sea pressure-balanced water system and discharging into the torpedo tube to order to displace the weapon. By controlling the amount of air feeding the pump the discharge characteristics of the submarine can be changed merely by altering the software. In addition it offers the possibility of being able to varying the acoustic signature, thus making detection more difficult.

The telescopic ram is actuated by high pressure air or hydraulics and impacts directly on the rear of the weapon accelerating it to the required exit velocity. However, few weapons are designed to withstand the force imparted by the ram, which restrict the choice of weapons available. In addition the system has operational limitations with regard to vessel speed and attitude.

The fixed displacement piston pump uses an air/water ram configuration. Operationally the system can fire most positive discharge types of weapon at any depth and at a wide range of speeds and attitudes. Air for the discharge system is supplied from the primary ship system via an air reservoir and control valves. The air acts on a piston, which forces water through a transfer tank into the torpedo tube to discharge the weapon. Because of its size and weight the system is only suitable for installation in larger submarines, typically nuclear boats, where the size of the prime mover does not have such an impact on the space requirements for other equipment. All US nuclear submarine employ this type of discharge system.

One of the most important aspects of weapon discharge is the safety interlocks which must be incorporated to ensure that tubes are closed and drained of water before loading occurs. The number and siting of torpedo tubes, the discharge system selected and its design requirements, together with the type and number of weapons carried have a significant impact on the design of a submarine.

The latest developments underway in torpedo design relate to new propulsion systems which will drive torpedoes faster and deeper, greater endurance coupled with greater autonomy which will be further developed to parallel this development with increased onboard computing power, improved signal processing and much more sensitive homing heads. Modular weapon design will enable parts of a weapon to be upgraded without the need to design a completely new weapon (leading to reductions both in cost and in time of entry into service). Other areas that are currently the subject of study include the development of quieting and stealth techniques, improved acoustic performance to overcome submarine quieting techniques, and counter-countermeasures (both soft and hard kill) and improvements in initial guidance.

Many of these developments are being driven by the shift in emphasis from deep water operations to the littoral environment where poor acoustic properties tend to dominate with quiet diesel/AIP submarines exhibiting extensive stealth capabilities forming the primary target.

Recent developments, which will become of increasing importance, are related to anti-torpedo torpedo devices. Italy has already developed a mini torpedo for use as a 'hard kill' anti-torpedo device. In the USA studies into similar devices are being conducted under the Advanced Anti-Torpedo Torpedo (ATT)/Tripwire demonstrator programme. This encompasses a narrow diameter (158.75 mm) ATT that would be used to defend ships and submarine against salvoes of between two and four torpedoes. It is proposed that the vehicle would be powered by high-efficiency propulsors and advanced engines to provide the required speed and range. A high-precision exploder would be incorporated in the vehicle, and together with the speed and range and high-precision detection, classification and localisation of incoming torpedoes, would enable engagements to be undertaken at a safe distance away from the torpedo's intended target.

Torpedo programmes

Australia

Under the Joint Project 2070 the Australian Defence Force is planning to acquire new lightweight torpedoes to replace the current Mk 46. Thales Underwater Systems has been selected to carry out a Project Definition Study for the lightweight torpedo and has teamed with GEIE Eurotorp to offer the MU 90/Impact weapon. A RFP was issued and an order for MU 90 was placed in 2002. Plans to acquire a new heavyweight torpedo have been terminated, and the RAN will, instead, acquire the Mk 48 ADCAPa Mod 6.

Denmark

Early in 1999 Denmark ordered the Eurotorp MU 90 Impact lightweight torpedo together with four torpedo launcher shipsets for the Flyvefisken class. The torpedo entered service in 2001. The contract was signed after Denmark withdrew from participating in the Torpedo 90/Tp 46 project with Bofors of Sweden when that project was delayed following budget reassessments by the Swedish Government. A new heavyweight torpedo will probably be purchased around the end of the decade for the planned new submarines.

France

It is anticipated that a new heavyweight torpedo will be procured towards the end of the decade as further development of the F17 has ceased. This may be an off-the-shelf procurement.

Israel

Israel is to acquire German DM2A4 torpedoes under a US Foreign Military Funding (FMF) deal, under which Lockheed Martin Tactical systems will build the torpedoes in partnership with ATLAS Elektronik. The weapons will be embarked on the Dolphin class submarines.

Netherlands

Replacement of existing heavyweight torpedos may be undertaken later in the decade.

Portugal

The Navy will probably seek to acquire a new heavyweight torpedo when a decision is finally made on ordering a new class of submarines

Spain

New heavyweight torpedoes will probably be required to equip the new class of submarines projected when they begin to enter service.

South Africa

A new heavyweight torpedo is required to equip the new class of submarines that have been ordered. This will probably be either the DM2A4 or the A184 Mod 3.

South Korea

The Defence Development Agency is developing two weapons – the lightweight Blue Shark torpedo and the heavyweight White Shark weapon.

Turkey

The Turkish Navy has ordered a batch of 24 DM2A4 torpedoes to equip the improved Preveze class submarines.

Taiwan

Developed jointly by the Navy Logistics Command and the Chung Shan Institute of Science and Technology, the Wan Hsiang (Panorama) torpedo is now said to be entering service aboard ships of the Taiwanese Navy. It is speculated that the weapon is an acoustic homing torpedo using a wideband active/passive sonar. It probably uses pre-programmed search and attack procedures, including re-attack manoeuvres in case of 'lost contact'.

United Kingdom

Various options are currently under consideration for a follow-on weapon to succeed the Spearfish around the middle of the next decade, for which Spearfish will probably form the basis of the programme. Longer term conceptual studies are underway to examine the requirement for a common weapon that might replace both heavyweight and lightweight torpedoes in Royal Navy service for deployment from all torpedo launch platforms. It is anticipated that such a weapon would probably enter service sometime around 2025.

The Spearfish heavyweight torpedo is to undergo a littoral upgrade to improve its capability against ultra-quiet SSKs operating in shallow water conditions. The last weapon was handed over on 24 November 2003. It is believed that about 400 warshot weapons are held in the inventory. ***UPDATED***

Table XV

Operational torpedoes[12]

Model	Manufacturer	Country	Role	Dimensions[1]	Guidance	Weight[2]	Charge[2]	Range[3]	Speed[4]	Depth[1]	Operators
A 184	Whitehead	Italy	Dual	6.00 × 0.533	wire-active/ passive	1,265	250	13.5/9	24/36		Italy
A 244/S-244	Eurotorp	Internat	ASW	2.75 × 0.324	active/passive	221	>42	>3.5	30/36	>600 m	Argentina, China, Colombia, Croatia, Ecuador, Greece, India, Indonesia, Iran, Libya, Malaysia, Morocco, Nigeria, Pakistan, Peru, Poland, Serbia, Singapore, UAE, Venezuela
APR-2E	Russian Federation	Russian Federation	ASW	3.7 × 0.35	active/passive	575	100	2	62	1,000	India, Poland, Romania, Russian Federation, Serbia, Syria, Ukraine
APSET-95	Dvigatel Zavod	Russian Federation	ASW	3.84 × 0.406	Active/passive	720	60	8	20/40	15 - 500	Russian Federation
AT-2	Russian Federation	Russian Federation	ASW	4.7 × 0.533	Active/passive		80	5.5	40		Russian Federation, Ukraine
DM 2A3[5]	STN ATLAS	Germany	Dual	6.08 × 0.533	wire-active/ passive		260	15/7	23/35		Germany, Israel, Norway
DM 2A4	STN ATLAS	Germany		6.08 × 0.533							Germany, Israel, Turkey
E14	DCN	France	ASV	4.27 × 0.55	passive	927	300	3	25	18	Pakistan, Portugal
E15	DCN	France	Dual	5.9 × 0.55	passive	1,387	300	6.5	31	25	Pakistan
F17 Mod 2	DCN	France	Dual	5.4 × 0.533	wire-active/ passive	1,428	250	15.5/10.8[11]	24/40[11]	600	France, Pakistan, Spain, Saudi Arabia
L3	DCN	France	ASW	4.3 × 0.55	active	910	200	3	25	300	Pakistan, Portugal, Uruguay
L5	DCN	France	Dual	4.4 × 0.53	active/passive	1,300	150	5	35	555	Belgium, France, Pakistan, Spain, Turkey
Mk 37/1-2		USA	ASW	4.09 × 0.483	wire-active/ passive	766	150	11.5	24	270	Argentina, Egypt, Turkey, Peru
Mk 46	Raytheon	USA	ASW	2.59 × 0.324	active/passive	231	45	11	36/45	>600	Australia, Bahrein, Brazil, Brunei, Canada, Chile, China, Ecuador, Egypt, France, Germany, Greece, Indonesia, Iran, Israel, Italy, Japan, South Korea, Kuwait, Mexico, Morocco, Netherlands, New Zealand, Norway, Pakistan, Peru, Portugal, Saudi Arabia, Spain, Taiwan, Thailand, Turkey, UAE, UK, USA
Mk 48 ADCAP	Raytheon	USA	Dual	6.1 × 0.533	wire-active/ passive	1,814	267	43/33 [11]	40/55 [11]	800	Australia, Canada, Netherlands, USA
Mk 50	Raytheon	USA	ASW	2.896 × 0.324	active/passive	363	45	10	>50	1,100	USA
Mk 54	Raytheon	USA	ASW	2.5 × 0.324	active/passive	231	45		36/45	>600	USA
MU90 Impact	Eurotorp	Internat	ASW	3.00 × 0.324	active/passive	300	c50	>10	29/50	>1,000	Denmark, France, Germany, Italy, Poland
NT37		USA	Dual	4.50 × 0.485	wire-active/ passive	750	150	13.5	32		Canada, Egypt, Israel, Norway, Netherlands, Peru
SAET-40	Russian Federation	Russian Federation	Dual	4.5 × 0.40	active/passive[6]		100	5.4	30		Bulgaria, Russian Federation, Ukraine, Vietnam
SAET-60	Russian Federation	Russian Federation	ASV	7.8 × 0.533	passive		400	8.1	40		Bulgaria, China, North Korea, Libya, Russian Federation, Syria, Ukraine, Vietnam
SET 53	Russian Federation	Russian Federation			active/passive		400	8.1	45		Poland
SET-65E[8]	Russian Federation	Russian Federation	ASW	7.8 × 0.533	active/passive		205	8.1	40		China, India, Libya, Russian Federation, Serbia
SET-72	Gidropribor	Russian Federation	ASW	4.5 × 0.406	Active/passive		100	4.5	30	300	
SET-92K[9]	Russian Federation	Russian Federation	ASW	7.8 × 0.533	active/passive						Russian Federation
SST 4	STN ATLAS	Germany	ASV	6.08 × 0.533	wire-active/ passive	1,263	260	6.5/15[11]	35/23[11]		Argentina, Ecuador, Turkey, Greece, Turkey, Venezuela

Model	Manufacturer	Country	Role	Dimensions[1]	Guidance	Weight[2]	Charge[2]	Range[3]	Speed[4]	Depth[1]	Operators
SUT	STN ATLAS	Germany	Dual	6.62 × 0.533	wire-active/ passive	1,420	260	15/7[11]	23/35[11]		Chile, Colombia, Ecuador, Greece, India, Indonesia, South Korea, Pakistan, Taiwan
Seahuntor	Raytheon	USA	Dual	4.76 × 0.433	active/passive	868	150	15			
Shkval	Russian Federation	Russian Federation	ASW	8.00 × 0.533				5	50/200		Russian Federation, China
Spearfish	BAE Systems	UK	Dual	6 × 0.533	wire-active/ passive	1,850	300	30/12	60	>900	UK
Sting Ray	BAE Systems	UK	ASW	2.597 × 0.324	active	265	45	6	45	750	Brazil, Egypt, Malaysia, Norway, Thailand, UK
Test-71[7]	Russian Federation	Russian Federation	ASW	7.9 × 0.533	wire-active/ passive[12]	1,820	205	8	40		Algeria, China, India, Iran, Poland, Russian Federation, Romania, Serbia
Test-96	Russian Federation	Russian Federation	Dual	8 × 0.533	wire/wake active/passive	1,800	250				Russian Federation
Tigerfish	GEC-Marconi	UK	Dual	6.46 × 0.533	wire-active/ passive	1,550	135	7/15.7[11]	35/24[11]		Brazil, Turkey
Tp 45	Saab Bofors	Sweden	ASW	2.85 × 0.40	wire-active/ passive	310	45	10.75	15/25/35		Sweden
Tp 613	Saab Bofors	Sweden	ASV		wire-passive		250	8.2	45		Sweden
Tp 617	Saab Bofors	Sweden	ASV	6.98 × 0.533	wire-active/ passive	1,860	250	10	25		Denmark, Norway, Serbia, Singapore
Tp 62	Saab Bofors	Sweden	Dual	5.99 × 0.533	wire-active/ passive	1,314	200	21.5	50		Brazil, Sweden
Type E45	Russian Federation	Russian Federation	ASW	3.9 × 0.45	Active/passive	100	8.1	30			Bulgaria, Cuba, Russian Federation, Ukraine
Type 53-65	Russian Federation	Russian Federation	ASW	7.8 × 0.533	Passive wake	2,100	305	13	55	2-14	Algeria, India, China, Iran, Poland, Romania
Type 65	Russian Federation	Russian Federation	ASW	11 × 0.65	Wire-passive wake	4,500	450	54/27	0/50		Russian Federation
Type 89	Japan	Japan		n/k × 0.533	Wire-active/ passive		267	27/21[11]	40/55[11]	900	Japan
UGST	Russian Federation	Russian Federation	ASW/ ASV	7,200 × 533	Wire – active/ passive	2,200	200	18	35/50	>300	Russian Federation
UMGT-1	Dvigatel Zavod	Russian Federation	ASW	3.8 × 0.406	active/passive	950	60	8	20/40	15 – 500	Russian Federation
USET-95	Gidropribor	Russian Federation	ASW/ ASV	4.7 × 0.406	Active/passive	650	80	10	50	200	Libya
VTT-1	Russian Federation	Russian Federation	ASW	3,900 × 450	Active/passive		90	8.1	30	300	Russian Federation
	IpqM	Brazil					9.7	45			Brazil

ASV Anti-Surface Vessel.
ASW Anti-Submarine Warfare.
FO Fibre Optic
[1] Dimensions of length and diameter and operating depth are in metres.
[2] Total weight and explosive charge in kilograms.
[3] In nautical miles.
[4] In knots.
[5] Seehecht.
[7] Export version Test-71 superseded by torpedo promoted for export as Test-96.
[8] Domestic designation ET80-67.
[9] Supersedes ET80-67 as an export variant.
[10] Details provided where available. Operators listed only where confirmed.
[11] Active/passive.
[12] Wire guidance optional.

UPDATED

France

E14

Type
Submarine/surface ship-launched acoustic anti-ship torpedo.

Description
Developed in the 1970s. This is a conventionally shaped, submarine- or surface ship-launched, anti-ship (or anti-submarine against noisy targets close to the surface) torpedo with a strong body in light alloy and a laminated nosecone. It has the following five compartments: acoustic/passive self-guidance and M-7 electromagnetic firing device; explosive charge and impact fuze; secondary nickel-cadium battery (76 cells); air tank and automatic pilot; and 40 kW (at 900 rpm) electric motor for propulsion. The seeker consists of four transducers and a phase detector operating at 25 kHz with a 1 kHz bandwidth. Detection range is in the order of 500 m with a maximum detection range of 800 m. The torpedo can attack surface vessels proceeding at speeds up to 20 kt and submarines at shallow depth. The fuze activation range is variable between 6 and 18 m. The E14 has the same geometry and mechanical features as the L3. Some E14 torpedoes have been upgraded to E15 Mod 2 standard.

Operational status
The E14 is no longer in service with French forces, but is still in service in some other navies (Pakistan and Portugal). The weapon is no longer in production.

Specifications
Length: 4,279 mm
Diameter: 550 mm
Weight: 927 kg
Warhead: 200 kg Tolite
Propulsion: electric
Speed: 25 kt
Range: 3 n miles
Operating depth: 300 m

Contractor
DCN, Saint Tropez.

UPDATED

E15

Type
Submarine/surface ship-launched acoustic anti-ship torpedo.

Description
Developed in the 1970s, this is a conventionally shaped, submarine- or surface ship-launched, anti-ship (or anti-submarine against noisy targets close to the surface) torpedo with a strong body in light alloy and a laminated nosecone, the E15 is a lengthened version of the E14 Mod 1 torpedo. It has the following five compartments: acoustic/passive self-guidance and M-7 electromagnetic firing device; explosive charge and impact fuze; secondary silver-zinc battery (120 cells); air tank and automatic pilot; and 50 kW electric motor for propulsion. The seeker consists of four transducers and a phase detector operating at 25 kHz with a 1 kHz bandwidth. Seeker detection range is in the order of 1 n mile. The search depth is 25 m, while the weapon has a variable depth setting of 6 to 18 m. The torpedo can attack surface vessels proceeding at speeds up to 20 kt and submarines at shallow depth. The self-guidance system is the same as the E14, but geometry, range and explosive charge are different.

The E15 has been upgraded to Mod 2 standard. This constitutes fitting a new homing head of the AH-8 type, and replacing the batteries with silver-zinc primary batteries.

Operational status
The E15 is no longer in service with French forces, but remains operational in some other navies (Pakistan, Portugal and South Africa). The weapon is no longer in production.

Specifications
Length: 5,900 mm
Diameter: 550 mm
Weight: 1,387 kg
Warhead: 300 kg Tolite A1
Propulsion: electric silver-zinc battery
Speed: 31 kt
Range: 6.5 n miles
Operating depth: 300 m

Contractor
DCN, Saint Tropez.

UPDATED

F 17

Type
Submarine/surface ship-launched wire-guided torpedo.

Description
The F 17 torpedo family comprises the following models: F 17 Mod 1, F 17P, F 17S and F 17 Mod 2. F17 Mod 2 is the only torpedo still to be produced by DCN.

These torpedoes are deployable from surface vessels or submarines and are able to destroy surface ships and submarines (except for the F 17 Mod 1 which can only be used against surface ships or noisy submarines close to the surface).

Launching by submarine may be performed in one of the following three modes:
- pneumatic ram
- water ram (including turbo-pump set)
- swimout (this mode has been qualified with a MAK tube).

The F 17 torpedo carries an extensive warhead charge which enables it to operate successfully against all naval vessels. The sonar homing system can operate either in passive or active mode (except F 17 Mod 1, which operates only in passive mode) giving a high-detection performance. An internal counter-countermeasures system enables the F 17 Mod 2 and F 17S to strike their targets under the most adverse conditions. These performance features, associated with a long-range, high-speed, great operating depth, plus the ability to operate with considerable stealth, give the F 17 torpedoes a formidable capability.

The F 17 Mod 1 and F 17P can be updated to the Mod 2 or S standard. (All the F 17 Mod 1 torpedoes in the French Navy have been updated to F 17 Mod 2.)

Maintenance time interval has been increased to 18 months, and also simplified.

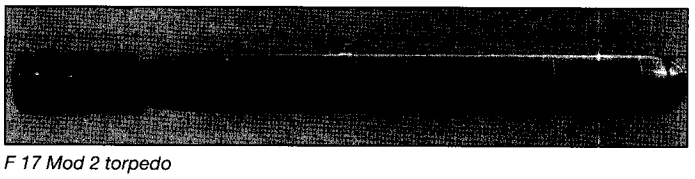
Physical characteristics of the torpedo and its tube container for Agosta class submarines

	Diameter[1]	Length	Weight
F 17 Mod 1	533 mm	5,914 mm	1,431 kg
F 17P	533 mm	5,914 mm	1,431 kg
F 17 S	533 mm	6,003 mm	1,539 kg
F 17 Mod 2	533 mm	5,406 mm	1,428 kg

Note: [1]can be increased to 550 mm if required

The F 17 Mod 2 is in current operational service. The Mod 2 has been upgraded, the main improvements relating to the propulsion, homing head and the counter-countermeasures capabilities. The weapon features a new all-digital control and guidance unit. At high speed the F 17 Mod 2 electric heavyweight torpedo has sufficient range capability to enable it to overtake most escaping targets.

Although the F 17 Mod 2 is quite stealthy at high speed, to take into account new detection performances of some targets, it now features a two-speed capability. The ability to command a slow speed (24 kt) enables the torpedo to carry out a very stealthy approach phase, but with the possibility of switching to high speed (40 kt)

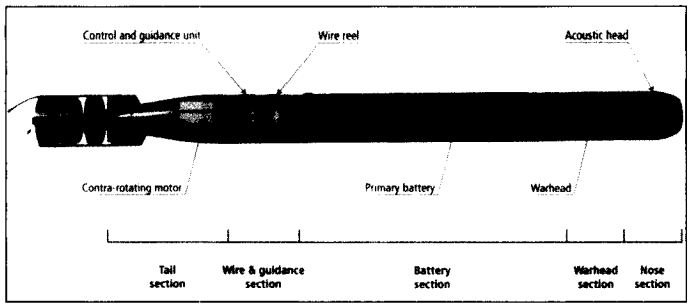


F 17 Mod 2 torpedo

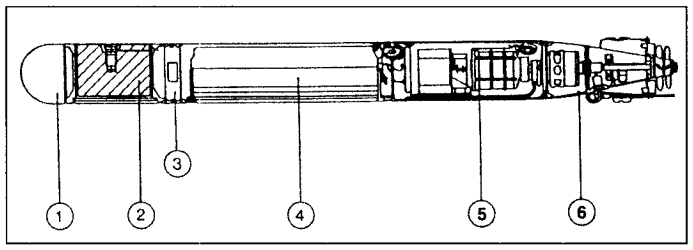
Operational characteristics: F 17

	Target[2]	Speed	Range	Counter-countermeasures capabilities	Maximum attack depth	Search depths[3]
F 17 Mod 1	ss	35 kt	18,500 m	low	>500 m	Za, 30, 100 or 200
F 17P	ss/sub	35 kt	18,500 m	low	>500 m	Za, 30, 60
F 17 S	ss/sub	35 kt	18,500 m	high	>600 m	Za, 30, 100 or 200
F 17 Mod 2	ss/sub	24/40 kt	20,000 m (at 40 kt)	very high	>600 m	Za, 30, 100 or 200

Notes:
[2]ss = surface ship; sub = submarine
[3]Za = depth against surface ship attack (Za = 6 to 20 m)



Block schematic of A 184 Mod 1 0093518



Cutaway of F 17 Mod 2B torpedo (DCN International)(1) Acoustic head with transducers and associated electronics
(2) Warhead with explosive charge and impact fuze
(3) Influence fuze
(4) Primary propulsion battery and secondary battery
(5) Guidance unit
(6) Propulsion motor, propellers and rudders 0093519

via wire-guidance commands. The homing head can operate in active or passive mode, or both simultaneously. The brushless, low-speed synchronous motor results in further reduction in self-generated noise. Power is provided by a PB32 Ag-Zn battery.

A special version of the F 17 Mod 2 has been designed for the A 209 or TR 1700 submarines (mechanical interfaces and adaptation for the swimout discharge). In addition, interoperability with different fire-control systems has been examined and is possible for most with few modifications.

Operational status
The F 17 Mod 1 and F 17P are operational with several navies (Pakistan and Saudi Arabia). F 17 Mod 2 has been in service with the French Navy since 1989 and the Spanish Navy since 1993. Only the F 17 Mod 2 remains in production. There are no plans to upgrade the F 17 Mk 2, although some product improvements may be incorporated.

Specifications
(Mod 2)
Length: 5,406 mm (with Agosta class tube container)
Diameter: 533 mm (can be increased to 550 mm if required)
Weight: 1,428 kg (with Agosta class tube container)
Warhead: 250 kg PBX3
Propulsion: electric
Speed: 24/40 kt
Range: 10.75 n miles @ 40 kt (15.5 n miles if the torpedo runs at 24 kt during the whole wire-guidance phase)
Guidance: wire and automatic homing
Fuze: magnetic proximity and impact

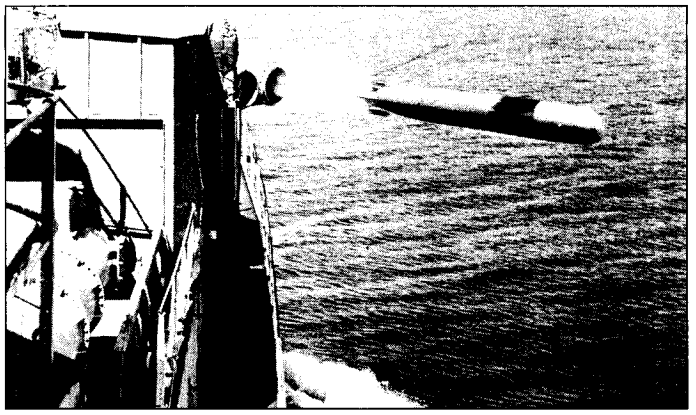
Contractor
DCN, Paris.

VERIFIED

L3

Type
Submarine/surface ship-launched active acoustic torpedo.

Description
Developed in the 1960s, this conventionally shaped, ship- or submarine-launched, anti-submarine torpedo has a strong body in light alloy and a laminated nosecone. It has the following five compartments: AS-3T active acoustic self-guidance and electromagnetic firing device; explosive charge and impact fuze; secondary nickel-cadmium battery (76 cells); air tank and automatic pilot; and 40 kW (at 900 rpm) electric motor for propulsion. Location in bearing and elevation is used to guide the torpedo along a pursuit curve. As the torpedo nears the target, the pulse rate increases to improve the accuracy of pursuit and of the acoustic detonator. If after a computed time the target has not been detected at the previous position, the torpedo commences a circular search (in shallow water) or a helical search (deep water). The torpedo can attack vessels proceeding at speeds up to 20 kt and down to a maximum of 300 m depths. The active seeker has a range of about 600 m. The fuze is a combined impact/acoustic type.



L3 acoustic torpedo launch

Operational status
The weapon is no longer in service with French forces but is still in service in other navies (Pakistan, Portugal, South Africa and Uruguay). Approximately 600 weapons were manufactured. The weapon is no longer in production.

Specifications
Length: 4,300 mm
Diameter: 550 mm
Weight: 910 kg
Warhead: 200 kg Tolite A1
Propulsion: electric
Speed: 25 kt
Range: 3 n miles
Operating depth: 300 m

Contractor
DCN, Saint Tropez.

UPDATED

L5

Type
Surface/submerged launch dual-role torpedo.

Description
Developed in the early 1970s, the L5 is powered by silver-zinc batteries which are activated at launch and provide the power for the motor, which drives twin contrarotating propellers. There are three models: L5 Mod 1; L5 Mod 3; L5 Mod 4.

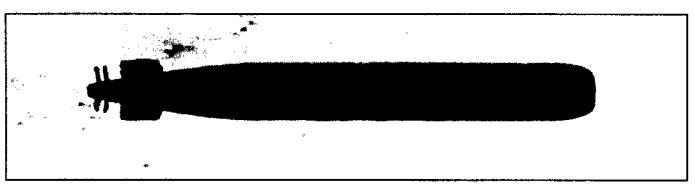
The Mod 1 and Mod 3 have been in operational service with the French Navy for a number of years. The Mod 4, derived from the Mod 1, is carried by surface ships of the French Navy and several other navies. All models are designed to attack both underwater or surface vessels. The Mod 3 is submarine-launched and the Mod 1 and Mod 4 are launched by surface ships and submarines. All models are fitted with a passive/active homing head with various operating modes, including direct attack or programmed search. The fuze is of the impact/magnetic type. The compact size of this weapon makes it ideal for operation from small displacement submarines.

Operational status
Operational with the French Navy and other navies (Belgium, Malaysia, Spain and Turkey). The weapon is no longer in production.

Specifications
(L5 Mod 4)
Length: 4,400 mm
Diameter: 533.4 mm (can be increased to 550 mm if required)
Weight: 1,300 kg (Mod 3), 1,000 kg (Mod 1)
Warhead: 150 kg HE
Propulsion: electric
Speed: 35 kt
Range: 5 n miles
Operating depth: 555 m

Contractor
DCN, Paris.

UPDATED



An L5 torpedo about to enter the water (H&L van Ginderen) 0529692

Pneumatic Ram

Type
Weapon discharge device.

Description
The pneumatic ram discharge device is designed to be capable of launching all types of underwater weapons.

The device consists of five (sometimes four) pistons designed to push the weapon out of the launch tube with the required velocity. The pistons are housed in a jacket which fits into the telescopic ram through the rear door of the tube.

The aft part of the ram device contains a high-pressure air chamber. The high-pressure air is released by the firing valve to act on the centre of each piston which is used to push the weapon out of the tube. To reduce the force of the high-pressure air at the end of the travel of each piston, water is allowed to escape through a series of small holes in the annular chamber which surrounds the end of each piston. The braking of the largest piston (the first to be extended) is achieved by the return of water to a tank through holes in the jacket, for the second by laminating water through the holes of the first piston, and so on.

The device is fully protected by circuits which control all safety systems before allowing the firing valve to open. This ensures full watertight integrity when the bow cap of the tube is opened prior to deployment of the weapon.

After firing, the device is reset by releasing air pressure in the telescopic ram, after which water is forced through the braking holes. This is achieved by putting pressure on the braking circuit of the largest piston which allows water to enter the annular chamber of the piston through the holes. Thus, the pistons are re-cocked in order of largest to smallest.

The telescopic ram is capable of launching weapons down to depths of 1,000 m using air pressure at 250 bar.

Noises generated by the extending of the telescopic ram are very distinct. However, the duration of the mechanical noise produced by the ram is of the order of only 0.5 s which is very short compared to other noises generated by the handling and launch of the weapon (that is, loading the weapon into the tube, flooding the tube with the weapon in situ, opening the bow cap prior to launch and so on).

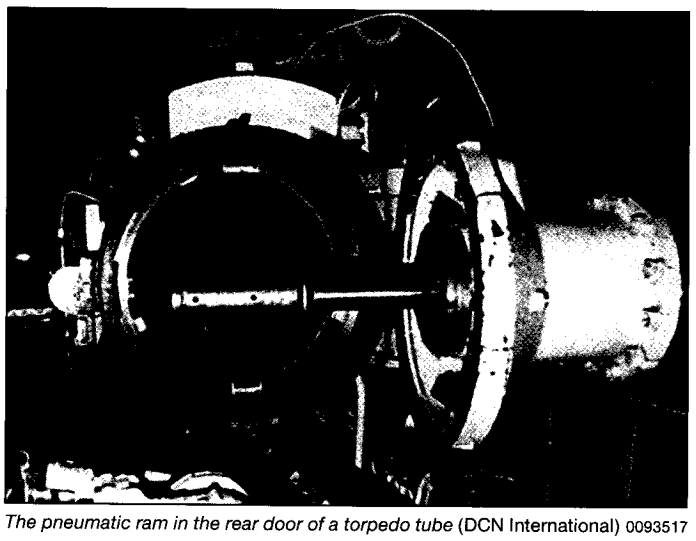
The acceleration imparted by the telescopic ram is of the order of 4 to 5 *g* for a standard torpedo. Lower accelerations (necessary for minelaying operations) can be imparted by reducing the air pressure in the air reservoir tank or through the control of the firing valve. Normal air consumption is around 14 kg, depending on the control of the firing valve.

The telescopic ram can launch a weapon at all submarine speeds as long as the tubes are parallel to the boat's axis. When the tubes are configured in a splayed arrangement then submarine speed at weapon launch has to be limited according to weapon attitude at the exit of the shutter cap in order to avoid imparting shocks to the weapon. In a typical example, deployment of a French torpedo using a telescopic ram from a tube inclined outwards at 15° will limit the speed of the submarine to 15 kt.

Operational status
In service aboard all French submarines.

Contractor
DCN, Paris.

VERIFIED



The pneumatic ram in the rear door of a torpedo tube (DCN International) 0093517

Primary batteries

Type
Batteries for heavyweight torpedoes.

Description
SAFT has developed the new aluminium silver oxide battery system which powers the lightweight MU90 Impact torpedo. The company also has a range of primary and secondary batteries for underwater defence applications including: silver-zinc, magnesium-silver chloride and advanced lithium-ion electrochemical systems.

SAFT is also working with WASS in Italy in developing a primary cell system for the Black Shark torpedo. SAFT already has a contract to supply the secondary cell system for the Black Shark.

Operational status
Operational in MU90 Impact lightweight torpedo.

Ag 0/Zn and Ag Cl/Mg batteries for underwater weapon systems are in service with the navies of: Argentina, Australia, Brazil, China, France, Germany, Indonesia, Italy, Norway, Peru, Singapore, Spain, Sweden, Taiwan, UK and USA.

Contractor
SAFT, Bagnolet.

VERIFIED

Germany

Permanent Magnet Motor

Type
High speed permanent magnet motor.

Development
The demand for high efficiency in torpedo propulsion has led to the development of a new drive for lightweight and heavyweight electric torpedoes. An analysis of various drive concepts linked with new and developing technologies has resulted in the development of a high speed brushless synchronous motor fitted with permanent magnets. To ensure that the motor is suitable for the demanding environment and scenarios in which torpedoes must operate, special emphasis has been laid on the specifications for weight, volume, power, speed change, efficiency and acoustic behaviour. Tests and wet runs have confirmed the design and development requirements.

Description
Compared to the power:weight ratio of previous drives of approximately 0.6 kW/kg, the new drive has achieved a ratio of 3.0 kW/kg. The efficiency (electric power input to shaft output) has been improved from approximately 80 per cent to approximately 92 per cent.

Operational status
The new propulsion drive has achieved international orders, and production of one motor size has already reached 1,000 units, while a production of a different sized motor has already reached the hundreds.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

Seapike

Type
Low cost anti-submarine weapon.

Development
Seapike has been developed to provide an immediate response against the threat of underwater targets of low confidence and poor classification such as a possible submarine operating in coastal and confined waters where high false alarm rates predominate. These conditions result from high ambient noise, rugged bottoms, rocks and wrecks result in high scattering of sonar echoes and poor discrimination, and temperature and salinity gradients, reverberation and biological life cause degradation in sonar echoes.

The need for low cost, immediate response weapons for use in conditions of short detection ranges and short reaction times was highlighted in the Falklands campaign of 1982, where large numbers of relatively expensive ASW weapons were expended against what were subsequently proven false alarms. Seapike has therefore been developed as a low cost homing weapon, which carries out a 'search while sink' procedure before initiating a powered homing attack against a proven target. Being of very small size and low weight compared to a lightweight torpedo, Seapike can be carried in large numbers for the prosecution of operations against a large number of potential targets, numbers of which may prove to be false alarms, but which ensures that any target within the scene of operations will be attacked.

Description
Seapike is designed in two configurations, either as a gravity-launched weapon for use from air platforms or as a rocket-launched weapon carrying out a ballistic flight from a sea platform. In both cases, a parachute retards the weapon before it enters the water. In the rocket-launched configuration, the weapon is stored with wings

folded in a sealed launch canister, which provides protection against the environment and for ease of handling. The gravity launched configuration comprises just the weapon and parachute, the round being housed in a logistic container for storage and transport only. The ship-launched weapon can be integrated into any existing launcher providing training in azimuth and elevation and stabilisation for low pointing errors. In this configuration, an interface is provided to the ship's combat management system allowing exchange of relevant threat, navigation and meteorological data, as well as control and display data. The MMI can be provided either with a dedicated control console or via a multifunction console within the combat management system. The shipboard fire-control processor determines the azimuth and elevation on firing and parachute release time. Preset data for the weapon before firing is the parachute release time, which is sent to the weapon control unit.

On entering the water, the parachute is discarded and the weapon's sidescan sonar is activated to conduct a 360° active search in a horizontal cylindrical pattern around the weapon as it sinks through the water. The side scan sonar features high vertical directivity, which allows the system to filter out and suppress reverberation and boundary echoes, which characterise littoral and shallow waters. As the weapon sinks, a nose-mounted sensor array is used to detect any targets positioned directly under the weapon, and as an echo sounder, which allows the weapon to be deployed in extreme shallow waters.

On detecting a 'real' target, the weapon's propulsion system is activated and the weapon is turned from its vertical attitude to a horizontal attitude. It returns to the detection depth and is turned in the direction of the target determined by the side scan sonar. During the homing phase, the weapon homes onto the target using signals from the sensor array mounted in the weapon's nose. In the vicinity of the target, the weapon carries out a special terminal phase manoeuvre, which ensures that the warhead with the small shaped charge strikes the submarine's hull in as perpendicular a way as possible. The shaped charge is capable of penetrating double hull boats, causing a mission abort.

For air launch the procedure is similar to that for a lightweight torpedo. On the command to launch, the weapon is released from the aircraft and lanyards attached to the aircraft's fuselage release the parachute.

The range of Seapike with sonobuoy dimensions, is in the region of several nautical miles.

Operational status

Large-scale trials have been conducted with a demonstration model to prove the 'search while sink' procedure and performance of the shaped charge against double hull submarine designs. It is estimated that further development to reach prototype/production stage will take about four years. A number of overseas navies have shown interest in the weapon including Sweden, which has a requirement for an LCAW for its 'Visby' class corvettes.

Any future development will probably be of a collaborative nature.

Contractor

ATLAS Elektronik, Bremen.

VERIFIED

Seehecht (DM2A3)/Seahake and Seehecht (DM2A4)/Seahake Mod 4

Type

Anti-surface and anti-submarine torpedo.

Development

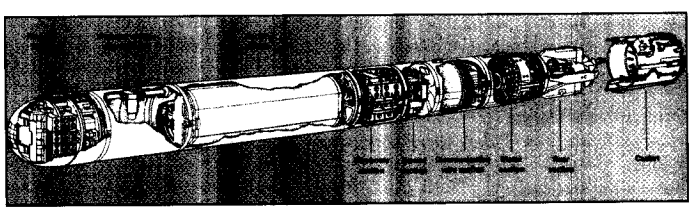
This wire-guided, heavyweight, 21 in (533 mm) acoustic homing torpedo has been developed to replace the Seal and Seeschlange torpedoes in service with the German Navy and NATO countries.

In a further development it is planned to modify the DM2A3 into the DM2A4 configuration incorporating a new propulsion system leading to increased speed and range, and improved electronics.

Based on the DM2A3 a new generation of torpedoes for a specific export market designated Seahake has been developed in accordance with the regulations of the German MoD. There are some differences in hard and software in order to meet the export regulations and the special requirements for worldwide application. However, the main characteristics of the DM2A3 (Seehecht) are incorporated in the new design.

Description

Seehecht is a dual-purpose torpedo which can engage surface and submarine targets and can be launched from both surface vessels and submarines. The main



Cutaway of Seehecht (STN ATLAS Elektronik) 0038527



Seehecht torpedo on test-stand

features of the weapon are: extremely long guidance distance; silent running resulting from the greatly improved propeller design (skew propellers in GRP) and other special measures (elastic motor suspension and special shaft bearings); impact and improved magnetic proximity fuze with high ECCM capability; improved communication system for two-way transmission of extended volume of data, including the complete acoustic panorama and wideband noise samples; stabilisation system with highly accurate sensors (course attitude reference gyro with depth maintained by pressure cells) and regulator systems optimised for multiple operational requirements; multistage guidance concept including highly intelligent internal guidance programs; the 3-D TOSO acoustic homing head with horizontal conformal array using PFB technology and covering a wide panorama; operation in active and passive modes in several frequency bands with preformed beam technology; ability to handle multiple target situations with numerous features capable of identifying or suppressing jammers and decoys; the latest technology using microprocessors connected via a MIL-BUS system and fibre optic conductors; and extensive BITE (Built-In Test Equipment).

The DM2A4 features an improved battery, new propulsion system driving contrarotating propellers and a redesigned after section. Speed will be increased by ×1.5 compared to the DM2A3 and propulsion energy will be increased by more than ×3. The high-speed electric motor of the DM2A4 is powered by modular silver zinc oxide (ZnAgO) batteries with an effective heat management system allowing a considerable increase in peak energy to be developed. The disc shaped batteries are combined in a standard unit which can be configured with one, two, three or four modules. This configuration allow a maximum range of >25 n miles to be developed and a maximum speed of >50 kt. However, some suggest that a configuration of just two modules would be sufficient to counter most of today's targets. The ability to add or remove battery modules provides the weapon with greater flexibility to counter different types of threat. The new motor is an electronically controlled stepless permanent magnet high speed, closed-loop cooled DC motor of modular design developing 300 kW and driving a carbon fibre skewed 5+9 bladed propeller. The same TOSO conformal sonar head as the DM2A3 is retained but with some hardware and software upgrades, notably a wake homing capability. The passive and combined passive/active multi-frequency sonar with very wide panorama angle uses full digital signal processing, offering multiple target engagement and TCCM features. The guidance wire is a fibre optic system. Precise navigation and attitude control is achieved using a digital strap-down system with fibre optic gyros. The proximity fuze is an active magnetic system using digital signal processing. The weapon can be discharged using either swim-out tubes or positive discharge.

Upgrade kits are being produced to allow remanufacture of the DM2A3 to DM2A4 standard. Further upgrades to the DM2A4 torpedo envisage enhanced sensor and guidance performance with the digital sonar using adaptive frequency and beam forming to improve detection ranges and resolution of multi-target situations. This software upgrade was scheduled for implementation during 2003-04. Other software upgrades will address the future introduction of new torpedo countermeasures systems, especially the use of hard kill effectors. This upgrade will be implemented around 2008. Finally, improvements to the battery system, possibly including the incorporation of new battery technology, will result in speed and range enhancements. This development is currently under design.

Operational status

DM2A3 - Entered service in the early 1990s. In service in the German, Norwegian and Turkish navies. The last DM2A3 was delivered to the German Navy at the end of 1997.

DM2A4 - In full scale development. Technical evaluation scheduled for 2000/2001, with 10 initial full production weapons ordered in 2001. Due to be delivered in 2003 to arm the German Type 212 boats. It is thought that series production for the German Navy will total less than 100 weapons due to the reduced requirement for heavyweight torpedoes since the ending of the Cold War. Turkey will also receive 50 warshot DM2A4 torpedoes fitted with a two-module battery.

Under FMF (Foreign Military Financing) funding the Seahake was supplied to Israel for the Dolphin class submarines. Lockheed Martin Naval Electronics & Surveillance Systems has signed the FMF contract with STN for series production and delivery of the Seahake.

Specifications
DM2A3/Seahake
Length: 615 cm (662 cm with guidance wire casket)
Diameter: 533 mm
Speed: 18-35 kt
Range: 7-15 n miles

DM2A4/Seahake Mod 4
Length: 6.62 m
Diameter: 533 mm
Speed: >35 kt
Range: >15 n miles

Contractor
ATLAS Elektronik GmbH, Bremen/Wedel.

UPDATED

SUT

Type
Anti-surface vessel and anti-submarine torpedo.

Description
Developed in 1975, the SUT (Surface and Underwater Target) torpedo is the export version of the DM1 Seeschlange and is the most versatile member of the Seal, Seeschlange and SST 4 family of torpedoes. It is a dual-purpose wire-guided torpedo for engaging both surface and submarine targets. The SUT can be launched from submarines and surface vessels, from fixed locations or mobile shore stations. Its electrical propulsion permits variable speed in accordance with tactical requirements, silent running and wakelessness. The wire guidance gives immunity to interference with a two-way datalink between vessel and torpedo. The acoustic homing head has long acquisition ranges (active – 1 n mile; passive – 3 n miles) and a wide search sector for active and passive operation. After termination of wire guidance, SUT continues operation as a highly intelligent homing torpedo, with internal guidance programmes for target search, target loss and so on. The large payload with combined fuze systems ensures the optimum effect of explosive power. The three-speed motors drive 5/7-bladed contra-rotating propellers. The SUT operates at great depths as well as in very shallow waters. Consort operation permits exploitation of the full over-the-horizon range of the SUT. The body is made of plastic or aluminium. SUT at present exists in three different versions with slight differences in the internal guidance programs and the extent of data transferred via the guidance wire. The latest version is SUT Mod 2 with its special feature of additional data from the homing head being signalled back to the vessel including an 'Audio Channel'.

Operational status
No longer in production. Remains in service with several navies including: Chile, Colombia, Ecuador, Greece, India (168 weapons), Indonesia, Pakistan, South Africa, South Korea and Taiwan. In the early 1980s Indonesia signed a contract for indigenous manufacture of the SUT within a long-term programme. A total of about 400 weapons have been sold for export.



Surface and Underwater Target (SUT) torpedo

Specifications
Length: 6,150 mm (6,620 mm with guidance wire casket)
Diameter: 533 mm
Weight: 1,420 kg (without casket)
Warhead: 260 kg
Speed: selectable, max 35 kt
Range: 15 n miles @ 23 kt or 6.5 n miles @ 35 kt
Fuze: magnetic proximity and impact
Operating depth: 2-460 m

Contractor
ATLAS Elektronik GmbH, Bremen/Wedel.

UPDATED

SST 4

Type
Special anti-surface vessel torpedo.

Description
Developed in 1968, the SST 4 (Special Surface Target) torpedo is comparable in its dimensions, construction and capabilities to the Seal weapon, except for those features which can only be applied within the operational area of the German Navy. In this respect the SST 4 has been adapted to a standard international version. It has an operating depth down to 110 m.

The basic design has been continually improved over the years, especially in the homing head functions and in the stabilisation and related control system.

Further improvements covering additional return signals (actual course, speed and depth) and magnetic proximity fuze are incorporated in the SST 4 Mod 1 configuration. A modification kit is available for conversion of SST 4 weapons to SST 4 Mod 1 configuration.

The weapon features an impact fuze and a fixed seeker. The search patterns are 'snake' and 'circle'.

Operational status
No longer in production. In service with navies of Argentina and Greece. A total of about 300 torpedoes were manufactured.

Specifications
Length: 608 cm (655 cm with guidance wire casket)
Diameter: 533 mm
Weight: 1,263 kg
Warhead: 260 kg
Propulsion: electric
Speed: selectable, 23/35 kt
Range: 19.5 n miles @ 23 kt or 6 n miles @ 34 kt.
Guidance: wire-guided, dual-core with two dispensing systems; active/passive homing sonar
Fuze: impact (SST 4 Mod 1 proximity magnetic also)
Operating depth: 2-110 m

Contractor
ATLAS Elektronik GmbH, Bremen/Wedel.

UPDATED

India

NST-58

Type
Lightweight torpedo.

Description
It is understood that this weapon is a derivative of the Italian A-244S (see A-244S entry) and that production commenced around 1986, but no precise details are available. Originally, some 12 A-244S weapons were delivered to India out of a total of 36 ordered. It may be that after the 12th weapon had been delivered, India undertook licence production of the weapon. Certain modifications were incorporated as a result of development work undertaken at India's Naval Science and Technology Laboratory in Vishakhapatnam.

Operational status
In service with the Indian Navy aboard the Brahmaputra and Godavari class frigates.

UPDATED

International

A244/S Mod 3

Type
Lightweight air- and surface-launched anti-submarine weapon.

Development
To meet its requirement for a lightweight anti-submarine torpedo, the Italian Navy purchased the US Mark 44 Mod 2. By 1968 the Italian Navy recognised that a replacement was needed for the Mark 44 and in that year, issued a staff requirement for a new lightweight torpedo.

To meet the requirement Whitehead Motofides (now Whitehead Alenia Sistemi Subacquei - WASS) began to develop the A244 and, in 1973, produced the prototype weapon. This reportedly entered production for the export market in 1975. A more sophisticated version, the A244/S, was developed almost simultaneously. This weapon, however, was not selected by the Italian Navy, which at the time had no requirement for a new lightweight torpedo. Nevertheless, Whitehead continued development of the weapon and began to sell it from 1978.

The A244/S was to have been replaced by the A 290, development of which began in 1981, but in 1990 this programme was merged with the French Murene to form the MU 90/Impact programme.

The latest model of the A244/S is the Mod 3, which is marketed by Eurotorp, together with the MU 90/Impact lightweight torpedo.

The A244/S Mod 3 torpedo is the latest evolution of the A244/S fire-and-forget ASW lightweight torpedo family, which is currently in service with 15 navies. The unique and extensively proven shallow water performance has been further enhanced in the A244/S Mod 3 to cope with the evolved capabilities of the submarine and its operational theatres, such as:

- Long engagement range to increase the escape probability of the launching vessel against a possible reaction from the target under attack
- Capability to counter more and more sophisticated anti-torpedo countermeasures released by the submarine
- Capability to counter more and more stealthy threats
- Capability to significantly delay the target's anti-torpedo alert and its reaction
- Capability to fully cope with littoral warfare scenarios

The A244/S Mod 3 torpedo has been designed to counter the threat posed by any conventional submarine as well as nuclear boats when engaged at the transit speed of up to 15 kt, even when they are acoustically treated or deploying anti-torpedo countermeasures and evading at a maximum speed of 30 kt.

The weapon can be deployed by surface platforms as well as by fixed and rotary wing aircraft.

Description
The A244 Mod 3 is a 324 mm 'NATO standard' calibre, lightweight anti-submarine torpedo. The weapon is powered using a hazard-free, pollution free, 246-cell silver chloride and magnesium alloy salt water battery which incorporates an electrolyte re-circulation system. The torpedo is propelled by a high efficiency dual speed (30/36 kt) DC motor directly driving the propeller shaft with two contra-rotating propellers.

With a DC-DC chopper feeding the motor the torpedo is able to operate at two constant speeds, automatically selected by the tactics of the weapon according to the scenario and the operational phase.

Featuring long range and endurance the weapon operates without any speed degradation in sea water as deep as 600 m and as shallow as 30 m and retains navigation capability up to 10 m.

The advanced acoustic seeker features multi pre-formed transmission and reception beams. Its multifrequency and multi-acoustic mode operation allow high engagement ranges and high performance in very shallow water and provide the weapon with high immunity to anti-torpedo countermeasures. The state of the art microprocessor-based control and guidance electronics accommodate the operational and tactical software including the signal processing, data processing and torpedo guidance laws.

The homing system, matched with the propulsion system capability, offers target engagement ranges in excess of 11,000 m. The homing head uses 10 preformed transmission beams and eight preformed receive beams. Transmission pulses are frequency/time coded and the weapon carries out spatial diversity and coherent analysis on signals. The computerised homing system also provides for presettable combinations of signal processing, spatial filtering and tactical torpedo manoeuvring.

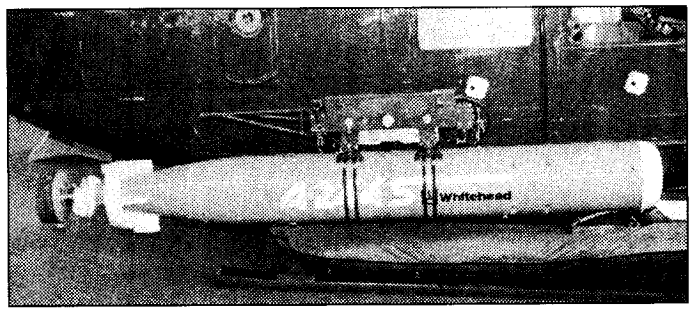
The very low radiated noise combined with a wide selection of weapon pre-set parameters allows a silent approach to the target minimising the alert range of submarine detection system and thereby increasing the overall kill probability of the weapon.

The payload consists of a blast charge warhead containing more than 42 kg of HBX-3 explosive, fully compliant with MIL-STD-1385 (Hero) and ignited through an impact type exploder incorporating four independent safety devices.

The exercise section, interchangeable with the warhead section, allows live exercise evaluation, warstock surveillance and training firings. Incorporating a pneumatic recovery system based on inflatable collar technology, it features high recovery reliability and easy localisation. The exercise head incorporates redundant safety and localisation devices as well as a solid state memory data acquisition system providing computer-based post-firing evaluation analysis capability. The length, weight and centre of gravity of the exercise round is strictly the same as the warshot weapon, thus allowing fully realistic live firings.

An upgrade kit offers customers to upgrade previous A244/S models to the Mod 3 standard. The kit offers improved operational characteristics to the weapon extending its shelf life at a fraction of the cost needed to replace the weapon with another lightweight weapon.

Operational status
The A244/S is in service and the latest model, the Mod 3, will remain in production for at least 10 more years. Total production of A244 family is believed to be some



Type A244 lightweight torpedo on helicopter

Country	Class/Ship	Type	Weapon	Sonar	Helicopter
Argentina	'MEKO 360'	DD	A244/S	DSQS-21	Alouette III
	'Type 42'	DD	A244/S	Type 162/184	Alouette III
	'A 69'	FF	A244/S	Diodon	
	'MEKO 140'	FF	A244/S	ASQ 4	Alouette III
China	'Luhu'	DD	A244/S	n/k	Dauphin
	'Luda'	DD	A244/S	Pegas/Tamir	Dauphin
	'Jianghu II'	FF	A244/S	Echo type 5	Dauphin
Colombia	'ES 1500'	FF	A244/S	ASO 4-2	
Ecuador	'Esmeraldas'	FF	A244	Diodon	Bell 206
India	'Delhi'	DD	A244/S	Spherion	Sea King
	'Godavari'	FF	A244/S	APSOH/Type 162	Sea King
	'Leander'**	FF	A244/S	Type 162/750	Alouette III
Indonesia	'Fatahillah'	FF	A244/S	PHS 32	Wasp
Libya	Dat Assawari	FF	A244	Diodon	
Malaysia	'Lekiu'	FF	A244/S	Spherion	Super Lynx
	'Laksamana'	FF	A244/S	ASO 84-41	Super Lynx
Nigeria	'MEKO 360'	FF	A244/S	EA-/80	Lynx
Peru	'Lupo'	FF	A244	Edo 6IO	AB212
Poland	-	-	A244/S	-	Mi-14 PL
Singapore	'Victory'	FS	A244/S	Edo 780	
	'Fearless'	FS	A244/S		
Sweden***	'Stockholm'	FS	A244/S	Salmon/SA 950	
	'Goteborg'	FS	A244/S	Salmon/SA 950	
UAE	'Kortenaer'	FF	A244/S	SQS-509	Couger/Panther
Venezuela	'Almirante Clemente'	FS	A244/S	PMS 26	
	'Lupo'	FF	A244/S	Edo 6IO	AB212

** In the Indian 'Leander' class the *Taragiri* and *Vindhyagiri* carry Sea King helicopters
*** The Swedish order for the A244/S Mod 2 is a stop-gap pending deliveries of Tp 45.
In addition the following countries use the A244/S in an air launched version: Greece, Morocco, and Pakistan.

1,200 units and it is in service with 15 navies. The latest country to purchase the A244/S Mod 3 is Poland, which leased an initial batch of 10 units for familiarisation and training from the Italian Navy. Poland had planned to purchase 32 A244/S Mod 3 by 2006, but now intends to purchase the MU 90 Impact. The A244 and A244/S family is used in, or ordered for, the vessels in the accompanying table.

Specifications (A244/S Mod 3)

Length: 2,750 mm
Diameter: 324 mm
Weight: 244 kg
Charge: >42 kg HBX-3
Speed: 38 kt (max)
Operating depth: 30-600 m
Range: 10,000 m (high speed)

Contractors

Eurotorp, Sophia Antipolis, France.
Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy.

UPDATED

B515

Type

Surface vessel torpedo launching system.

Description

Originally developed by Whitehead Motofides of Italy and now manufactured by Whitehead Alenia Sistemi Subacquei SpA (Italy) and marketed by Eurotorp (a French/Italian consortium between DCN International, Thales and Whitehead Alenia Sistemi Subacquei), the B515 torpedo launching system is suitable for a wide range of lightweight anti-submarine torpedoes such as the A244/S (Mod 0, Mod 1 and Mod 3), Mk 44, Mk 46, Sting Ray and MU90 Impact.

The launcher is designed to be installed on the ship's deck. Normally the B515 launchers are embarked in pairs, a launcher on the starboard side and the other on the port side of the ship. The following three configurations are possible:

- B515/M-1 launcher - consists of a single barrel
- B515/M-2 launcher - consists of two barrels mounted in horizontal or vertical plan
- B515/M-3 launcher - consists of three barrels.

The system for the launching of two different torpedoes in three combinations:

- MU90 Impact with A244/S
- MU90 Impact with Mk 46 or
- MU90 Impact with Sting Ray

The launching system comprises the extruded aluminium torpedo tube, stainless steel lightweight removable breech door, side-mounted high pressure air flasks and associated air supply system.

The launcher can be fixed or trainable by means of a suitable retractable handle, in this case the torpedo is fired after the tube has been trained into the designated sector.

The launcher is provided with an electrical heating system, meant to ensure suitable temperature for the torpedo loaded into the barrel. Similarly heaters are installed on the base. Moreover, the launcher is equipped with an alarm circuit that signals overheating in the tubes.

Each tube is also provided with manual safety lock in the pneumatic circuit and a series of electric interlocks to prevent anomalous and/or unwanted firing operations.

Torpedo firing is achieved through compressed air-pulse that is released upon remote electrical order provided by the ship fire-control system (STS). A local and selective emergency push-button is provided for degraded mode operations or jettison firings.

The compressed air is stored in a 15 dm^3 capacity bottle accommodated on the side of each barrel. Torpedo firing is achieved at a pressure ranging between 110 and 130 bar, corresponding to a torpedo muzzle velocity of 15 to 21 m/s. A pressure switch prevents torpedo firing when pressure is below a given threshold. Loading of the torpedoes inside the tube is achieved through a special torpedo trolley or through the ship's torpedo handling system (if available) when the torpedo tubes are accommodated within the ship's torpedo magazine.

The torpedo pre-setting is carried out electrically via a cable (snap connector) connected to a plug mounted on each tube. Pre-setting is normally remote controlled but in case of a failure of the launching network or/and of the remote-control panel, the pre-setting and firing sequence can be performed by means of a portable pre-setter which has to be directly connected to the aforementioned plug. Torpedo launching can be controlled either electrically, by means of the Shipborne Remote-Control Panel (Whitehead Alenia Sistemi Subacquei production), or manually, acting on a special push-button located on each tube.

The torpedo launching system for the Horizon frigate will consist of two single tubes, designated B 515/H/I on each frigate. These could subsequently be modified into two twin horizontal tubes. The launchers, together with a racked handling system, will be fully integrated with the combat system multifunction consoles.

Operational status

In production. In service with the Italian and over 20 other navies. A contract has been awarded to supply the B 515 torpedo launching system for the Franco/Italian Horizon frigate (two each for France and Italy).

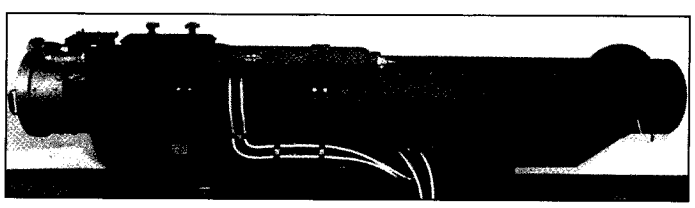
Specifications

Length: 3,400 mm
Width: 1,300 mm (triple barrel), 1,200 mm (twin barrel), 805 mm (single barrel)
Height: 1,285 mm (triple barrel), 1,000 mm (twin barrel), 630 mm (single barrel)
Weight: 1,050 kg (triple barrel configuration unloaded)

Contractors

Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy
Eurotorp, Sophia Antipolis, France.

VERIFIED



A single fixed B515 torpedo launching tube (Eurotorp) 0114388

MU 90 Impact

Type

Lightweight anti-submarine weapon (secondary anti-ship role).

Development

The development of the MU 90 has been a fairly lengthy and complicated process.

In 1981 Whitehead Motofides began development of the A290 torpedo as a successor to the A244. The weapon was to use an advanced guidance system with a new battery, and achieve improved tracking ranges, greater passive and enhanced classification capability as well as a speed in excess of 50 kt. Water testing of subsystems began in early 1986 and an in-service date of circa 1996 was anticipated.

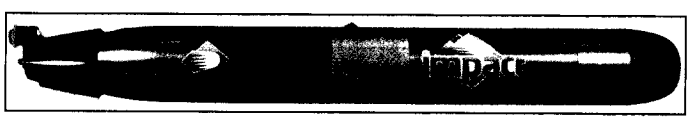
Simultaneously the French Navy was also seeking to develop a new lightweight torpedo and the Direction Technique des Constructions Navales (DTCN), later Direction des Construction Navales (DCN), discussed the possibility of a joint project with the British Ministry of Defence between 1976 and 1982. The failure of these talks led to the design of a national weapon which began in 1983, with first trial scheduled for 1986. The weapon was reportedly capable of a speed of between 38 and more than 50 kt as well as operation down to 1,000 m; an in-service date of 1995 was anticipated.

During the French naval exhibition - Le Bourget Navale - in October 1990, the French Defence Ministry announced that France and Italy would co-operate in the development of a lightweight ASW torpedo and active collaboration began in January 1991.

On 16 May 1991, the two governments signed an agreement to merge the two programmes and develop the MU 90 (Murene and A290) which was given the name Impact.

On 10 July 1991, DCN International, Whitehead Alenia Sistemi Subacquei and Thomson-CSF signed an agreement to create an industrial organisation, GEIE Eurotorp, to develop and market both Impact and the Whitehead A244/S.

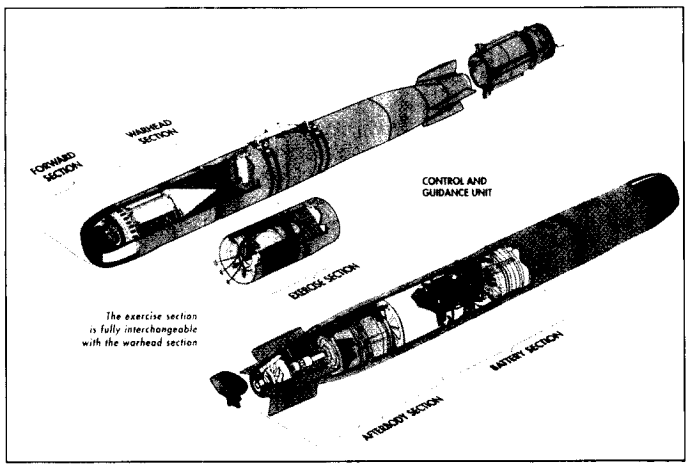
During 1992, the definition phase of the new weapon was completed and, the following year, the manufacture of the first subassemblies began. These were assembled with completely new software and during the Summer of 1994 the first preproduction weapons were successfully launched. Qualification trials involving up to 50 rounds were scheduled for completion during the second half of December 1995. In 1997 the first contract with the French, Italian and German navies for about 1,000 torpedoes became effective. In December 1998, the Danish Navy also signed a contract for MU 90 torpedoes and launching systems for the STANFLEX ships.



Impact MU 90 0024775



Launching an MU 90 torpedo from a surface ship (Eurotorp GEIE) 0063632



Block schematic of Impact MU 90 showing additional unit at tail for air-launched version (EuroTorp) 0103964

The MU 90 Impact advanced lightweight torpedo is of the fire-and-forget type conceived to cope with any task and any environment capability requirements and meet the ASW operational needs of the 21st century.

Impact has been designed to counter any type of nuclear or conventional submarine, acoustically treated, deep and fast evasive, deploying active or passive anti-torpedo effectors.

The torpedo can be deployed from any type of platform such as surface vessels, fixed- or rotary-wing aircraft or missile. Pre-arrangements to cope with Submarine-Launched Anti-Air Missile (SLAAM) have already been incorporated in the system. Hard-kill (anti-torpedo torpedo), continental shelf mine and submarine launching capability have been included during the torpedo design process.

Description

Externally the MU 90 is formed from a cylinder with whale nose, rhomboid-shaped fins in cruciform configuration and a pump jet propulsor. It uses the seeker of Murene, the A290 warhead and guidance system (with new software), the battery of the Murene and the A290 afterbody.

Power is provided by a DCN-developed SAFT manufactured high energy/weight ratio aluminium-silver oxide (Al-AgO) battery using dissolved sodium-dioxide powder as electrolyte and incorporating an advanced close-loop electrolyte re-circulation system. This provides the weapon with an 8 n mile range (up to 15.5 n miles at slow speed). The sodium dioxide dissolves on contact with seawater. The battery powers a stepless, variable speed, electronically controlled high rpm brushless ATLAS Elektronik motor with permanent magnets and low-noise speed reducer, which drives a skewed multibladed pump-jet propulsor giving a continuously linearly variable speed from 29 to over 50 kt. Four independent actuators and related fins give the weapon a very high rate of turn in any direction (over 100°/sec in horizontal and vertical planes) with low drag losses. The weapon thus offers a linearly variable speed automatically selected by the tactics of the weapon according to the scenario, environment and operational phase in which the weapon is operating (such as searching, homing or terminal). Of extremely long endurance, the weapon operates without any speed degradation and without any limitation of salinity and temperature in water depths in excess of 1,000 m and as shallow as 25 m and retaining navigation capability up to 3 m.

The advanced acoustic homing head of the Murene was developed by Thomson Marconi Sonar SAS and is based on the Mangouste digital signal and data processor, which is capable of achieving high detection ranges using very sophisticated signal processing and high-capacity data processing. Several types of pulse transmitted at different frequencies, CW or FM pulses of different duration are used. The composition of the transmissions is predetermined according to the operational mode chosen by the guidance and control system. These modes are: search, detect, pursuit and attack. The allocation of frequencies to each of the numerous transmission patterns depends on the operational mode. The acoustic sensor operates in six frequency bands with a bandwidth of >10 kHz. Transmitted signals are sent over 47 preformed beams and signals are received over 33 preformed beams. Acoustic coverage is 120° horizontal and 70° vertical.

The receiver unit uses a range of preformed beams that are simultaneously processed by frequency filters. Depending on the operational mode, different beam groupings can be selected. During the pursuit phase, for example, different groups of beams can be simultaneously processed. Using this capability the weapon can independently track potential targets allowing it to differentiate between the real target and countermeasures. It uses a 30 transducer planar array and a depth finder, all of which will operate on separate frequencies. This, together with multiple lobing and constant or modulating waveforms, enables the seeker to overcome reverberation and false echo problems. Using both active and passive detection and homing, it is designed to be effective against anechoic-coated submarines in both deep and very shallow water.

The control and guidance electronics accommodate the operational and tactical software including the signal processing, data processing and torpedo guidance laws which allow the weapon to continuously self-adapt its configuration and tactics according to the evolution of the operational situation and of the threat.

The guidance system, which features a strap-down inertial guidance unit, integrates the functions of depth determination, direction control and stabilisation, autonomous guidance, tracking counter-countermeasures and automatic tactics. This provides the weapon with excellent manoeuvrability and an all-attitudes capability, including bottom following capability and high accuracy for the final impact on the target.

Acquisition range is in excess of 2,500 m and target engagement range in excess of 15,000 m. Its multifrequency, parallel processing and simultaneous acoustic modes of operation allow multitarget tracking, high engagement range and high performance in very shallow water conditions providing the weapon with high immunity to the most advanced anti-torpedo countermeasures.

The weapon is reportedly capable of handling up to 12 targets simultaneously.

The weapon exhibits very low radiated noise, which is achieved through the use of the most modern pump-jet technologies combined with an extended selection of torpedo preset parameters and proper tactics which allow a silent approach to the target thus minimising the alert range of even sophisticated submarine detection systems and increasing the overall kill probability of the weapon.

For the anti-submarine role, weapon is armed with a directed energy charge warhead of V350 explosive weighing about 50 kg. This warhead has been proven to kill double hulled submarines and is ignited through an impact type exploder incorporating two mechanical and six electrical independent safety devices. A semi-directional warhead is also available for the anti-surface vessel role.

The exercise section is interchangeable with the warhead section, which allows live firing exercise evaluation, warstock surveillance and training firings. It comprises a pneumatic recovery system based on inflatable collar technology with high recovery reliability and easy localisation. The exercise head also incorporates redundant safety and localisation devices, and an underwater tracking capability as well as a solid state memory data acquisition system providing computer-based post firing evaluation analysis capability. The length, weight and centre of gravity of the exercise round is exactly the same as the warshot weapon, which provides for fully realistic firings.

For surface vessels an integrated console and linked presetter are available for the weapon, which is capable of being launched from existing 324 mm tubes.

Operational status

Under production with initial deliveries underway. About 1,000 weapons are being built in France and Italy for the French, German and Italian navies. The Danish Navy has also ordered the Impact MU 90 together with four torpedo launching systems for installation on Standard Flex 300 type ships (the 'Flyvefisken' class).

GEIE Eurotorp and Thales Underwater Systems in Australia signed an Alliance Agreement with the Australian Defence Force on 13 April 2000 for the replacement torpedo programme (Project Djimindi) for the Australian Defence Force. New Zealand will also participate in the first phase of the project. Early in 2002, the Australian government confirmed that an order for a substantial number of MU 90 torpedoes and associated systems had been placed with Eurotorp and Thales Underwater Systems Pty. Ships, helicopters and maritime patrol aircraft will deploy the MU 90. A further order for additional torpedoes was confirmed in December 2003.

The MU 90 and associated systems has also been ordered by the Polish Navy.

The weapon is in mass production for five major NATO countries.

In 2001 Poland began negotiations for the purchase of 36 MU 90 Impact torpedoes to replace the A244/S Mod 3. Delivery commenced in 2002 and is scheduled to complete in 2003.

Specifications

Length: 3,000 mm
Diameter: 324 mm
Weight: 300 kg
Warhead: 50 kg V350 explosive
Speed: 29->50 (+) kt continuous
Operating depth: <25 m to >1,000 m
Range: >25,000 m at minimum speed; >12,000+ m at max speed.

Contractors

Eurotorp, Sophia Antipolis, France.
Thales Underwater Systems, Sophia Antipolis, France.
Whitehead Alenia Sistemi Subacquei SpA Livorno, Italy.
DCN, St Tropez, France.

UPDATED

Italy

A 184 Mod 3

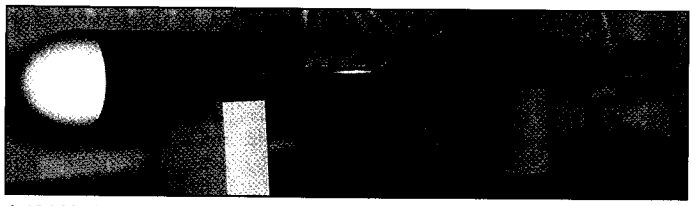
Type

Submarine- or surface-launched heavyweight torpedo.

Description

The A 184 Mod 3 is a compact, wire-guided, torpedo with the following operational characteristics:

- dual purpose anti-submarine/anti-ship
- push out/swim out launching mode
- deep and shallow water capabilities
- high speed and endurance
- direct electric-drive motor.



A 184 Mod 3 torpedo (Whitehead Alenia Sistemi Subacquei) ***NEW***/1022771

The weapon is equipped with:

1. A wide yaw acoustic head with digital technology extended detection range and improved immunity to countermeasures. The homing head is composed of two semi-circular electro-acoustic transducer arrays, the horizontal base located in the yaw plane and the vertical base located in the pitch plane and has the following characteristics:
- multiple modes of operation – active, passive or combined
- sonar array frequency optimised signal-to-noise ratio
- multibeam forming
- highest volume of explored water.

2. A propulsion system composed of:
- direct electric drive motor with no gear or pump, very quiet and difficult to detect acoustically
- new composite (carbon fibre) counter-rotating propellers which offer extremely quiet running and generate no tonals
- energy storage provided by one-shot silver-zinc primary battery

3. A wire guidance system equipped with gyroscopes and guidance sensor that provide accurate and stable running and allow the fire-control system to send the weapon the following data:
- course, speed, depth and stop
- modification of presettings
- search mode
- request of target position
- change of target
- homing consent and mode
- enabling/disabling of fuzes
- type of attack
- ACCM

And to send to the fire-control system the following data:
- execution of received commands
- depth, course and distance
- target acquired
- target bearing, range and elevation
- target loss
- start of close-in attack
- attack failure

4. A warhead section composed of:
- explosive charge that guarantees a proven high effectiveness both against surface vessels and new generation submarines
- exploder
- impact fuze
- acoustic influence fuze consisting of an electronic box and two electro-acoustic transducers facing upwards and downwards which provide the weapon with excellent wake detection capability

5. An afterbody section composed of servo controlled rudders and elevator that provide accurate and stable running.

The A 184 Mod 3 simply and easily integrates with modern combat systems.

A dedicated fire-control system exists in different versions for submarine and surface vessels, but the weapon can be easily integrated with existing combat systems.

Operational status
In production. The A 184 Mod 3 will equip upgraded Sauro class submarines and the new Type 212A boats building for the Italian Navy.

Specifications
Length: 6,000 mm
Diameter: 533 mm
Weight: 1,315 kg
Warhead: 240 kg
Speed: 24 or 37 kt (typical maximum 39 kt)
Range: 13.5 n miles @ 24 kt or 8 n miles @ 39 kt

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy. ***UPDATED***

Astra

Type
Torpedo sonar head.

Description
The new ASTRA (Advanced Sonar Transmitting and Receiving Architecture) seeker featuring improved signal processing with real-time multiple digital processing incorporates a new flat, steered, multibeam planar array which offers increased bandwidth in two operating frequency bands – 10 kHz medium passive only and 30 kHz active and passive high frequency. The ability to use low frequencies during the acquisition phase allows the weapon to achieve a much extended acquisition range of up to 3.7 n miles. The high-frequency mode provides high resolution over a short range while the medium frequency provides long-range acquisition. The seeker can operate simultaneously in both frequencies in passive mode, allowing the torpedo to discriminate between signals from the real target and signals from acoustic countermeasure decoys. In active and passive mode, both frequencies are independently processed on each lobe. Digital pulse compression techniques are used in any transmission mode. Signal and data processing algorithms include spatial and frequency filtering, constant false alarm rate processing, echo elongation analysis and spatial coherence and angular extension analysis. The seeker transducers have been carefully sited so that high-speed flow noise does not interfere with transmission or reception of acoustic signals. Damping materials are sited around the weapon's nose to further limit self-generated noise, resulting in increased acquisition ranges in both active and passive modes. The ASTRA seeker has already been fully tested at sea and is now in production (the wake homing feature is a proven capability of the weapon).

Operational status
Entering service with the Black Shark torpedo.

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

NEW ENTRY

Black Shark

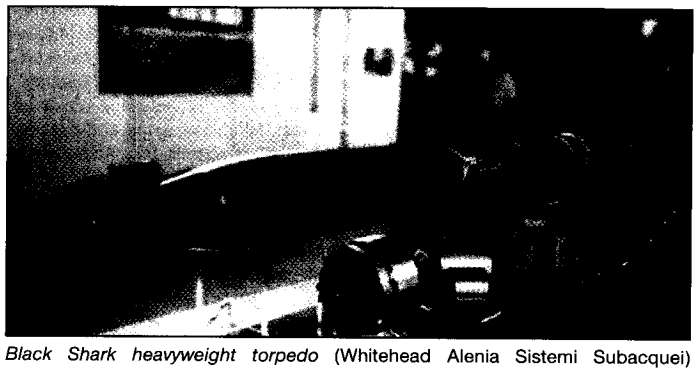
Type
Heavyweight torpedo.

Description
The Black Shark torpedo currently undergoing sea trials evaluation and production will offer a considerably enhanced capability in respect of currently available torpedoes. Three major areas are being upgraded: the homing head, the propulsion system and the control and guidance unit.

The new ASTRA (Advanced Sonar Transmitting and Receiving Architecture) seeker featuring improved signal processing with real-time multiple digital processing incorporates a new flat, steered, multibeam planar array which offers increased bandwidth in two operating frequencies – 15 kHz medium passive only and 30 kHz active and passive high frequency. The HF mode provides high resolution over a short range while the MF mode provides long-range acquisition. The seeker can operate simultaneously in both frequencies in passive mode, allowing the torpedo to discriminate between signals from the real target and signals from acoustic countermeasure decoys. In active and passive mode, both frequencies are independently processed on each lobe. Digital pulse compression techniques are used in any transmission mode. Signal and data processing algorithms include spatial and frequency filtering, constant false alarm rate processing, echo elongation analysis and spatial coherence and angular extension analysis. The seeker transducers have been carefully sited so that high-speed flow noise does not interfere with transmission or reception of acoustic signals. Damping materials are sited around the weapon's nose to further limit self-generated noise, resulting in increased acquisition ranges in both active and passive modes. The ASTRA seeker has already been fully tested at sea and is now in production (the wake homing feature is a proven capability of the weapon).

The propulsion system features a new brushless axial flux motor and skewed direct-drive contrarotating propellers connected to a new tail cone and actuation system. The new arrangement allows continuous regulation of the speed over the entire speed envelope. The redesigned propellers with 11 and nine skewed carbon fibre blades are very quiet and, with the new motor, exhibit a very low acoustic signature. The AgO-Al battery offers improved capacity. It will both improve endurance and provide the more powerful new motor with increased energy, allowing speed to be raised to in excess of 52 kt.

The new guidance and control unit features a new fibre optic link to the submarine in place of the traditional wire-guidance link. The fibre optic link carries sensor data and command and guidance signals to and from the submarine. This allows the torpedo to operate as an advanced sensor for the submarine. The fibre



Black Shark heavyweight torpedo (Whitehead Alenia Sistemi Subacquei) ***NEW***/1022772

optic cable allows a higher data exchange rate between the submarine and the weapon, giving a 100 per cent increase in normally available torpedo guidance range. The guidance unit incorporates a strapdown inertial navigation system using three laser gyros and three accelerometers for guidance and control.

Operational status
2004 - First submarine launch scheduled.

The weapon is undergoing sea trials evaluation and production. The weapon is planned to equip the new Type 212A boats of the Italian Navy. Chile and Malaysia have also ordered the Black Shark to equip their new 'Scorpene' type submarines.

Contractors
Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy.

UPDATED

Japan

Type 73

Type
Lightweight anti-submarine torpedo.

Description
The Type 73 (formerly known as the GRX-4) began development in 1987 as a short-range, air/surface ship-launched ASW torpedo to replace the US Mk 46 in Japanese service. The weapon is said to be comparable to the US Mk 50, and is fitted with a SCEPS propulsion system powering a shrouded pump-jet propulsor. The weapon is armed with a shaped charge warhead, which was tested against a double-hulled target section in 1989.

Operational status
Development contract awarded 1987. Entered service with the Japanese armed forces in 1995.

Contractor
Mitsubishi Heavy Industries.

UPDATED

Type 89

Type
Heavyweight active/passive submarine-launched homing torpedo.

Description
Developed in the early 1980s. Under the Medium-Term Defence Programme (FY86-90), the Type 89 (formerly the GRX-2), has been developed as an equivalent to the US Mk 48 ADCAP weapon. Powered by a thermal propulsion system with a maximum speed said to be in the region of 70 kt, the wire-guided Type 89 uses active/passive homing and has an optional wire-guidance mode.

Operational status
Entered service in the early 1990s and in production. Operational aboard Yuushio, Harushio and Oyashio class submarines. It is believed that some 600 weapons have been manufactured to date.

Specifications
Diameter: 533 mm
Warhead: 267 kg
Speed: 55 kt
Range: 27 n miles @ 40 kt; 21 n miles @ 55 kt
Operating depth: 900 m (max)

Contractor
Mitsubishi Heavy Industries.

UPDATED

Russian Federation

65-73 and 65-76

Type
Submarine-launched anti-surface vessel 650 mm torpedo.

Description
Development of this long-range, wire guided wake-homing weapon the 65-73 probably began in the early 1960s. Designed primarily for attacking large surface targets, the torpedo was scheduled to arm the Victor II class SSNs and entered service in 1972. The 65-76 entered service around 1976.

The propulsion compartment, with the fuel tanks and turbine, occupies most of the midships section of the weapon. Propulsion is said to comprise a closed-cycle thermal system (HTP) powering contrarotating propellers that are not protected by a shroud. The weapon uses a passive/active seeker mounted in the nose section, while the guidance section is sited to the rear of the weapon in front of the drive shaft and actuators which form the rear compartment. Guidance is carried out using the wire datalink to the launch platform with depth and course commands being continuously fed to the weapon. A re-attack capability is incorporated in the weapon's on-board guidance section. The warhead, mounted behind the nose section, is either a 500 kg conventional charge detonated by impact and/or proximity fuze, or a low-yield nuclear warhead.

The export variant of the Type 65-73 is the DST 92 and of the 65-76 is DT. This is powered by a gas turbine propulsion system using HTP, kerosene and compressed air fuel. The sensor operates in a vertical direction to detect the edge of the target's wake and then sweeps to either side until, in the terminal phase, the distance to the target can be gauged from the wake's width.

The weapon can be fired at depths to 100 m and its running depth is 20 m.

Operational status
The initial variant of these torpedoes first became operational in 1957 and equips the later generations of Russian submarines fitted with 650 mm tubes such as the Victor III, Akula and Sierra classes. Following the disaster to the *Kursk*, the 65-76 was removed from service early in 2002.

Specifications

	65-73	65-76
Length	9,140 mm	11,000 mm
Diameter	650 mm	650 mm
Weight	4,750 kg	4,500 kg
Warhead	500 kg	500 kg
Speed	50 kt	50 kt
Range	27 n miles @ 35 kt	27 n miles @ 50 kt; 54 n miles @ 30 kt

Contractor
Dvigatel Zavod, St Petersburg.

VERIFIED

APR-2E

Type
Air-launched lightweight active/passive anti-submarine torpedo.

Description
The APR-2E lightweight torpedo, said to have been developed specifically for airborne ASW, is designed to destroy current and advanced submarines operating at depths of 600 m and travelling at speeds up to 43 kt.

The torpedo is of standard shape featuring a long cylindrical body with flattened rounded nose and four long stabilising fins at the rear. It incorporates a shroud at the rear but there is no propeller as it is a solid-propellant rocket-propelled (APR) weapon. A retarding parachute pack is fitted at the rear, which is discarded on entering the water.

The weapon consists of six major elements: sonar and guidance electronics; warhead, fuzing and arming circuits; control system; rocket motor; control surface actuators; parachute brake.

The weapon is designed to strike its target outside the pressure hull in the bow section housing the sonar sensor and torpedo tubes, in the region of the propellers, or in the region of the control room.

The torpedo is fitted with a new sonar system described as a hydro-acoustic correlation-phase guidance system. This features a multichannel detection and direction-finding system, which is capable of detecting underwater targets in active mode at ranges up to 1,500 m (surface target range is stated to be 1,000 m). The sensor uses a search pattern of 90 × 45° and has a signal-to-noise resolution claimed to be 0.2 to 0.3 dB maximum and bearing accuracy 1.5 to 2°. In passive mode the sensor has a detection range of 500 m and two search patterns are available: a flat spiral search pattern for shallow water operations between 50 to 250 m; a downwards spiral search trajectory for deep water operations between 150 to 600 m.

Following launch the parachute brake opens and stabilises the weapon's descent until it enters the water with a minimum of noise at an angle of 17°. The parachute pack is then discarded and the weapon sinks to a depth of 20 m before the various safety devices are de-activated, the fuzing system armed and the passive search mode activated. If the torpedo reaches a depth of 150 m without detecting the target the propulsion system is activated, active sonar is switched on and the weapon continues the search in active mode for a further 15 to 20 minutes. If, after this time, the target has still not been detected, the weapon self-destructs. As the weapon sinks in a spiral trajectory the sonar carries out a passive search for its target.

When the target is acquired the rocket motor is ignited and the sonar switches to active mode and locks on to the target. The torpedo then homes on to the target at speeds up to 62 kt and down to a depth of 600 m.

An upgraded variant, the APR-3 has been developed. This weapon is powered by a turbine-driven pumpjet propulsion system with a variable controlled speed and is effective to 800 m depths. The motor has a running time of 113 seconds. The acquisition range of the APR-3 is said to be 2,000 m, operational range 5.5 n miles and operational depth 800 m. It is armed with a 76 kg warhead. It incorporates a multichannel active sonar with a bearing accuracy of around 2° and uses phase-correlation data processing with matched filtration and amplitude selection.

Operational status
In service with the Russian Navy aboard shipborne helicopters since 1992 (Mi-14 Haze). The weapon is also being exported to countries believed to be: Poland, Romania, Serbia & Montenegro and Syria. India may also have acquired the APR-2E.

Specifications

	APR-2E	APR-3
Length:	3,700 mm	3,200 mm
Diameter:	350 mm	350 mm
Weight:	575 kg	450 kg
Warhead:	100 kg of Trotyl equivalent	76 kg
Speed:	62 kt	65/100 kt
Range:	2 n miles	5.5 n miles
Operating depth:	1,000 m	800 m

Contractor
Zvezda OKB, Moscow.

UPDATED

AT-2 (NATO designation Type E53-72)

Type
Air-launched ASW torpedo.

Description
The AT-2 is designed to be launched from fixed-wing aircraft or the SS-N-14 ASW rocket system and is powered by an electric motor. The terminal homing phase is carried out using an active/passive seeker.

Operational status
Operated by the Russian Navy and deployed from fixed-wing aircraft. May no longer be in service.

Specifications
Length: 4,700 mm
Diameter: 533 mm
Weight: n/k
Warhead: 80 kg HE
Speed: 40 kt
Range: 5.5 n miles @ 40 kt

VERIFIED

TEST-71 Series

Type
Submarine-surface vessel-launched ASW torpedo.

Description
The torpedo consists of five main compartments running from fore to aft: active/passive seeker section, warhead with acoustic/magnetic/contact influence fuzing system, battery compartment (batteries are of the AgO-Zn type), guidance section and electric motor and actuators in the aft section together with twin propellers. The submarine-launched weapon incorporates a two-speed electric motor.

The TEST 71ME export variant is a submarine-launched ASW weapon fitted with active/passive homing and with an external dispenser for the wire guidance link. This is used for depth and course control. The warhead is equipped with both impact and proximity fuzes. The weapon is stored and carried in a watertight container with nitrogen. Reported to be wakeless.

Upgraded variants include UTEST-71E (wire guided with wake homing capability) and TEST-96 (improved seeker).

The latest version of the TEST-71 is the TEST-71ME-NK. This wire guided homing weapon can be used against both surface as well as sub-surface targets. The torpedo is designed for launching from Kilo class submarines Project 877EKM and 636, replacing 53-65 weapons. The TEST-71ME-NK is fitted with acoustic/magnetic influence fuzing system and it is claimed to be able to detect a submarine target at 1,500 m and a surface target at 180 m.

Operational status
In service with Algeria, China, India (36 weapons for Kilo class), Iran, Poland, Romania and Russia. The TEST-71ME-NK is in service with the Russian Navy and it is understood that some 15 examples have been sold to China and eight to India.

Specifications
(UTEST-71E)

Length: 7,930 mm
Diameter: 533 mm
Weight: 1,820 kg
Warhead: 205 kg
Speed: 40 kt
Range: 10 n miles @ 20 kt or 8 n miles @ 40 kt
Operating Depth: 400 m

Contractor
Dvigatel Zavod, St Petersburg.

VERIFIED

TEST-96

Type
Submarine/surface vessel-launched dual-role torpedo.

Description
The wire-guided TEST-96 torpedo has now superseded the TEST-71ME weapon for export. It is a dual-role (ASW/ASUW) weapon equipped with impact and proximity fuzes and active/passive/wake homing sensors; the wake homing sensor being used in the ASUW role.

The weapon consists of five main compartments: improved seeker section, warhead, guidance section, battery section, electric motor and actuators. The rear section may also internally house the wire dispenser.

Depth and course are controlled by the launch platform, with commands being sent to the weapon via the wire link. The weapon is said to be capable of attacking a surface target at an angle of 90°.

Specifications
Length: 8,000 mm
Diameter: 533 mm
Weight: 1,800 kg
Warhead: 250 kg
Range: n/k

Contractor
Gidropribor

VERIFIED

Type 53 Series

Type
Submarine/surface vessel-launched heavyweight torpedoes.

Description
The Type 53 is a long-running series of weapons that has been continually updated over the years with new technologies, as they have become available. Type designations appear to indicate (within a year or two) the date of entry into service of the weapon, thus 53-68 indicates that this weapon entered service about 1968.

The standard 533 mm torpedo of the Second World War was the Type 53-38 Type 3. This 7.27 m long weapon weighed 1,610 kg (dry) and had a maximum range of 6.5 n miles. Maximum speed was 46 kt and the torpedo was armed with a 300 kg TNT/tetryl warhead.

Post-Second World War torpedo development in the former Soviet Union has generally proceeded along similar lines to that in the UK, France and the US. This was primarily derived from experience gained with wartime German pattern running and homing torpedoes, together with intelligence acquired concerning developments in the West.

Around the late 1950s, variants of this torpedo began to be deployed armed with a nuclear warhead. This was subsequently confirmed in 1981 when a Soviet Whiskey class submarine ran aground in Swedish waters. The former Soviet Union regarded it as normal practice to fit alternative nuclear warheads to its torpedoes. Swedish sources estimated a warhead yield of about 15 kT.

The Type 53-56 is a straight or pattern running weapon powered by reciprocating air/steam propulsion and is mainly deployed from FACs and submarines.

The Type 53-65 is an anti-surface vessel wake homing torpedo powered by high-test peroxide (HTP). It is understood that this weapon has, at times, been armed with a nuclear warhead. The Type 53-65KE weapon is deployed in coastal defence systems covering ranges from 17 to 20 n miles within a 0° to ± 170° sector. It is also the standard anti-surface vessel weapon aboard the Kilo class submarines. The wake-homing weapon is fully automatic in operation and is fitted with an acoustic homing system and dual electromagnetic/contact inertia exploder. A Morteplotekhnika 2DT gas turbine engine is powered by a mixture of gaseous oxygen, kerosene and seawater provides propulsion. Four variants of the weapon exist including a warshot, practice, mine carrier and simulator for training personnel on construction, maintenance and repair.

The Type 53-66 is an electrically powered, straight and pattern running weapon.

The Type 53-68 straight running torpedo is derived from the Type 53-65 and is armed with a 20 kT nuclear warhead. It is said to be capable of operating down to depths of 300 m.

The Type 53-83 HTP powered, wake-homer is the latest variant of this torpedo.

Operational status
The Type 53-56 and 53-68 are now probably withdrawn from service. Other Type 53 weapons remain in production for use in Russia, China and India. A total of 51 53-65K weapons have been sold to India for the Kilo class submarines and Delhi class destroyers.

Specifications

	53-68	53-56V/VA	53-65	53-66
Length (mm):	7,200	7,800	7,945	
Diameter (mm):	533	533	533	
Weight (kg):	n/k	2,100	2,070	
Warhead (kg):	400	305	305	20 kT
Speed (+) (max):	51	55	55	
Operating depth:	300 m			
Range:	2 n miles @ 51 kt 4.5 n miles @ 41 kt	7.5 n miles @ 55 kt 13 n miles @ 40 kt	19,000 m	

Contractor
Dvigatel Zavod, St Petersburg.

VERIFIED

UGST

Type
Multipurpose heavyweight torpedo.

Description
The UGST is the latest torpedo under development. It is designed for deployment from both surface ships and submarines in either autonomous or remote control mode. Two variants have been developed in differing lengths. The weapon is fitted with digital data processing software in a hardware module that has both far and near and wake homing capability. The weapon is armed with a combined acoustic/magnetic fuze and its guidance system directs the torpedo on to the most sensitive area of the target. The torpedo uses a number of channels for detection of targets in both shallow and deep water. The UGST incorporates extensive ECCM capability designed to counter anti-torpedo jamming countermeasures and natural interference. An axial piston engine that derives its energy from a single component fuel driving a pump-jet propulsor, powers the weapon. Self-noise generation has been considerably reduced resulting in a much more effective weapon.

Operational status
Entered service with the Russian Navy in 2002.

Specifications
Length: 7,200 mm
Diameter: 533 mm
Weight: 2,200 kg
Warhead: 200 kg
Speed: 35-50 kt
Range: 18 n miles (max)
Operating depth: >300 m

VERIFIED

UMGT-1 (NATO designation E40-79)

Type
Air-launched lightweight ASW torpedo.

Description
Based on intelligence reports, this weapon is thought to have been developed as an equivalent to the US Mk 46. The weapon consists of four main sections: a nose-section housing the active/passive sonar seeker (which is said to operate on a frequency of 12 kHz) and the guidance electronics; the warhead with acoustic proximity fuze (range 3 m) and impact fuze; a centre section housing the seawater-activated copper-magnesium battery; and a rear section with the electric motor and fin actuators. The rear of the weapon contains a parachute retarding pack which is discarded just before the weapon enters the water. The rear also contains shrouded propulsor.

The weapon is understood to be capable of acquiring a target at a range of 1,200 m. On entering the water the torpedo performs a circular pattern run in passive mode, turning to active when a target is detected, followed by a straight running active terminal homing phase.

The export variant is the APSET-95 or UMGT-1ME. This weapon is said to have an unusual pointed nose shape with a seawater scoop on the underside and four clipped-tip delta fins.

Operational status
Stated to be operational on board some small destroyers and deployed by some large helicopters and from SS-N-14, SS-N-15 and SS-N-16 missiles. The APSET-95 was offered for export in 1994.

Specifications
Length: 3,500 mm (3,840 mm APSET-95)
Diameter: 406 mm
Weight: 950 kg (720 kg APSET-95)
Warhead: 60 kg HE
Speed: 20/40 kt
Range: 8 n miles @ 40 kt
Operating depth: 15-500 m

Contractor
Dvigatel Zavod, St Petersburg.

VERIFIED

USET-95

Type
Surface-ship/submarine/aircraft launched torpedo.

Description
The USET-95 is a standard shape torpedo with cruciform fins and twin contrarotating propellers mounted in front of the rudder. The weapon is driven by an electric motor powered by silver-zinc oxide batteries. The USET-95 is armed with impact and magnetic fuzes and an 80 kg warhead. The torpedo is fitted with an active/passive seeker with an acquisition range of 500 m and possibly also a wake-homing seeker for use against surface ships. The weapon can be launched from standard 533 mm torpedo tubes using a liner.

An upgraded version of this weapon, designated SET-72, is designed for submarine launch.

Operational status
An export torpedo in widespread use around the world.

Specifications
(USET-95)

Length: 4,700 mm
Diameter: 400 mm
Weight: 650 kg
Warhead: 80 kg
Speed: 50 kt

SET-72

Length: 4,500 mm
Diameter: 406 mm
Warhead: 100 kg
Speed: 30 kt
Range: 4.5 n miles

Contractor
Gidropribor

VERIFIED

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

VA-111 Shkval

Type
Submarine-launched anti-submarine torpedo.

Description
Shkval was developed as a short-range anti-submarine torpedo to provide former Soviet submarines with a rapid reaction defence system against US submarines, in case the latter remained undetected by the Soviet submarine's sonar system. The concept was to provide a short-range defensive weapon which cannot be avoided by a hostile submarine and which was to be immune to countermeasures.

The cone-shaped, liquid-fuelled rocket-powered torpedo is deployed from a standard 533 mm torpedo tube being expelled from the tube at high speed (50 kt) by a plug of gas ignited by a trigger. When it reaches a safe distance from the submarine the rocket is fired, propelling the weapon to a speed of some 200 kt. It has been reported that the exhaust gas from the rocket is fed internally to the weapon's nose where it is exhaled through forward facing vents to create a supercavitating bubble around the nose and along the torpedo's body considerably reducing hydrodynamic drag and friction and enabling it to reach a very high speed. Guidance is provided by a gyroscopic system. The weapon is fired in a straight line, and with no homing system the range is reported as being in the region of 7,500 m.

Trials of an upgraded Shkval were reported to have been undertaken in 1998 and there have been unsubstantiated reports that an upgraded Shkval was on board the submarine *Kursk* when she was lost in an accident in October 2000. Further unsubstantiated reports referred to the possibility of such a weapon being prepared for firing when the submarine was lost. Some reports indicate the upgraded weapon could have a speed of 300 kt and be capable of searching for a target at 60 kt.

Operational status
Entered service aboard Russian submarines in 1977 and 40 units were exported to China in 1998.

Specifications
Length: 8,200 mm
Diameter: 533 mm
Weight: 2,721.6 kg
Charge: 210 kg
Speed: 50/200 kt
Range: 3.5 n miles

Contractor
Dvigatel Zavod, St Petersburg.

VERIFIED

VTT-1 (NATO designation Type E45-75A)

Type
Helicopter/aircraft/missile deployed lightweight anti-submarine torpedo.

Description
Development of post Second World War air- and small ship-launched torpedoes started during the 1950s and 450 mm weapons, powered either by steam or solid propellant motors, emerged.

The VTT-1 is designed to be launched by helicopter or the SS-N-14 or SS-N-16 ASW rockets. The torpedo is fitted with an active/passive homing head and is powered by an electric motor. On entering the water the weapon performs a circular search pattern at a set depth between 20 and 200 m at a speed of 30 kt. Alternatively it can perform a helical search pattern moving up and down between 20 and 300 m. On target acquisition in passive mode (range 500 to 1,000 m) the weapon locks on and steers straight for the target.

Operational status
In service with the Russian Navy. Carried by SS-N-14 and SS-N-16 missiles.

Specifications
Length: 3,900 mm
Diameter: 450 mm
Weight: n/k
Warhead: 90 kg HE
Speed: 30 kt
Operating depth: 300 m
Range: 8.1 n miles @ 30 kt

VERIFIED

Sweden

Torpedo propulsion system

Description
The torpedo propulsion system developed by Saab Bofors Dynamics has been designed to meet torpedo requirements demanding a minimum speed of not less than 25 kt, a running depth of 500 m and very low noise levels. A number of propellants were considered and a system based on a bipropellant using a combination of hydrogen peroxide (HTP) and kerosene fuel was selected. This combination was chosen because of its high-energy content, high density, the fact that the propellants remain liquid at prevailing temperatures and the combustion reaction products (steam and carbon dioxide) can be fed directly into a heat exchange engine, the exhaust leaving no visible wake as CO_2 is soluble in water.

By using a mixture of HTP (85 per cent) and kerosene (15 per cent) fuel a number of working modes can be chosen for the engine. The semi-closed cycle method has important advantages in that engine performance is not significantly influenced by the ambient pressure. The HTP is decomposed into water and oxygen by a catalyst prior to feeding into the steam generator, where the HTP reacts with the aviation fuel to generate a large amount of thermal energy. This is fed to the engine where the thermal energy is converted into mechanical energy. By adding fresh water the temperature of the reaction products is reduced to 700 to 800°C, which is acceptable to the engine.

The exhaust from the engine mainly consists of steam and carbon dioxide at a temperature of 200 to 300°C. The steam is condensed in a condenser and most of the condensation is recycled back into the system. The remaining part of the exhaust gases is compressed in a compressor before being released into the surrounding sea.

The HTP is stored in a flexible bag located in a special tank that is directly connected to the water and kerosene fuel tanks, so that all tanks are the same pressure. A water pump supplies pressurised seawater to the water tank to provide feed pressure. The capacity of this pump is controlled by the engine speed.

The engine is a seven-cylinder axial piston engine (cylinder bore 70 mm, stroke 70 mm), the engine pistons acting against a sinusoidal double rise cam. With the selected shape of the cam curve a complete dynamic balance of the inertial forces is achieved. The engine is designed to run at low speed so that the cam rollers of the pistons are always in contact with the cam. This design reduces engine vibration and improves stealth capabilities.

The admission gas is supplied via a central connection, distribution being controlled by inlet and outlet valves. The engine pistons are linked to the compression pistons with compression being achieved in two stages. The condenser is built around the engine which assists in dampening any engine noise, and the whole unit is mounted in shock-absorbing elements in the torpedo shell.

The prototype engine was designed to produce a power of 25 to 300 kW at 600 to 1,500 rpm at an admission pressure of between MPa 2-8 and with a fuel consumption of between 3.5 and 5 kg/kWh.

Operational status
The propulsion system forms the power unit of the Torpedo 2000.

Contractor
Saab Bofors Dynamics AB Karlskoga.

VERIFIED

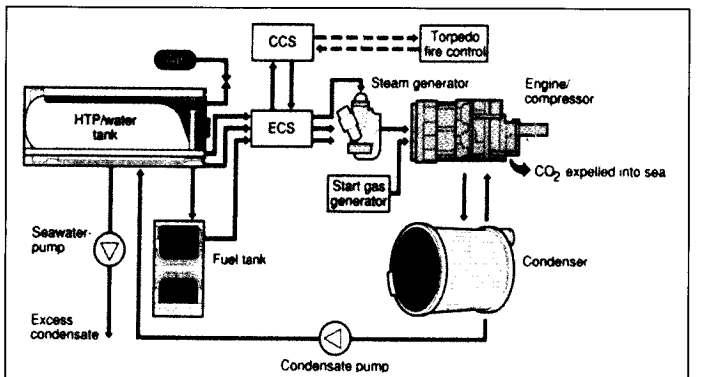


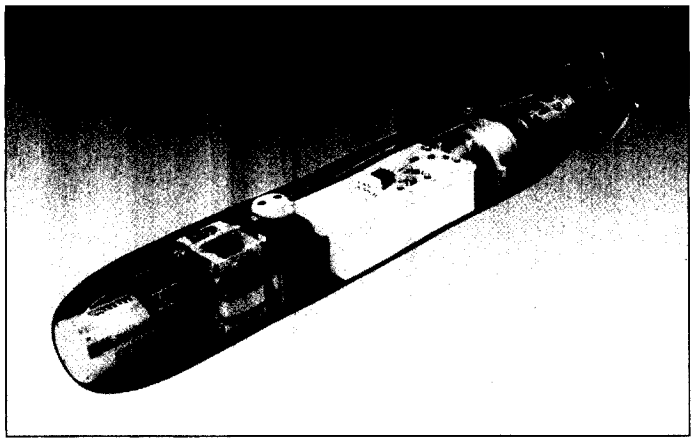
Figure 4. Block diagram of energy system

Block schematic of propulsion system (Saab Bofors Dynamics) 0524643

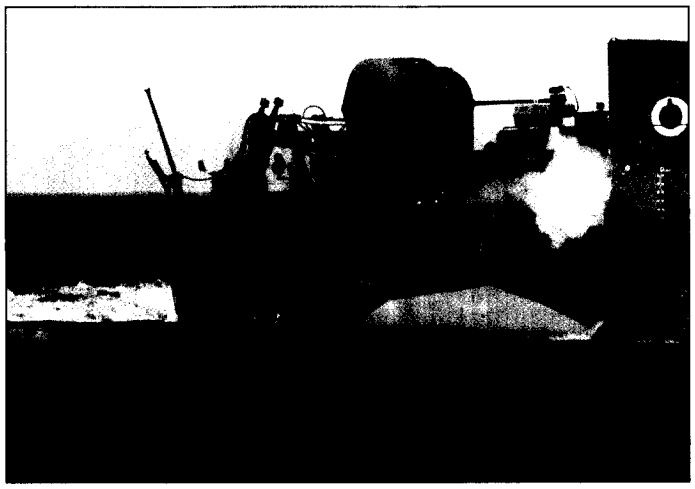
Tp 45 (43X2)

Type
Multipurpose lightweight torpedo.

Description
This series of torpedo has been developed to meet the challenge of ASW in shallow waters. The Tp 45 (Tp 43X2 for export purposes) is the fourth generation of Swedish ASW torpedoes. Like the previous 43X0, from which it is developed, the Tp 45 is wire-guided, using a hydro-acoustic homing system for the terminal guidance phase. The weapon can be launched from submarines, surface ships



Arrangement of the 43X2 torpedo



Launching a 43X2 torpedo from a Swedish Navy corvette

and helicopters (the last flying at up to 70 kt), and can be wire-guided from a flying or hovering helicopter, being deployed without the use of a parachute. Although designed primarily for ASW, the Tp 45 also has an anti-surface vessel capability. For submarine launch the weapon uses the swim-out mode of deployment at a speed of 10 kt.

The weapon is fitted with an onboard computer system which monitors the comprehensive volume of data which it both gathers itself and which is fed to it via the wire communication link and which makes highly accurate inertial navigation possible. The wire link enables more than 80 different types of message to be transmitted in both directions. This information controls the weapon's parameters and targeting, supervises homing procedures and so on. In the event of breakage in the wire communication, the computer takes full control of the weapon using the latest data received as well as computed search patterns incorporating safe/attack zones and so on.

The guidance wire is of the single copper core plastic coated type which uses the surrounding water as a return conductor. For helicopter deployment a second wire is required for the return connection as the helicopter is not in contact with the water. The wire link allows more than 80 different message types to be transmitted in both directions.

The seeker is almost identical to that fitted in Torpedo 2000 and specifically developed for use in shallow water using advanced signal processing carried out by the computer housed in the electronics module of the weapon. Three selectable homing modes are possible: active, passive or simultaneous active/passive. The weapon can track several targets simultaneously, classifying target signals and rejecting all false signals from the environment and from acoustic countermeasures. Data generated includes among others: target presence in one or more of the preformed beams; the sign and value of the target's position in both azimuth and depth; plus the data necessary for countermeasures action.

The main computer software is written in Pascal/Ada high-level language, which simplifies software maintenance.

The torpedo is fitted with a multifrequency hydro-acoustic proximity fuze operating on several frequencies, and which can also detect the presence of targets overhead. An impact fuze is also incorporated. The transducers are positioned in a recess in the front end of the hydrodynamically shaped nose, which is designed for low self-noise at high speed. Advanced analysis of the received echoes enables waves, wakes and countermeasures from the hull of a ship to be discriminated.

Propulsion is by a secondary silver-zinc oxide 4.2 kW h battery feeding a DC electric motor. The torpedo uses three selectable speeds (managed through a thyristor battery switching unit and believed to be 15, 25 or 35 kt) in order to optimise hit probability, minimise time from launch to strike and overcome the need for reduction gearing.

The torpedo is launched from a helicopter at 20 m altitude into less than 20 m of water without the use of retarding parachutes. The weapon enters the water at an angle of 15 to 35°. On entering the water the propulsion system is activated and the weapon steered towards the target from data processed on the launch platform and fed to the torpedo via the wire datalink. In the vicinity of the target the torpedo is commanded to activate its housing system for the final attack phase.

The body of the weapon is made from aluminium alloy castings and comprises interchangeable modules.

Operational status

A production contract worth in the region of SKr80 million was awarded to Swedish Ordnance (subsequently renamed Bofors AB now Saab Bofors Dynamics) in the Autumn of 1991 for series deliveries to commence in 1993. In May 1992 the Swedish FMV placed a contract worth approximately SKr100 million for a second batch of Tp 45 weapons. The torpedo is deployed from Swedish Navy Västergötland and Gotland class submarines as well as Boeing Vertol 107 helicopters and the Göteborg class corvettes. In the Spring of 1994 Pakistan placed an order for the 43X2 for use on the Type 21 frigates acquired from the UK.

A test firing in the Autumn of 1995 using a warshot weapon against a target similar to a submarine proved the ability of the weapon to both strike and destroy a target.

Specifications

Length: 2,800 mm
Diameter: 400 mm
Launch weight: 310 kg
Warhead: 45 kg shaped charge
Speed: 15, 25 or 35 kt
Range: (approx) 10.75 n miles @ 15 kt

Contractor

Saab Bofors Dynamics AB, Karlskoga.

UPDATED

Tp 46 Grampus/Torpedo Weapon System 90

Type

Surface ship/submarine launched lightweight torpedo.

Development

The Swedish FMV signed a project definition contract with Bofors Underwater Systems on July 1, 1996 for work to begin on the development of the next-generation lightweight torpedo, the Tp 46 Grampus (also known as Torpedo Weapon System 90). This project is being undertaken in collaboration with Denmark whose own FMV is providing part of the funding for the project. It is envisaged that the weapon will be deployed by the new 'Visby' class YS 2000 surface effect ship, the next generation submarine – Submarine 2000 – and the Danish 'Flyvefisken' class vessels.

Description

The wire-guided torpedo will incorporate an improved propulsion system with a wide speed range and fit a new digital homing system that will remain effective at great depths. The requirement for the weapon is to be deep diving, and be powered by a variable speed drive using a SO_6AL_4 thermal battery system and 100 hp AC permanent magnet (brushless) motor (with stepless speed control) and a pumpjet propulsor to achieve a maximum speed of 45 kt. The battery incorporates three modules that can be connected to an AC motor in any elective order with excellent power and torque. This overcomes the need for a gearbox which helps reduce self-generated noise. Manoeuvrability is a primary objective in the development of the new weapon with emphasis being placed on slow speed, hovering and finally high-speed terminal phase. It is intended that the weapon will be able to detect submarines on the seabed and at ranges in excess of 2,500 m and report their presence to the launch platform. Data will be transmitted via a two-way fibre-optic communications link while a radio buoy will be used to relay data for air-launched weapons. The torpedo will offer very high detection and classification performance in both shallow water and open ocean environments using digitally processed multiple preformed transmit and receive beams.

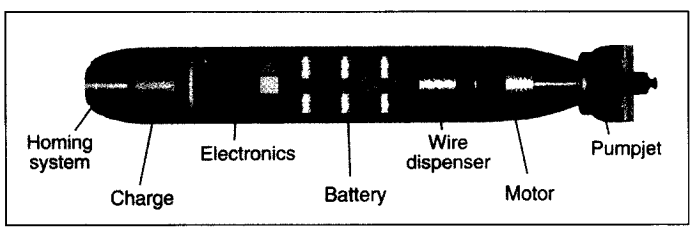
The warhead can have either a blast or shaped charge function.

Operational status

Full development/initial production was anticipated for early 1999 with prototypes undergoing sea trials in 2001. However, due to financial restructuring within the company, development of the Tp 46 has been abandoned.

Specifications

Length: c 2,800 mm
Diameter: 400 mm



Block schematic arrangement of the Tp 46 (Bofors Underwater Systems) 0038526

Weight: c 300 kg
Warhead: PBX blast (shaped charge available as option)
Operating depth: >600 m

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED

Tp 62/Torpedo 2000

Type
Heavyweight torpedo.

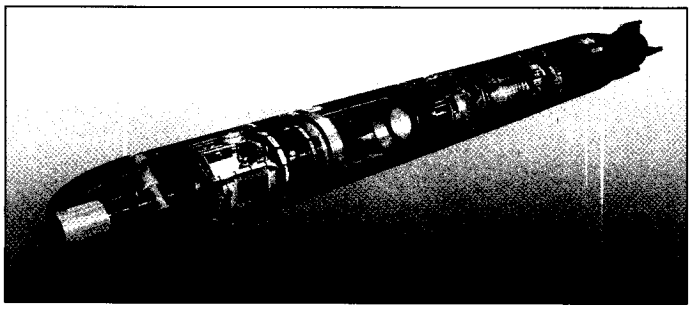
Description
The 533 mm dual-purpose wire-guided heavyweight Tp 62 began development in 1988 for the next generation of Swedish submarines and surface vessels for use against underwater and surface targets. The weapon is discharged using the swim-out method at a speed of 10 kt. The weapon is powered by a new, high-powered thermal pump jet propulsion system with a very high energy content based on Saab Bofors' long experience of High-Test Peroxide (HTP) systems. The system discharges only CO_2, which is soluble in water, resulting in a wakeless system and a weapon with high speed (in excess of 45 kt) and long range (in excess of 50 km) down to considerable depths with low radiated noise level. The motor is an axial two-stroke piston engine with seven cylinders and bore and stroke of 70 mm. Admission temperature is 800°C and the engine uses a two-stage compressor with compression pistons linked to the engine pistons. The propellant comprises 85 per cent HTP and kerosene together with hydrogen peroxide (H_2O_2), the engine developing between 25 and 350 kW of power. A condenser is built around the engine and the whole unit is mounted in shock-absorbing elements in the weapon's body.

The pump jet is based on the system used in the British Spearfish and developed by BAE Systems. This comprises a rotor connected via a flexible coupling to the engine shaft and a stator. The individual elevators and rudders are located behind the stator. The exhaust gases are led out through the starboard fin. The exhaust port is fitted with a non-return valve to prevent sea water from entering the system. The after body also incorporates a water flap, a connector for the torpedo communication channel in the starboard fin, power supply, and guide key for locating and securing the weapon in the tube. The lower fin incorporates the tube for the communication wire.

The HTP tank contains a plastic bladder that fills with water and thereby subjects the HTP to a pressure that drives out the HTP for consumption. The fuel section contains an annular fuel tank in which the kerosene is stored inside a rubber bladder. The bladder is surrounded by water under pressure which drives the fuel out of the bladder and into the combustion chamber. The fuel section is located between the engine section and the after body.

The weapon is equipped with an advanced active/passive homing head and a wire guidance communication link. The wire link consists of a plastic-coated copper wire, the system using the surrounding water as return conductor. Sonar operating modes cover active, passive and simultaneous active/passive using multiple frequency and wide bandwidth. The long range homing system features a multilobe function which, with the target analyser, allows the weapon to discriminate between a very large number of false targets while at the same time operating against several real targets. The fire control system sets the size of the attack volume and if the torpedo should follow the target's course and speed, or if it should be stationary. Different search programs can be selected prior to launch or during the attack. When the torpedo reaches the attack volume the warhead is armed and the homing system is activated. The warhead charge is initiated by a computerised, unjammable, hydro-acoustic proximity fuze against surface targets and by direct impact on submarines. The hydro-acoustic proximity fuze function senses the underwater contour of a vessel and initiates the warhead charge when the torpedo is below the target. The proximity fuze consists of a transducer mounted in the body of the weapon above the electronics and a signal processing system. The warhead has a main charge consisting of a low sensitive explosive, PBX, with high energy content.

The majority of the weapon's electronics are located in the electronics section, which incorporates computers, signal processing for the homing system and the proximity fuze. This section also houses the power supply unit for the torpedo and sensors for navigation and depth. The guidance and control system is set up as a



Schematic of Tp 62 (Bofors Underwater Systems) 0038525

neural net processor offering advanced control and signal processing algorithms, which allows several targets to be tracked simultaneously and their signals classified. In the event of a communication breakdown between platform and weapon, the torpedo's onboard computer takes full command of the weapon and calculates the target's anticipated position and guides the weapon to the predicted point of impact initiating one of several possible search patterns programmed into the computer.

The weapon can be launched from a submarine lying on the seabed because it does not execute a deep downward swing while increasing speed as it is launched. It can also travel at very low speed which enables it to be deployed as a search of mine torpedo at extended range. Series production commenced in December 1999.

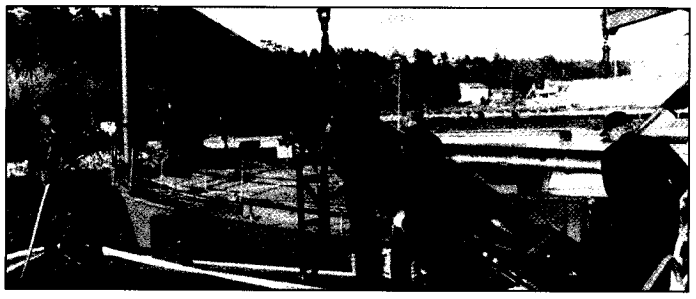
The weapon is designed to operate at great depth but can also be used in shallow waters and coastal areas.

Operational status
An initial contract for Tp 62 for the Swedish Navy was signed on 17 December 1997. The first batch of production torpedoes was handed over to the Swedish Navy on 12 June 2001. An export order from Brazil for Torpedo 2000 was signed early in 1999. It will equip the Improved Tupi class submarines replacing the Tigerfish Mod 1/2 torpedo.

Specifications
Length: 5,990 mm
Diameter: 533 mm
Weight: 1,450 kg
Warhead: c 200 kg PBX
Speed: >45 kt
Range: 21.5 n miles @ >45 kt
Operating depth: >500 m

Contractor
Saab Bofors Dynamics AB Karlskoga.

UPDATED



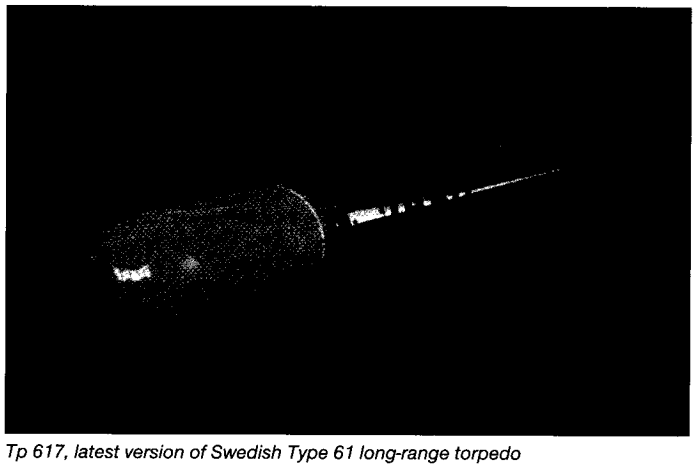
Loading a Tp 62 weapon on to a Swedish submarine (Saab Bofors Dynamics AB) 0067388

Tp 617

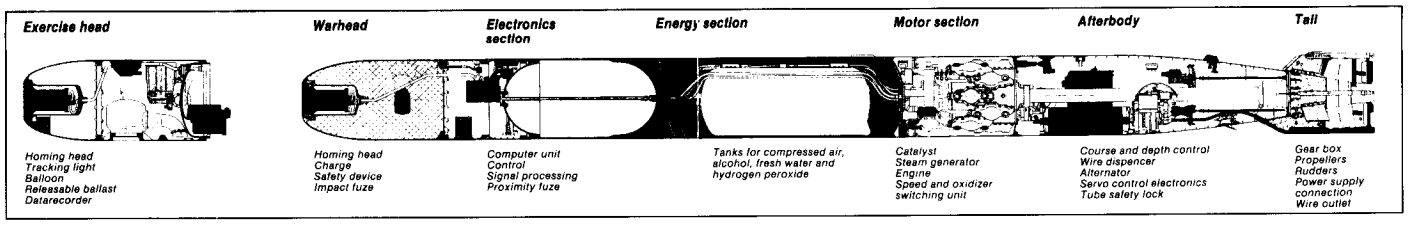
Type
Anti-surface vessel heavyweight torpedo.

Description
The Tp 617 is a wakeless, homing, wire-guided, long-range torpedo for launching from submarines and surface ships against surface targets. It is based on the well-proven Tp 61, which entered service in 1966 and retains the thermal propulsion system with hydrogen peroxide/alcohol/water as propellants.

The Tp 617 is divided into five main sections comprising: nose with acoustic sensor; electronics guidance section with fuzes; fuel compartment with tanks containing ethyl alcohol and HTP; motor; and afterbody with the course and depth control fins electric alternator and wire dispenser.



Tp 617, latest version of Swedish Type 61 long-range torpedo



Tp 617

The electronics guidance section houses a programmable digital computer that controls the homing system, communication with the launching fire-control system and the torpedo navigation system. The guidance wire communication link allows the launch platform to transmit orders to the torpedo controlling speed, depth, course, and target data. The torpedo reports its position, speed, course and depth, homing system parameters and target noise. In the event of communications being interrupted, the torpedo computer calculates the expected target position, guides the torpedo to the predicted point and initiates one of several possible search patterns.

The fuzing system consists of a dual-impact/computerised proximity fuze, both of which can be controlled from the launch platform's fire-control system.

The homing system is designed for use against surface targets and is mounted in a recess in the nose with the acoustic sensor using pre-formed beams for horizontal homing. Some weapons have been fitted with a wake homing capability.

The 12-cylinder, double star, single-stroke steam engine is powered by superheated steam produced through the combustion of the alcohol with the oxygen from the decomposed HTP. Water is added to cool the process and to produce the superheated steam. The torpedo can be driven at one of two speeds, which are pre-selected before launch, and can be changed according to the tactical situation during the torpedo's search and homing phase. Exhaust and steam leave the weapon through the propeller shaft leaving no visible trace as it contains 20 per cent carbon dioxide and 80 per cent steam.

Operational status

The Tp 617 has been in operational service with the Royal Swedish Navy (as the Tp 613) since early 1984 and is also in service with the Danish, Norwegian, Singaporean and Yugoslav navies. From 2001 the Tp 613 began to be replaced by the Torpedo 2000 in Swedish service.

Specifications

Length: 6,980 mm
Diameter: 533 mm
Weight: 1,860 kg
Warhead: 250 kg
Speed: 60 kt (max)
Range: 16 n miles

Contractor

Saab Bofors Dynamics AB, Karlskoga.

UPDATED

United Kingdom

Spearfish

Type

Submarine-launched torpedo.

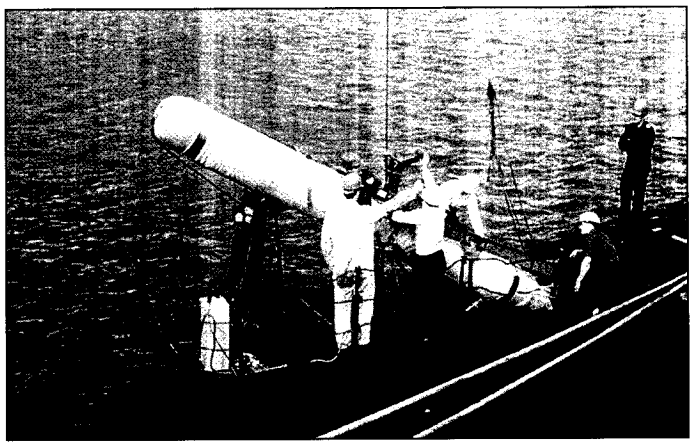
Development

Following a competition between Spearfish and the US Mk 48 ADCAP, carried out in 1979-80, the UK MoD awarded a fixed-price contract to GEC-Marconi for full development and initial production of Spearfish.

Description

Spearfish is a submarine-launched heavyweight torpedo designed to operate totally autonomously from all Royal Navy submarines and interfacing with a minimum of modification to all weapon handling and fire-control systems. Spearfish meets the Royal Navy staff requirement to counter faster, deep diving, quieter and stronger-hulled submarines, as well as dealing with surface targets and is equally capable in shallow coastal waters.

Spearfish is equipped with an open-cycle variable speed Sundstrand 21TP01 1,000 hp turbine thermal engine powered by an advanced Otto II/HAP fuel mixture contained in separate tanks. The maximum speed, endurance and diving depth significantly exceed those of all other torpedoes, either thermally or electrically propelled and double that of other electrically propelled heavyweight torpedoes. The prime mover is a ducted pump jet propulsor consisting of a rotor and stator using design techniques from the successful Sting Ray development. This arrangement reduces the need for gearing which, in turn, results in weight saving and lower self-noise signature. The pump jet propulsor duct is carried in eight profiled fins. The four primary fins extend rearwards into pods housing the hydraulic actuators for the control surfaces. The cruciform control surfaces mounted in the flow of the propulsor are configured as two vertical rudders acting together to control the torpedo in azimuth and two horizontal elevators working together to provide pitch control while superimposing differential action to control roll.



Spearfish torpedo (QinetiQ) 0096609

The thermal propulsion system has been designed to be very quiet in operation to provide the covert operation needed to protect the firing submarine from detection on torpedo launch and subsequent counterattack. The use of the HAP (Hydroxyl Ammonium Percholate) oxidant leads to greater combustion efficiency, significantly extended range as well as improved acoustic discretion as insoluble waste products which appear in the wake have been reduced to a minimum. Small control surfaces mounted in the efflux from the pump jet make Spearfish extremely agile.

The torpedo's advanced sonar and homing system enable it to operate primarily in a passive mode. However, when required to operate against a very quiet target, or in the final stages of attack, the active mode is used. In this mode, the powerful transmitters give Spearfish a long detection range and enable it to burn through enemy countermeasures. The detection capabilities are further enhanced by an array offering a large search volume with frequency-agile transducers which enable salvo firing to be carried out.

Communication between submarine and torpedo is via a guide wire link. The torpedo normally operates autonomously, relaying data back to the submarine, but the command team can assume control at any time. The wire is dispensed from two reels, one in the torpedo and one in the submarine launch tube, through a tube-mounted dispenser which allows discharge at high submarine speeds as well as complete freedom of manoeuvre for the submarine after launch.

Spearfish contains a number of homing and tactical computers to control the weapon, enabling it autonomously to select search, detection and attack modes, to classify signal returns, to decide on appropriate tactics including re-attacks on the target if necessary, and to classify, track and overcome countermeasures and decoys. The torpedo's capability can be enhanced by software updates as target and countermeasure characteristics evolve in the future.

A control sensors unit incorporating a strapdown inertial navigational system provides speed, course and depth data to the onboard tactical computer.

Spearfish carries a large shaped charge warhead to allow both double-hulled submarines and major surface units to be effectively engaged. Against submarines, the homing system guides the torpedo to the optimum impact point on the target's hull. Against surface targets the torpedo detonates the warhead under the hull creating a whipping effect which breaks the target's back.

Data given below relate to the warshot torpedo; there are also exercise and handling and discharge versions. The exercise version is identical to the warshot except that the warhead is replaced by a Recovery and Instrumentation (R and I) section. This section carries a tracking system and an advanced data recorder with a large data capacity, together with a recovery system. At the end of run the torpedo, which is heavier than water, is floated to the surface by means of a toroidal bag contained in the R and I section. Developed from the Sting Ray system, it uses cold gas (CO_2) to inflate the bag and is clean, effective and reliable.

The weapon can interface with a wide range of fire-control systems and is compatible with any submarine using a positive discharge weapon system.

A new generation of compact and relatively simple positive discharge systems will allow non-nuclear submarines to deploy Spearfish.

The torpedo is to be upgraded with improved sonar and signal processing capabilities to improve its capabilities against very quiet SSKs operating in littoral waters. Research is currently in progress on the upgrade in a collaborative venture between BAE Systems and QinetiQ. Referred to as the Advanced Spearfish Programme (ASP), the research will seek to evaluate new technologies which will improve the weapon's capabilities and overcome obsolescence which is impacting

its current hybrid processing architecture. The ASP will enable the weapon to operate effectively in shallow water against small, slow underwater targets such as AIP/diesel electric submarines equipped with complex countermeasures.

A wide range of digital signal processing techniques is being investigated with COTS microprocessing technology offering the capability to handle the high volume of computational data which the upgrade programme will demand.

Among the specific areas being investigated are:

- wide bandwidth (octave bandwidth) processing to suppress reverberation in shallow water
- complex waveforms with additional modulations providing Doppler discrimination and range information using matched filters
- low probability of intercept active wave forms
- adaptive beam forming to help reduce reverberation and the effect of noise jammers
- neural net classification
- advanced tracking.

As part of the development programme QinetiQ has adapted an existing homing head to perform as a digital homing head demonstrator. For this the existing analogue beam-formers have been replaced by analogue to digital converters while the analogue recorder was replaced with digital recording at element-level, and the signal processor removed, recorded data being processed ashore. Captive trials with the digital homing head have been carried out in shallow and very shallow water environments (15 m). The trials covered a range of bandwidths including 1/5, 3/5 and full octave to test the capability of the transmit and receive systems. Adaptive beamforming will provide potential benefits of between 10 and 20 dB improvement in performance.

Operational status

Spearfish is in production and in service with the Royal Navy. The final weapon was handed over on 24 November 2003. It is believed that around 400 warshot weapons are held in inventory. The weapon is projected to remain in service until 2025.

Specifications

Length: 6,000 mm
Diameter: 533 mm
Weight: 1,850 kg
Warhead: 300 kg shaped charge PPX-104 HE
Speed: >70 kt
Depth: >900 m
Range: 12.5 n miles @ 60 kt

Contractor

BAE Systems, Underwater Systems Waterlooville, Hampshire.

UPDATED

Sting Ray

Type

Anti-submarine lightweight torpedo.

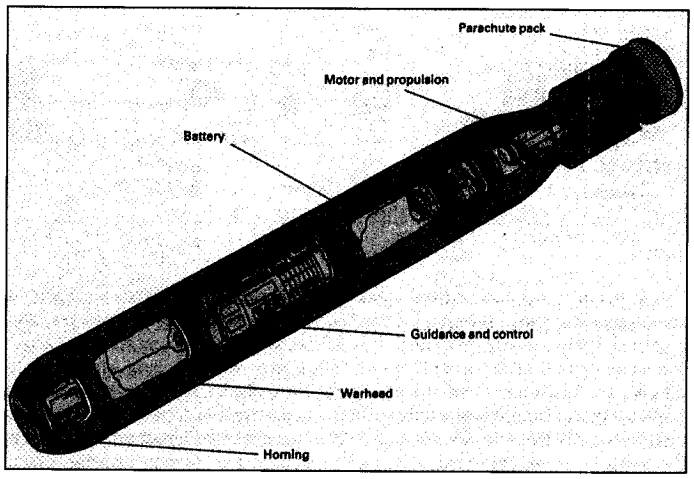
Development

1985 – Fleet Fleet Weapon Acceptance trials successfully completed.
September 1983 – Weapon officially handed over to the RAF and RN.
December 1982 – Design certificate issued.
April 1982 – Acceptance trials commence.
August 1981 – First production weapon delivered.
November 1979 – First fixed-price production contract placed.
1971 – Development commenced by GEC-Marconi.

Subsequent to the Fleet Weapon Acceptance Trials an RAF Nimrod successfully launched a Sting Ray and actually sank a submarine target in the open sea. The torpedo will be updated to Sting Ray Mod 1 standard and will remain capable of countering submarine threats effectively until well into the next century.

Description

Sting Ray is an advanced lightweight torpedo designed for launching from helicopters and fixed-wing aircraft as well as from surface ships. It has a multimode, multibeam sonar, quiet, high-speed propulsion system and a fully programmable onboard digital computer, which together give the weapon a high performance not only in deep water, but also in shallow water where sonar conditions are difficult. The weapon uses multiple preformed transmit and receive beams in association with multiple frequency channels. A very considerable effort was put into gathering acoustic data in shallow water with many hundreds of trials in order to optimise the torpedo's tactics and software algorithms under such conditions. Its computer system enables it to make tactical decisions during an engagement to optimise the various homing modes to suit the environment and target behaviour. The computer can be reprogrammed 'through the skin' whenever updated software, or programs tailored to a particular customer's operational requirements are required. These programs then adapt themselves to the particular tactical and environmental conditions in which the torpedo operates. The acoustic operation of the weapon is achieved through a large number of electrically activated transducers mounted in the nose of the weapon. By controlled switching and multiplexing these transducers can transmit high-power sound into the water or detect and receive



Sting Ray outline

relatively low-power returns. The onboard computer forms and shapes the transmit and receive beams according to environmental conditions and preprogrammed target parameters. In active mode the transmitted signal is frequency modulated to distinguish between targets, non-targets and countermeasures.

The high-speed performance of Sting Ray comes from its pump jet propulsion system (two contrarotating propulsors housed in a duct to form the pump jet). Vehicle hydrodynamics are accomplished by an electrohydraulically driven proportional control system. The four control surfaces are mounted in the efflux of the pump jet to maximise turn rate and agility. The advanced seawater-activated magnesium/silver chloride battery from Enersys gives extended endurance and no performance degradation with depth. A carefully controlled flow of seawater through the battery removes heat sludge and hydrogen gas, while electrolyte recirculation offsets the effects of cold water or lack of salinity. The use of partial re-circulation of the seawater, a highly reactive negative paste alloy and a special design which reduces inter-cell leakage currents ensures that on-load voltage and weapon speed are maintained throughout the weapon's run. The battery is fitted in all current weapons.

Sting Ray carries a directed energy warhead required to counter modern submarine design. This type of warhead demands high-accuracy guidance to ensure the torpedo strikes the most vulnerable part of the target.

The shaped charge produces a highly directional jet of molten copper to penetrate the pressure hull of a submarine as well as generating a significant isotropic blast effect.

In operation, when the torpedo enters the water and frees itself from its parachute, it sets up a preprogrammed search pattern designed to maximise the chances of target detection. On acquiring the target, the computer and active/sonar sensors make it almost impossible for the target to evade attack. The advanced software of the guidance/homing system allows it to filter out background noise and decoys and to make an interception rather than perform a conventional tail-chase attack. It is believed to have a maximum speed of about 45 kt with an estimated endurance of more than 8 minutes at that speed. Maximum operating depth is believed to be about 1,000 m.

Data given below relate to the warshot torpedo; there are also exercise and dummy (handling, carriage and release) versions. The exercise version is identical to the warshot except that the warhead is replaced by a novel design of recovery and instrumentation section. This 'R and I' section carries a tracking system, a data recorder and a recovery system. At the end of the run the torpedo, which is heavier than water, is floated to the surface by means of a toroidal bag contained in the R and I section which is inflated by a solid-propellant hot gas generator. The system has been demonstrated to be effective and reliable.

Over 1,700 in-water runs were conducted both in development and usage, mainly against targets, not only making it one of the most tested torpedoes in the world but also ensuring an ever expanding database of in-water and environmental data to enable continuous upgrading of its software and algorithms to be made.

The Sting Ray Mod 0 is to be upgraded to the Sting Ray Mod 1 version featuring an upgraded homing system with newly developed acoustic and tactical processing software with a new digital correlator. The tactical and processing algorithms will be optimised using real-time hardware-in-the-loop simulation prior to in-water testing. Hardware improvements will include:



Sting Ray torpedoes on a Sea King helicopter of the Royal Navy

- a substantially modified front-end array;
- digital signal processing (capable of executing the most advanced classification algorithms);
- navigation and guidance computers (a solid-state autopilot of increased power and memory able to execute highly complex tactical software routines required in shallow water operations and using an increased input of data supplied by the launch platform and a solid-state inertial measurement unit of improved accuracy able to support complex tactical software modes being used to overcome the latest acoustic countermeasures;
- a new motor controller (designed to manage the start-up of the high energy power system)
- a lighter and more energy efficient auxiliary power supply system;
- an electro-mechanical actuation system for the control surfaces.

The use of electro-mechanical actuation in place of the electro-hydraulic servo system of the Mod 0 will result in much quieter operation and improved stealth.

Much of the signal processing, navigation and guidance subsystems will be based on COTS hardware.

The nose section will retain the existing transducer technology of the Sting Ray Mod 0, but the array and associated electronics are being modified to provide for higher power acoustic transmission and increased receiver sensitivity. The electronic units will use digital beamforming which will provide improved transmit and receive directivity. All hardware units in the nose are being repackaged to minimise interference with the direction action of the shaped charge warhead which is fitted immediately behind the nose section.

Plans are also in hand to develop a new Mod 1 warhead to meet requirements for insensitive munitions.

Improvements will also be made to the Mg-AgCl (magnesium/silver chloride) batteries, together with an option for variable speed operation to increase endurance.

The torpedo will be equipped with the Northrop Grumman LN-200 low power, low radiated noise, inertial measurement device. The hermetically sealed device uses fibre optic gyroscopes and micro machined accelerometers, which results in a compact unit with no moving parts. The device will be used for sensor stabilisation and motion compensation.

With these improvements shallow water performance will be considerably enhanced.

Operational status

In full production. In service with RN and RAF (since 1985) and the Norwegian, Thai and Egyptian navies. A production order for 2,500 torpedoes was signed in January 1986 by UK MoD.

On 15 December 1989 Marconi signed a contract with the Norwegian Navy and Air Force for a substantial number of Sting Ray torpedoes with a contract value in excess of £25 million. Delivery commenced early in 1991 together with the work necessary to modify the Norwegian Air Force P-3C Orions and Mk 32 launch tubes to take Sting Ray.

In July 1996 BAE Systems was awarded a £109 m contract for the full development and pre-production phase of the Sting Ray Mod 1. The UK MoD has since awarded BAE Systems a £441 million contract for Sting Ray Mod 1 main production programme with full production commencing in the first quarter of 2005 and an in service date of around May 2006. The weapon underwent contract acceptance trials in November 2003 with seven runs to hit at the BUTEC range. The upgrade will extend the life of Sting Ray for another 25 years. The final development trial of the Sting Ray Mod 1 was successfully completed towards the end of 2003. The final in water trials were conducted against the submarines *Sceptre* (Royal Navy) and *Ulstein* (Norwegian Navy)

Specifications

Length: 2,597 mm
Diameter: 324 mm
Weight: 265 kg
Warhead: 45 kg Torpex shaped charge HE
Propulsion: electrically driven, contrarotating pump jet
Speed: 45 kt
Range: 6 n miles @ 45 kt
Operating depth: 750 m

Contractor

BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

STLS

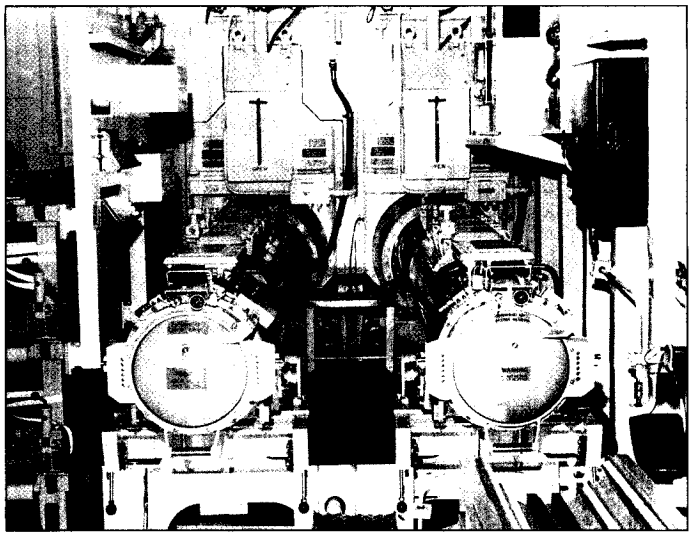
Type

Shipborne torpedo launch system (STLS).

Development

Developed in 1999, the Shipborne Torpedo Launch System (STLS) builds on the proven in-service record of the Magazine Torpedo Launch System (MTLS) and its deck-mounted derivative the Shipborne Torpedo Weapon System 3 (STWS 3).

The primary design objective was to provide a modular system using common equipment, which can be tailored to suit a customer's requirements. Ranging from the fully combat-system integrated, magazine-mounted system similar to that used in the British Type 23 frigate, to a stand-alone deck-mounted launcher, or many combinations in between.



STLS tubes mounted in a protected compartment (J & S Marine) 0089214

The STLS uses commercially available modules and sub-assemblies in conjunction with state-of-the-art bespoke PEC designs, which provide a high degree of flexibility, capacity for future expansion. high reliability, with low procurement and through-life costs.

Description

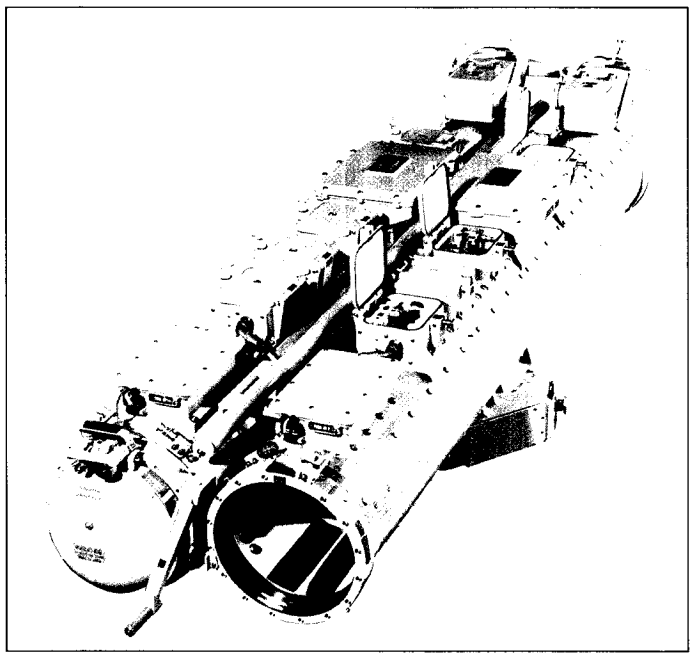
The existing tubes have been retained and can be mounted either in a protected compartment, such as the air weapons magazine, or exposed on deck. In both cases the tubes are shock-mounted enabling them to be adapted to launch a variety of lightweight torpedoes. Each tube is fitted with an innovative design of breech handling mechanism, which speeds reload and improves safety. The system can be easily configured to operate with 2, 4 or 6 tubes.

In the magazine area the launchers are mounted port and starboard athwart ship in fixed positions, whereas in the deck-mounted variant they can be trained in or out for loading and firing respectively.

The system of muzzle closures range in complexity from doors designed to provide protection under severe environmental conditions but operationally limited to lower sea states, through to magazine bulkhead closures capable of operating up to and including green sea conditions. In all cases the muzzle closure is capable of being fired through in cases of emergency.

The primary launch facility is a shock-mounted 19 in equipment cabinet providing the interface to the combat system, tube interface, display interface, processor and diagnostic electronics. The design employs a standard VME backplane, PowerPC embedded processor with the operational firmware programmed into a standard PCMCIA card. The operational firmware uses generic in-service proven tracker and predictor algorithms with operator-selected input variables. A range of standard Local Area Network (LAN) interfaces can be provided to adapt the system to a number of combat systems. Diagnostic test results are relayed to the operator control unit, although a connector within the primary launch facility enables the results to be displayed on a PC for local diagnosis and repair.

The system design also provides for a secondary launch capability, which can be mounted either within the citadel or on deck, providing either computer-aided or



STLS tubes mounted on a trainable deck launcher (J & S Marine) 0089213

manual torpedo launch capability. The local launch facility can be fitted port and starboard to give a dual redundant capability or as a single facility configured for the number of tubes employed. In its computer-aided launch mode it is integrated to the combat system via the primary launch facility where the fire control solution is relayed to the local launch facility. In its manual mode the local launch facility can be programmed with a sub-set of the launch data. A torpedo jettison facility is also provided to launch the weapon in case of emergency.

Additional functionality can be included in the local launch facility to provide a direct link to the combat system to make it the primary launch facility, without loss of functionality.

Operator displays are provided on an operator control unit and an optional jettison unit. With a sub-set of the data being fed to a bridge display unit for the Officer of the Watch. The operator control unit provides torpedo selection and fire control facilities through a touch-sensitive screen as well as displaying the results of diagnostic testing. The jettison unit provides the facility for safe jettison of the torpedo in emergency conditions.

Operational status
In service aboard Type 23 frigates of the Royal Navy.

Contractor
J & S Marine, Barnstaple.

VERIFIED

Tigerfish Mod 2

Type
Submarine-launched torpedo.

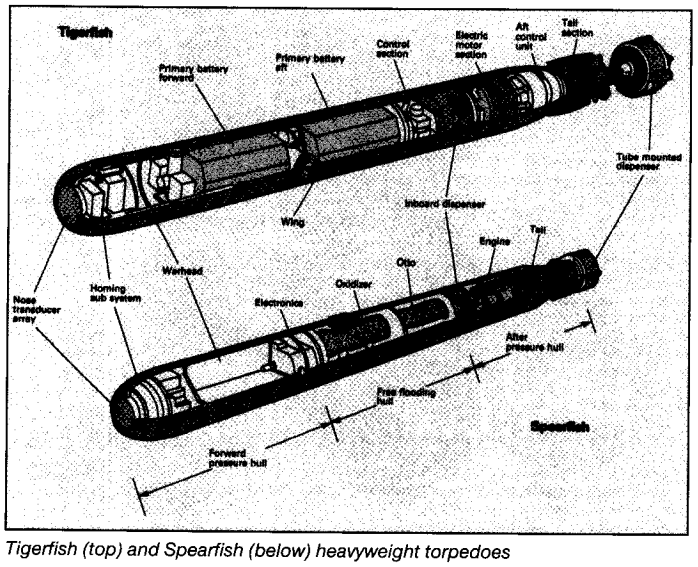
Development
Development of Tigerfish Mod 2 was completed in 1985 incorporating homing improvements based on techniques developed in the Sting Ray lightweight torpedo. It also incorporates the wire guidance system developed for the Spearfish heavyweight torpedo. Performance of the Mod 2 was demonstrated successfully in a series of trials which culminated in the sinking of a decommissioned Type 12 frigate. A modification kit has been developed which enables Mod 1 torpedoes to be upgraded to Mod 2 standard.

Description
Tigerfish is a 533 mm wire-guided acoustic homing torpedo capable of engaging surface and submarine targets in all operational scenarios from deep water to the littoral. The weapon is designed for minimum radiated noise and is used in passive sonar mode whenever possible to take full tactical advantage of covert operation. Tigerfish can either swim out or be ejected with a positive discharge system, making it compatible with all classes of submarine.

Wire guidance is used in the initial stages of an engagement up to the point where the torpedo's automatic three-dimensional passive/active acoustic homing system can control the run into the target. Wire is dispensed from both torpedo and submarine to avoid any wire stress due to their relative motion.

The torpedo carries its own computer which is connected through the guidance wire to the computer of the submarine's torpedo fire-control system. During the wire guidance phase the torpedo's computer responds to the demands of the submarine computer and during the homing run it interprets the data from the homing system sensors and calculates and commands the appropriate course.

The sonar can operate in either passive or active mode. During the attack the interrogation rate is progressively increased, as the torpedo nears the target, so as to improve system accuracy. The interrogation rate is controlled by the onboard computer, which performs several functions during this phase: interrogation control, sonar data computation, torpedo steering control and data transmission to the submarine to update its own computer memory.



Tigerfish (top) and Spearfish (below) heavyweight torpedoes

Tigerfish is propelled by a powerful two-speed electric motor driving a pair of high-efficiency, low-noise, contrarotating propellers.

Power for the motor is derived from two high-capacity zinc/silver oxide primary batteries developed by Enersys. The dry-charged zinc and silver peroxide plates use potassium hydroxide as the electrolyte which is released into the cells just before firing. Fast run-up gyros for directional and attitude stability provide a very quick reaction time. High or low speed is selectable at all times.

The torpedo is fitted with a dual-action fuzing system comprising an impact fuze and an all-round proximity fuze, designed to operate at the point of closest approach to the target.

Operational status
Tigerfish Mod 2 is in service with the Royal Navy. Data given below relate to the warshot torpedo; there are also exercise and dummy (handling) versions. The exercise version is similar to the warshot but has rechargeable batteries, becomes buoyant at the end of the run, and has an instrumentation pack for data analysis in place of the warhead.

Tigerfish has been released for export with sales of Mod 1 to Brazil for the Type 209 Tupi class submarines and sales of Mod 2 to Turkey for the Type 209 Preveze class. Tigerfish has been successfully integrated into a number of fire-control systems including all UK Royal Navy equipments, the KAFS system and ISUS 83. Tigerfish warstocks in the Royal Navy are due to have been completely replaced by Spearfish by the end of 2003.

Specifications
Length: 6,464 mm
Diameter: 533 mm (21 in)
Weight: 1,550 kg (in air)
Propulsion: electrically driven contrarotating propellers; 2 speeds
Speed: dual high/low selectable at all times, 35/24 kt
Range: 13 km @ 35 kt (active), 29 km @ 24 kt (passive)
Fuze: impact and proximity
Warhead: 135 kg PBXN 105 HE

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire. ***UPDATED***

Torpedo launchers

Type
Deck and magazine launchers for lightweight torpedoes.

Description
The family of Mk 32 launchers together with STWS 1 and STWS 2 comprise deck-mounted or magazine-mounted triple or twin GRP torpedo tubes. Deck tubes are mounted on a training mechanism, allowing the tube assembly to be trained outboard. Muzzle closures and anti-condensation heaters provide an all-weather storage capacity for the torpedoes. The Mk 32 family comprises a triple-barrelled (Mod 5) or twin-barrelled (Mod 9) variant.

The family of Mk 32 launchers can be supplied to fire the US Mk 46 (all variants), Sting Ray (all variants) and Italian A 244/S, torpedoes. Weapons are fired by the release of compressed air stored in a breech assembly air reservoir. Air reservoir charging terminals are installed at each launcher position and connected to the ship's high-pressure air supply.

The launchers can be interfaced with a variety of launch controllers and presetters giving the option of either automatic or local control.

Various configurations are available through the use of modular construction, including the ability to fit onto small ships which lack a combat information system. Various interfaces can be fitted allowing the system to integrate with the ship's other ASW systems including sonar.

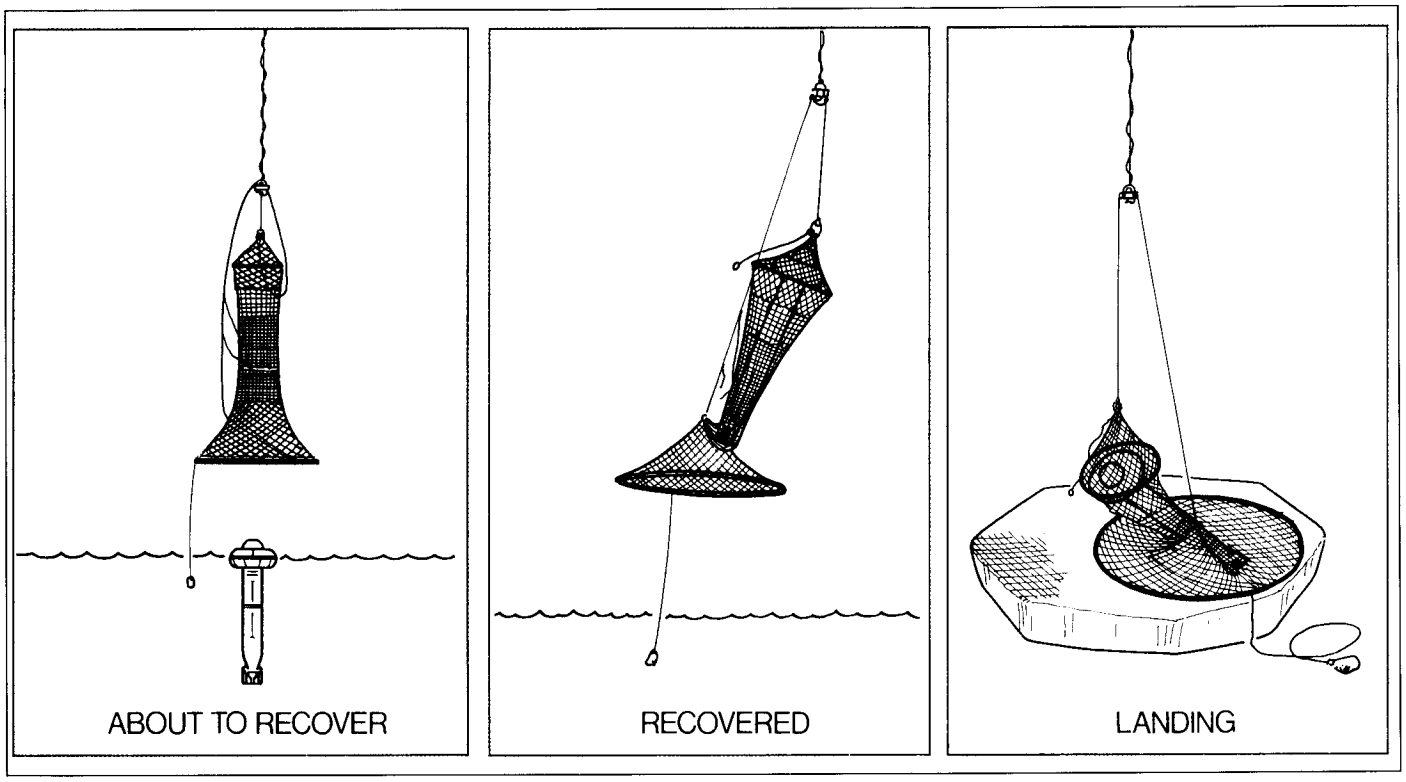
Operational status
Launchers are in service with 19 navies worldwide and can be adapted to launch all current standard lightweight torpedoes.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire. ***VERIFIED***

Torpedo recovery system

Type
Torpedo recovery system.

Development
Originally designed for the recovery of the Sting Ray torpedo in a vertical floating recovery position the system has since been adapted to recover both Mk 44 and Mk 46 lightweight torpedoes, including the horizontally floating Mk 46 exercise variant. The system has been engineered for use from Sea King (RN), Lynx (RN), Puma (RAF), Sikorsky SH-3 (USN), Agusta 109, Dauphin and Bell LongRanger helicopters. The system has also been cleared by the Joint Air Transport Establishment in the UK to fly under any suitable UK military aircraft.



Principle of operation for the torpedo recovery system

Description

The system comprises two elements: a recovery net and a landing platform. The conical net arrangement is suspended by a 9 m cable from the standard cargo hook on a helicopter. A remote SACRU (Semi-Automatic Cargo Release Unit) is attached to the end of the cable and is activated from the aircraft cabin by a completely independent power supply. The SACRU supports three colour-coded lines whose relative lengths are changed by SACRU release, to effect weapon capture. Auxiliary lines consisting of a rubber bungee and weak link arrangement also assist in this automatic procedure. The polyester braided net is kept in shape by means of two aluminium hoops, which are coated to prevent damage to the torpedo.

The transportable landing platform is a sectioned octagonal frame of tubular aluminium, across which is stretched a braided net which is kept under tension by means of ratchet tensioners. This strong but soft platform all but eliminates the risk of damage to the weapon. Attached to the inside of the frame is a PVC sump to catch any effluent.

Weapons can be recovered by the system in up to Sea State 6. Turn round time on weapons is kept to a minimum and the requirement for personnel in the water during recovery has been eliminated.

Operational status

To capture a floating weapon the aircraft hovers over the weapon until the catchment area of the bottom hoop is approximately centred over the weapon. The aircraft and net are then lowered until the nose of the weapon is seated in the apex of the net. The remotely operated cargo hook is then released allowing the net to drape fully over the weapon. The pilot then slowly increases hover height, allowing the net's trapping lines to operate thus enclosing the weapon with the bottom hoop folded under and to one side of the net. The aircraft then lifts the net complete with the weapon from the water and proceeds to the landing site where the net is lowered onto the landing platform and released from the aircraft.

Specifications

Length of net: 5,480 mm (from apex to bottom hoop)
Bottom hoop diameter: 3,000 mm
Top hoop diameter: 1,200 mm
Weight: 94 kg

Contractor

Bridport Aviation (a Division of AMSAFE Bridport Ltd), Bridport, Dorset.

VERIFIED

Torpedo steering actuation systems

Type

Integrated steering actuation systems for torpedoes.

Description

Typically the source of power for a long-endurance control system necessary in torpedoes such as Spearfish is a hydraulic pump with a return oil system. To cover essential control activity in the immediate post-launch period and prior to the run-up speed of the propulsion engine, a stored-pressure system gives a smooth hand-over to pump-driven operation.

The following subassemblies are required:

- High-pressure pack
- Low-pressure pack
- Ring main
- Fins (with rudder and actuator)
- Electronic controller.

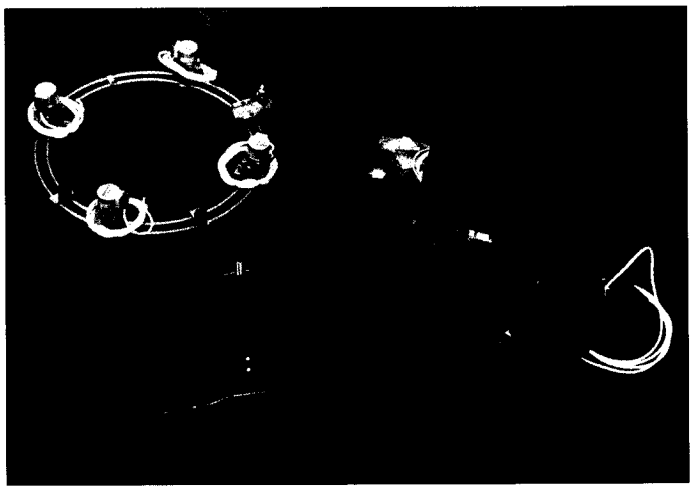
These hydraulic systems are specifically configured to suit the space envelope constraints in a torpedo tailcone. The ring main integrates the following essential components in an electrohydraulic system: pump, hoses (pressure and return) with quick-disconnect couplings, pressure and return ring-main pipes, relief valve, accumulator with gas cartridge release valve and filter, pressurised reservoir, electrohydraulic servo valves (four), rotary actuator with position feedback (four), and the control system's electronic package.

In electrohydraulic systems a pump, usually near the torpedo motor and remote from the ring main, is connected via hoses and quick-disconnect couplings. Particular attention is paid to pump noise levels and to mounting structure stiffness for maximum noise attenuation.

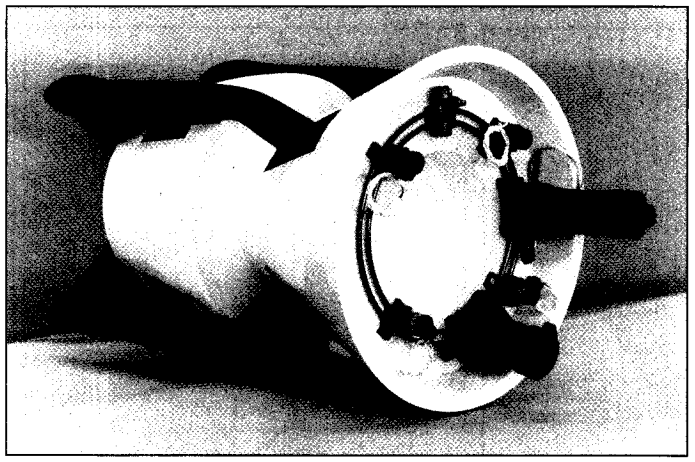
Quick-disconnect couplings enable a modularised torpedo to be broken down easily for servicing without draining oil from the system.

A ring main of concentric pressure and return rigid pipes links mounting pads to which are attached accumulator, reservoir, relief valve, and four electrohydraulic servo valves. These components are arranged around the propeller shaft giving an optimum use of space. A low-hysteresis relief valve limits the pressure peaks in the hydraulic system and discharges from the high- to the low-pressure ring main. An accumulator provides a back-up source during the starting period and when actuator demands momentarily peak above the pump output flow.

On torpedo release an electrical signal actuates a frangible valve in a sealed gas bottle. This gas immediately pressurises accumulator fluid to provide hydraulic power to the actuators via the electrohydraulic valves.



Part of FHL Division Claverham Ltd system components for the Spearfish heavyweight torpedo showing a fin with rudder



Part of FHL Division, Claverham Ltd's electrically signalled, hydraulically powered control system for the rudders of the Spearfish heavyweight torpedo

A spring-loaded reservoir maintains a positive return-line pressure at all times and absorbs fluid displacements due to accumulator discharge and fluid expansion.

Four two-stage electrohydraulic servo valves mounted on the ring main control four rotary actuators. Each valve receives an electrical signal from the torpedo guidance system via an electronic control loop-closure package.

Four rotary actuators directly coupled to the control rudders are fitted in the fins. The actuator/control rudder position is monitored through a mechanically linked rotary potentiometer which provides the position feedback signal to the electronics package. The fins are individually attached to the torpedo tailcone.

Test sets are provided to put the four-axis control system through its paces by injecting various electrical demand input signals, including steady-state, sinusoidal and other forms. Hydraulic power is used to energise the ring main of the control system under test; an electronic section simulates the torpedo control. A microprocessor is programmed to take each control system through the complete test routine.

Contractor
Claverham Ltd, Bristol.

VERIFIED

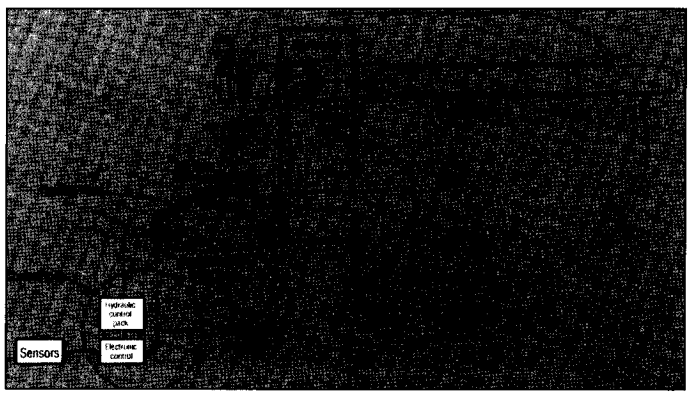
Weapon handling and launch system

Type
Positive discharge system for submarines.

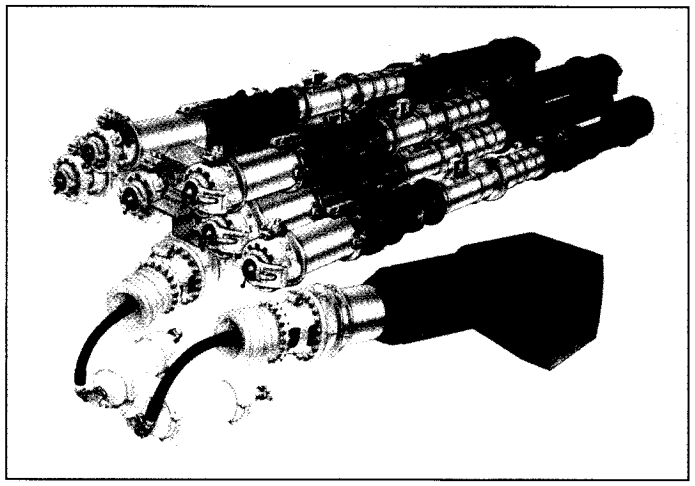
Description
The design can accommodate various weapon types including:
- Mk 24 'Tigerfish' wire-guided torpedo
- Spearfish heavyweight torpedo
- Royal Navy anti-ship missile Sub-harpoon
- Mk 48 US wire-guided torpedo
- mines
- Tomahawk Land Attack Missile.

The equipment takes the weapon through embarkation, stowage, loading and launching from four-, five- or six-tube configurations, incorporating a variety of stowage requirements, including hull-mounted dependent or independently shockmounted stowages and integral raft structures.

The equipment provides for all the handling systems, the torpedo tubes and electronic firing equipment necessary for a positive discharge launch method, utilising one of the following processes:
- Air Turbine Pump (ATP)
- water/air ram discharge
- high-pressure air discharge system.



Diagrammatic arrangement of weapon discharge system



Submarine weapon discharge system

Whilst all current Royal Navy submarines are fitted with positive discharge air/water ram systems, the new Astute class boats will have ATPs, as installed on the ex-RN Upholder class submarines leased to the Canadian Navy, and the Collins class submarines in service with the Royal Australian Navy. The principle of operation is similar to the water-ram except that the fixed displacement ram is replaced by a rotary pump. Air-turbine driven pump systems, which are claimed to be far more versatile than swim-out systems, enabling the flexible discharge of a wide range of weapons whilst manoeuvring at both low and high speeds, are compact and light when compared to water ram systems. They are installed as a unit and have low-maintenance requirements. Such pump systems offer a satisfactory discharge performance at all depths and, when combined with mircroprocessor based control systems, which include a Programmable Firing Valve (PFV) are able to precisely match discharge requirements to the weapon type, boat depth and tube discharge characteristics.

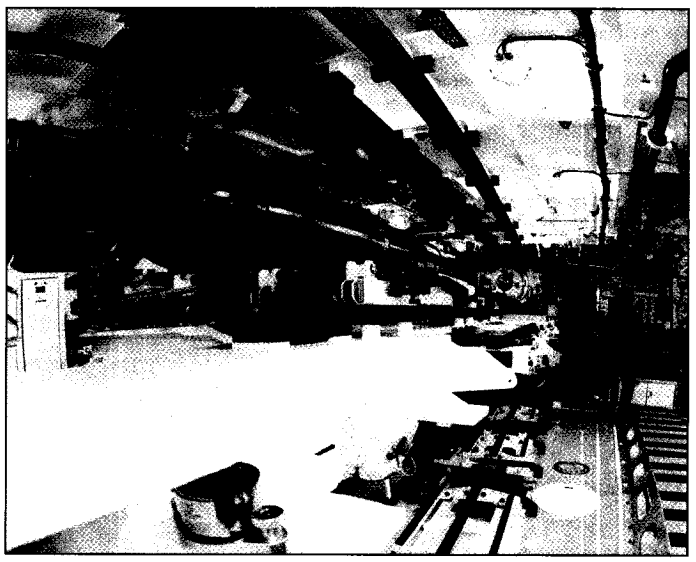
There is a growing demand for positive discharge systems brought about by the adoption of tube-launched missiles with no 'swimout' capability and the increasing need for quiet discharge.

Operational status
Systems are operational with the Royal Navy, Royal Australian Navy and Canadian Forces, aboard the following current and future classes of submarine:
- Swiftsure class SSN
- Trafalgar class SSN
- Victoria class (ex Upholder class)
- Vanguard class SSBN
- Collins class SSK.
- Astute class SSN

For the 'Astute' class the company delivered in late 2001 the first three main starboard torpedo tubes, each 5.5 m long and nearly 1 m in diameter. These will form the main part of the hull interfacing torpedo disharge system.

Contractor
Strachan & Henshaw Ltd, Bristol.

VERIFIED



The weapons handling system aboard the torpedo room of the HMS Vanguard. *A Spearfish torpedo can be seen on the upper cradle ready for loading into the torpedo tube immediately in front of it* (Royal Navy) 0067387

United States

HOTTorp

Type
Training torpedo.

Description
The aluminium-hulled HOTTorp (Honeywell Operational Training Torpedo) has been developed to provide a low-risk device to train military personnel in the handling, preparation, launching and recovery of lightweight torpedoes. The system is compatible with all existing lightweight torpedo handling systems, launch platforms, fire-control systems and recovery equipment. The system contains no explosives or hazardous materials and requires no additional personnel, equipment, tools or power supplies. The system incorporates launch platform interfaces and hookups.

The external dimensions, weight and centre of gravity are the same as a Mk 46 lightweight torpedo, and enable HOTTorp to simulate an actual lightweight torpedo up to and including water entry characteristics.

The system is programmable at any time prior to launch, enabling it to provide fire-control preset training. A self-contained, hull-mounted liquid crystal display provides a readout of the fire-control presets for verification after recovery. The fire-control module also monitors hull integrity and battery life. Training aids include a simulated sea water battery and a plug for training operators in how to refuel a torpedo. Free windmilling propellers are fitted.

The system features a dual weight release mechanism which ensures recovery. Water impact is the primary mechanism for weight release. Upon entering the water a mechanical plunger-piston mechanism releases six 11.5 kg drop weights from the system's nose. As a back-up, HOTTorp uses the increasing static water pressure to release the weights at a depth of 11 m. The release of these weights allows HOTTorp to return to the surface and float vertically 25-30 cm out of the water. A dye container is seawater-activated to help locate the position of HOTTorp. If it is not recovered within 24 hours of launch, HOTTorp automatically scuttles to avoid becoming a shipping hazard. An optional pinger is available to aid in tracking HOTTorp on the ship's sonar.

Turnaround time on board ship is less than 60 minutes. This enables personnel to be trained more quickly and with greater frequency. On board the turnaround cycle includes a complete washing with fresh water, removal and replacement of the flooding valve and dye container, testing of the vacuum, releasing the piston and installing new drop weights, recaging the gyro, inserting a seawater lanyard and installing any launch accessories.

Designed for a minimum of 150 launches, HOTTorp requires minimal maintenance, with preventative maintenance based on an annual basis or after 10 launches.

The system's shallow plunge depth enables its use in all operating environments. It will not exceed 23 m when launched from a torpedo tube, or 37 m when launched from rotary- or fixed-wing aircraft.

Operational status
In service with the navies of Canada, Chile, Portugal and the US.

Specifications
Length: 2.591 mm
Diameter: 325 mm
Weight: 230 kg
Weight (in water): 52.36 kg

Contractor
Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

Mk 37 Mods 1 and 2

Type
Submarine-launched anti-submarine torpedo.

Description
These versions of the Mk 37 torpedo differ from Mods 0 and 3 in their size and method of guidance; in other respects they are substantially similar.

Both versions are wire guided, whereas the Mk 37 Mods 0 and 3 are free-running torpedoes. Both are 4,099 mm long and weigh 766 kg (warshot) or 657 kg (practice).

Just as Mod 3 is an updated version of Mod 0, so is Mod 2 a version of Mod 1, updated by the incorporation of a number of minor modifications.

Operational status
The Mod 2 is operational with the navies of Norway, Turkey and Venezuela.

Specifications
Length: 4,099 mm
Diameter: 483 mm with guides to fit 533 mm tubes
Weight: 766 kg (warshot); 657 kg (practice)
Warhead: 150 kg HBX-3
Speed: 24 kt (Mod 2)
Range: 11.5 n miles
Operating depth: to 270 m (Mod 2)

Contractor
Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

Mk 44

Type
Air/surface/missile-launched anti-submarine torpedo.

Description
This is a lightweight torpedo designed for launching from fixed- or rotary-wing aircraft, from surface vessels (using Mk 32 tubes), or by the ASROC rocket system.

Two models were produced but the differences in dimensions are trivial. Both torpedoes are electrically propelled and their calibre is 12.75 in (324 mm). Approximate length is 2.56 m and the torpedoes weigh about 233 kg with a 34 kg warhead. Active acoustic homing is used. Depth and course settings are entered by umbilical cable. Estimated maximum submersion depth is approximately 300 m. A range of about 5,000 m at a speed of 30 kt has been reported. Arming is by seawater scoop.

The battery uses silver chloride and magnesium electrodes with seawater as the electrolyte.

Operational status
Obsolescent. No longer in production. Licence production was initiated in a number of foreign countries. Replaced by Mk 46 in most navies. A number of navies (including Australia and Taiwan and also possibly Argentina, Canada, Chile, Egypt, Indonesia, Iran, Malaysia, Philippines and Thailand) still deploy the Mk 44 and a few possibly remain in the US inventory.

During the 1990s South Africa developed an upgraded variant of the Mk 44 with a 325 mm 61 kg directed energy warhead, new guidance system and new sonar, but no sales have been reported.

Specifications
Length: 2,560 mm
Diameter: 324 mm
Weight: 233 kg
Warhead: 34 kg HE
Speed: 30 kt
Range: 2.5 n miles
Operating depth: 300 m

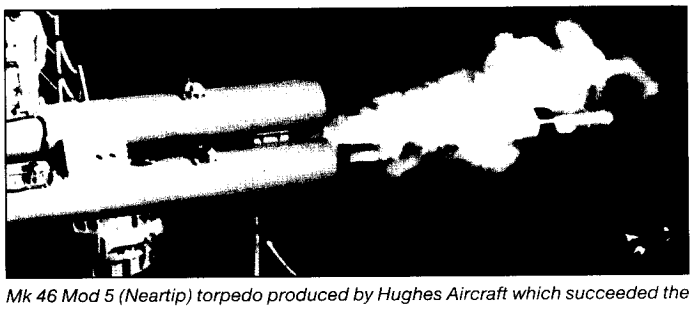
UPDATED

Mk 46

Type
Surface-, ship-, or air-launched lightweight torpedo.

Development
Developed as a successor to the Mk 44 in the early 1960s. Deliveries of first Mod 0 model were made to US Navy in 1965. The Mod 1 was introduced into US Navy in April 1967 followed by Mod 2 in 1972. The latest version is the Mod 5 resulting from the Near-Term Improvement Programme (Neartip), which was aimed at improving acoustic performance, countermeasure resistance, guidance and control system and fire-control system. This latest version is in full production and was introduced to combat the adoption of anechoic coatings by former Soviet submarines (Codename Clusterguard).

Description
This is a deep-diving, high-speed torpedo fitted with active/passive acoustic homing and is intended mainly for use against submarines. After water entry it



Mk 46 Mod 5 (Neartip) torpedo produced by Hughes Aircraft which succeeded the Mk 46 Mods 1 and 2

starts a helical search pattern, acquires and attacks its target; if it misses the target it is capable of multiple re-attacks. Two search modes are available: snake or circle. It has two operating speeds 36 and 45 kt (for the Mod 5A version). The Mk 46 Mod 0 used a solid-fuel motor whereas the Mod 1, which is slightly lighter, uses a five-cylinder liquid monopropellant (Otto fuel II) motor. This latter propulsion system was introduced because of the maintenance problem with the original solid-fuel motor. The Mk 46 Mod 1 and Mod 2 have been upgraded to Mod 6 under NEARTIP (Near Term Improvement Programme). The Mk 46 Mod 4 forms the payload for the CAPTOR mine.

The latest version is the Mod 5A which features a new passive/active sonar capable of detecting most types of underwater submarine target including anechoically coated hulls at ranges up to 1,500 m. The sonar offers improved target acquisition capabilities in all types of acoustic environment, including shallow water. The advanced digital computer features built-in EPROM logic and processes and stores a predetermined set of tactics, including optimised search and re-attack patterns. The Mod 5A(S) is fitted with the Mk 103 Mod 1 conventional warhead with proximity fuze. The propulsion system features a two-speed capability and range and endurance have been increased by 30 to 50 per cent. A current Service Life Extension Program (SLEP) for the Mod 5A(S) will further improve shallow water performance (improved shallow-running countermeasures and bottom avoidance) and maintainability, enabling the weapon to remain effective until about 2017. This weapon is designated Mk 46 Mod 5A(SW). This upgrade concentrates on addressing the shallow water multiple threat scenario.

The Mk 46 can be launched by surface vessels, rocket-assisted ASROC and Vertical Launch ASROC (VLA), as well as by fixed- and rotary-wing aircraft.

Mk 46 Mod 5 upgrade kits are available which allow Mod 1 and Mod 2 weapons to be upgraded.

Operational status

Mk 46 Mod 0 weapons entered service in 1963 and were produced in limited quantities, for use as air-launched torpedoes only by the US Navy.

Since 1965 more than 25,000 Mk 46 torpedoes have been produced for the USN and other navies. The current SLEP programme will ensure maintainability and full support through to 2017.

The Mk 46 Mod 5A(SW) is being introduced into the US Navy in a series of upgrades which commenced in 1996. The weapon currently features a new stern gland to correct a seawater leakage problem and a bottom avoidance capability. A total of 1,000 Mk 46 weapons remain in US service, all being the Mk 46 Mod 5A(SW) version, all other Mk 46 variants having been replaced by the Mk 50 Barracuda.

Users of various Mk 46 variants include: Australia, Bahrain, Brazil, Canada, Chile, People's Republic of China, Ecuador, Egypt, France, Germany, Greece, Indonesia, Italy, Japan, South Korea, Morocco, Netherlands, New Zealand, Pakistan, Portugal, Saudi Arabia, Spain, Taiwan, Thailand, Turkey, UAE and USA.

Specifications

Length: 2,590 mm
Diameter: 324 mm
Weight: 231 kg
Warhead: 45 kg PBXN-103 HE
Propulsion: monopropellant
Speed: 40 kt
Range: 11,000 m (max)
Operating depth: >370 m

Contractor

Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

Mk 48 ADCAP/Mk 48 Mod 5

Type

Submarine-launched dual-purpose torpedo.

Development

Anticipation by the US authorities of impending advances in submarine technology by the former USSR, noted in the 1960s and 1970s, led to studies of the Mk 48's capabilities against likely threats. In 1975 an Operational Requirement was issued by the Chief of Naval Operations for a programme to develop appropriate modifications to the Mk 48 torpedo to allow it to keep pace with anticipated submarine threat developments. The origins of the Mk 48 ADCAP (advanced capabilities) (Mk 48 Mod 5) programme lay in this requirement, but the extent and rate of Soviet submarine technology advance hastened both ADCAP progress and another Mk 48 improvement programme.

Recognition (by the US) of the impressive operational characteristics of the former Soviet Alfa class submarine in late spring 1979 resulted in a decision, taken in September 1979, to accelerate the ADCAP programme. It was also responsible for an intensive test and analysis programme to determine the true limits of the then current Mk 48 in terms of depth, speed and acoustic capabilities. This was known as the expanded operating envelope programme. Moreover, it showed that the Mk 48 was structurally reliable at the depth needed to engage Alfa class submarines. It also showed that the target speed recognition capability required could be achieved, that the vertical coverage was adequate, as was the self-noise at higher speeds with the existing nose and array, and that additional speed could be achieved. Laboratory modifications were made to a few torpedoes for tests and these changes were implemented in the form of a programme to update fleet Mk 48 torpedoes to what is now the Mk 48 Mod 4 standard.

Of the performance requirements demanded by the ADCAP programme, the most important are:

- sustained long acquisition range
- minimised adverse environment and countermeasure effects
- minimised shipboard tactical constraints
- enhanced surface target engagement capabilities.

Hardware changes involved in ADCAP entail replacing the entire nose of the weapon housing the acoustics and beam-forming circuits, and replacement of the signal processing by the latest electronics. The latter will also incorporate the current command and control electronics. Warhead sensor electronics will be improved.

Application of the expanded operating envelope programme findings to ADCAP has resulted in the upgraded ADCAP, which incorporates: upgraded acoustics and electronics; an expanded operating envelope (depth, target speed, weapon speed options); increased fuel delivery rate and capacity for optimum speed and endurance; improved surface target capabilities.

Description

The torpedo is wire-guided through a two-way communications link in the Mod 3 version.

The Mk 48 torpedo is propelled with an axial flow pump jet propulsor with twin contrarotating propellers driven by an external swashplate combustion six cylinder, hot-gas piston engine. This engine, like that in the Mk 46 torpedo, is a Gould design. The fuel for the engine is a monopropellant: Otto fuel II which uses nitrogen ester and an oxidant.

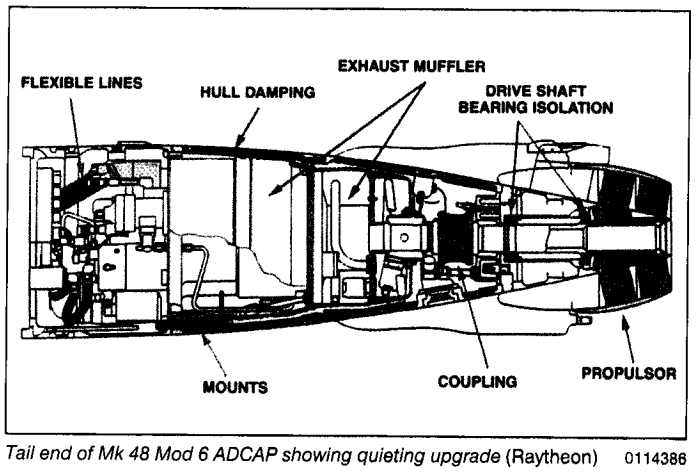
The Mk 48 and Mk 48 ADCAP torpedoes are capable of operating with or without wire-guidance using active and/or passive, acoustic homing. On launching, the weapon executes a programmed target search, acquisition and attack procedures, with the capability to conduct multiple re-attack procedures if the target is missed. The seeker has an active electronically-steered 'pinger' that enables the torpedo to avoid having to manoeuvre as it approaches its target.

The Mk 48 ADCAP Mod 6 (MODS) features two hardware upgrades: the guidance and control upgrade and the torpedo propulsion upgrade. The guidance and control upgrade replaces the obsolescent guidance and control unit with current technology, improves the acoustic receiver, and adds additional memory and improves processor throughput to handle the expanded software demands anticipated for near term upgrades. It incorporates COTS signal and data processing hardware implemented in an open architecture configuration. The propulsion upgrade seeks to reduce the radiated noise signature through the incorporation of a number of sound isolation techniques. These include isolating the prime mover, muffling the exhaust, isolating the drive shaft, the use of flexible fluid hoses, hull damping and using a new low noise pumpjet propulsor. This programme did not meet expectations and modification was suspended at 600 torpedoes.

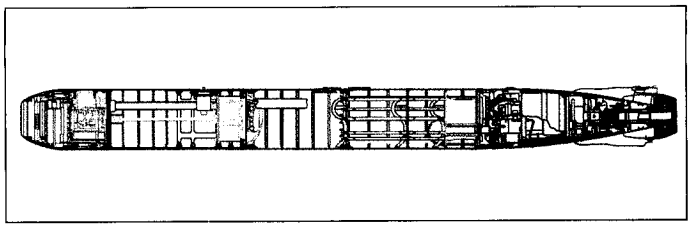
For the Mod 7 upgrade a Common Broadband Advanced Sonar System (CBASS) will develop a fully digital wideband sonar capability to enable the torpedo to operate effectively both in shallow water (<180 m) to counter diesel electric submarines operating in the littoral and deep water environments. The other upgrade area is termed the Torpedo Advanced Processor Build (APB). For this the torpedo will also feature frequency agility and optimal frequency selection. This capability will allow the Mk 48 ADCAP to identify torpedo countermeasures and discriminate them from the target. Both upgrade areas will make considerable use of COTS components. Full rate production of this upgrade is scheduled to begin in FY04 with the redesignated weapon Mk 48 CBASS (Mod 7) to commence delivery in 2006-07.

Further upgrades are envisaged under the Stealth Torpedo Enhancement Program (STEP), which will be introduced in two phases. Phase 1 will build on the CBASS capability providing guidance upgrades and eliminate sonar footprints, while Phases 2 and 3 will see stealthy and higher power density propulsion improvements leading to longer range and lower radiated noise and an upgraded warhead with increased lethality.

A half-length variant of the Mk 48 ADCAP is undergoing tests by the US Office of Naval Research. The torpedo incorporates a new high resolution sonar that can detect tethered mines even in cluttered littoral waters. The sonar head uses a very high number of transducers which, combined with advanced signal processing,



Tail end of Mk 48 Mod 6 ADCAP showing quieting upgrade (Raytheon) 0114386



General arrangement of Mk 48 Mod 6 ADCAP warshot (Raytheon) 0114385

allows the weapon to find and attack moored mines typically of around 1 m in diameter. With this capability the torpedo would also be able to detect 7 m long mini-submarines. The lightweight weapon (c 730 to 820 kg) would enable a 'Los Angeles class submarine to carry up to 52 such weapons instead of the normal 26 torpedoes, providing it with an enhanced capability for operations in littoral minefields. The weapon would retain its full blue water capability.

The warhead of the Mk 48 ADCAP is the Mk 107 Mod 2 incorporating the Mk 22 Mod 1 electronic sensors and Mk 21 Mod 3 exploder. It is a large bulk charge warhead featuring multiple fuzing modes. The aluminium shell is filled with PBXN-105 explosive. The warhead has been in service since 1982.

Operational status

The Mk 48 has been in production since 1972 and is used aboard USN attack submarines and strategic submarines for self-defence. By early 1980, more than 1,900 torpedoes of this type had been delivered to the USN and an estimated 800 plus were in the production and procurement line. It was then estimated that another 1,050 might be required to meet inventory objectives and to allow for peacetime training and testing.

In August 1979, Hughes Aircraft Company received a contract for development of digital guidance and control electronics for the Mk 48 ADCAP programme.

The first test run was carried out by the USN at Nonoose Bay in early 1982, using the inertial guidance system developed for the ADCAP programme. About 240 more runs were programmed before completion of this phase of the programme, after which it was expected that entry into service would take place in 1983-84. However, the 1985 report by the US Secretary of Defense amended this to indicate anticipated deployment of the system in the mid- to late-1980s.

In the US Secretary of Defense's Annual Report to Congress in February 1985, it was stated that following completion of a successful test programme in 1984, it had been decided to accelerate production of the ADCAP torpedo. The five-year programme called for production of 1,890 ADCAP units and included 123 in 1986 at a cost of US$433 million and 280 units in 1987 costing US$671 million. Hughes began production of the ADCAP version in 1985 and it became operational in 1988. In 1986, Gould (subsequently taken over by the former Westinghouse Company) was named the second ADCAP source.

Hughes Aircraft Company was awarded contracts for 370 plus Mk 48 ADCAP torpedoes and related test equipment, and the former Westinghouse Electric Corporation a contract for 96 Mk 48 ADCAP. In June 1989, the US House Armed Services Seapower subcommittee cut US$331 million from the US Navy's US$493 million procurement request for Mk 48 ADCAP for 1990, reducing the proposed buy from 320 to 140 for 1990. At the beginning of 1989, the Pentagon had approved ADCAP for full-rate production. Final deliveries of Mk 48 ADCAP were conducted under the FY94 programme. The Navy seeks to maintain a total inventory of 1,046 ADCAP torpedoes. The only known foreign users of the Mk 48 (Mk 48 Mod 5) ADCAP are Australia, Canada, and Netherlands (100 Mk 48 Mod 4 plus a number of ADCAP weapons).

Procurement plans for the future envisage NAVSEA purchasing 76 rounds of the Mk 48 ADCAP Mod 6 in FY04 followed by about 80 in FY05. In addition NAVSEA will purchase 14 rounds of the Mk 48 CBASS (Common Broadband Advanced Sonar System) Mod 7 variant in FY04 followed by about 350 in the time frame FY05-08.

Specifications

Length: 5,862 mm (Mod 6)
Diameter: 533 mm
Weight: 1,678 kg
Warhead: 295 kg PBXN-105
Max speed: 55 kt
Range: 38 km @ 55 kt or 50 km @ 40 kt
Max depth: 800 m

Contractor

Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

Mk 50

Type

Advanced lightweight torpedo.

Development

The Advanced LightWeight Torpedo (ALWT) (now designated the Mk 50) was developed as a successor to the Mk 46 Mod 5 (Neartip) torpedo to counter deep diving Soviet submarines such as the 'Alfa' and succeeding designs. It was designed for delivery by surface ships, submarines and aircraft, and to be interoperable with existing Mk 46 launch platforms. Development commenced in the late 1970s and is now completed.

Description

The Mk 50 has similar dimensions to the Mk 46 but has improved speed (multiple speeds from slow speed to in excess of 50 kt), greater endurance, greater operating depth (1,000 m) plus improved shallow water and terminal homing, signal processing and greater destructive effect. It also features greater search volume and increased ECCM. In addition to the ability to operate against fast, deep-diving submarines there is also a requirement for capabilities against shallow, slow-moving submarines and surface ships.

For maximum effect the directed energy blast must strike normal to the submarine hull amidships. The US Navy has established a programme to improve the performance of the warhead, but for the present there will be no major upgrades.

From the two original competing contractors under US procedure A-109, Alliant Techsystems (formerly Honeywell Defense & Marine Systems and then Hughes Aircraft Naval and Maritime Systems) was selected in 1981 as the prime contractor for Mk 50 development and production, with the Garrett Division of AlliedSignal Corporation being responsible for propulsion. Northrop Grumman Naval Systems became second source in 1987 and is currently completing the delivery of the last purchase of 212 torpedoes.

Propulsion is achieved by a closed-cycle steam turbine engine in a Stored Chemical Energy Propulsion System (SCEPS) with the energy being supplied by a chemical reaction in which a block of solid lithium metal coated with teflon and stored in a stainless steel cylinder, is ignited by the oxidant (sulphur hexafluoride) with an extreme high-energy density. The resulting chemical reaction generates very high temperatures needed to produce superheated steam for driving the turbine. The steam is then converted back to water for recycling through the boiler. The turbine powers a contrarotating pump-jet propulsor. A very low volume of residence is left after the chemical reaction which means the torpedo does not have to counter increasing water pressure when it operates against a deep running target. The propulsion unit develops full power at all depths and is capable of multiple speed settings as required by the tactical situation.

Development testing of the Mk 50 terminal homing system was carried out by using seven modified Mk 45 torpedoes as high-speed mobile torpedo targets (ADMATT). These ran at 41 kt and towed a hydrophone/echo repeater array to simulate the spatial extent of a real submarine. A three-dimensional instrumented shallow water range was also developed for Mk 50 evaluation.

The active/passive sonar operating at 25 kHz comprises a low-noise nose array assembly, transmitter unit, receiver and two digital signal processing units. The sonar features a multiple beam/multiple ping capability with acquisition ranges in excess of 2,700 m using FM pulses. It operates with multiple, selectable transmit and receive beams. Acoustic returns are analysed in real time.

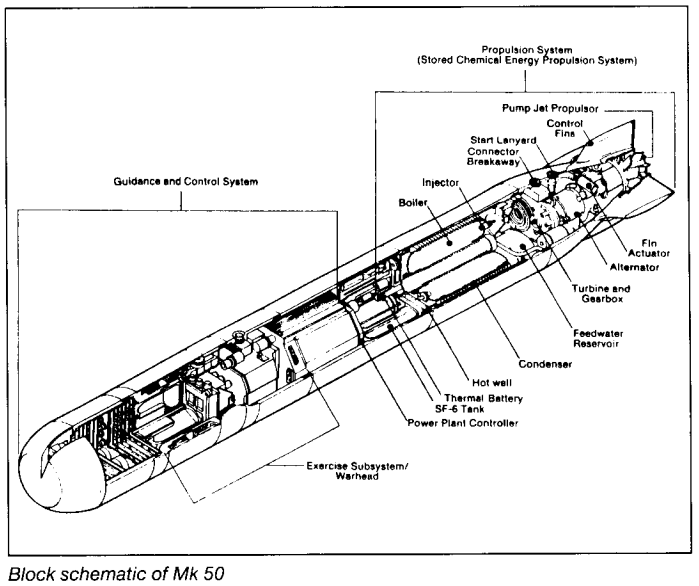
Mission control, including commands to the sonar and propulsion subsystems, autopilot navigation and target detection, classification, tracking and countermeasures, is carried out by an AN/AYK-14 standard US Navy computer. Guidance is carried out using two digital signal processors, processing sonar data to generate a range map for the AYK-14 missile computer.

The Mk 50 is deployed from the Mk 32 Surface Vessel Torpedo Tube (SVTT).

Operational status

Airdrop tests were carried out in February 1987, followed by operational tests in March 1987. In June 1987, Northrop Grumman Naval Systems won a US$7.5 million initial contract to act as a second manufacturing source. Full-scale development of the Mk 50 concluded in 1992 with completion of operational evaluation trials. The Mk 50 entered service in late 1992. A total of 1,063 Mk 50 torpedoes were manufactured. Production was terminated in FY96.

Block Upgrade 1 software upgrades currently in progress will enhance shallow water capability.



Block schematic of Mk 50

Specifications
Length: 2.896 mm
Diameter: 324 mm
Weight: 363 kg
Warhead: 45 kg shaped charge HE
Propulsion: closed-cycle
Speed: >55 kt at all depths
Range: >12,000 m @ >50 kt, 15,000 m @ normal speed, 55
Operational depth: >1,100 m

Contractors
Northrop Grumman Corporation, Electronic Sensors and Systems Division, Naval Systems, Baltimore, Maryland.
Raytheon Systems Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island. ***UPDATED***

Mk 54 LHT

Type
Lightweight surface ship, aircraft-launched ASW torpedo.

Development
As a result of its reassessment of undersea ASW weapon requirements for the next century, the US Navy has noted a significant shift in the most likely threat scenarios. The current generation of lightweight torpedoes were specifically designed and built to counter high-speed Russian SSNs operating in blue water, open ocean environments. Studies now indicate that the main threat in the future will come from SSKs operating in shallow water, littoral areas.

To face this threat in 1995 the US Navy embarked on a new programme referred to as the Lightweight Hybrid Torpedo (LHT now designated as Mk 54, formerly Mk 46 Mod 8). This programme is designed to maximise on the technologies developed for the Mk 50 and Mk 48 ADCAP programmes together with proven Mk 46 warhead, the Mk 103, and propulsion subsystems (modified to incorporate the thermal battery and dual-winding alternator). This is designed to provide an effective low-cost weapon system optimised for littoral warfare. Raytheon was awarded the engineering development contract to deliver 31 LHT engineering development models in June 1996.

Description
The LHT (Lightweight Hybrid Torpedo) will integrate components from various existing weapons (Mk 46, Mk 50 and Mk 48 ADCAP) with COTS signal and tactical processors and components. It will use the Mk 50 sonar array, beamformer and transmitter; a new digital receiver, signal processor, tactical processor and depth sensor using COTS technology with open system architecture software; the Mk 46 warhead and propulsion system; the Mk 50 forebody; Mk 48 ADCAP and Mk 50 software. On the propulsion side the variable speed fuel control valve used in the Mk 48 ADCAP will be adapted for the LHT, together with the same OTTO II fuel-based motor and the dual-winding alternator from the Mk 50, together with the Mk 50 thermal battery for quick start-up. The fuel tank contains 33 litres of Otto II fuel.

The sonar is enclosed by a specially designed hydrodynamic nose contour which delays and stabilises the intense acoustic noise-generating laminar-to-turbulent flow transition zone to achieve minimal acoustic array self-generated noise. The polyurethane transducer cover material has been carefully selected to match seawater impedance for maximum acoustic transmissibility, and provides an isolation layer between the transition noise source and the acoustic array structure ensuring that the maximum acoustic energy is transferred into the water.

The 52 element array is arranged in eight vertical and eight horizontal staves providing a much narrower beam capability. The computer can simultaneously process 62 independently steered narrow beams in the horizontal and vertical planes. The transmitter generates complex signals including FM and pure tone waveforms. Programmable phase and amplitude shading on each channel provides beam steering and reduced sidelobe levels.

The fully programmable receiver operates in multiple frequency bands with multiple receive beams.

The primary new components will be the receiver, signal processor and tactical processor, which will be housed in the nose assembly. The new COTS-based processors will provide memory capacity and processing speed necessary to run extremely complex software algorithms. This is necessary to overcome the problems of distortion in return sonar signals caused by the turbulence from surface waves, bottom scattering and incidental acoustic interference from marine life and surface craft. A further complication in detecting SSKs is the fact that it is extremely difficult to make use of Doppler signals because of their very slow speed (6 to 8 kt). Detecting slow-moving submarines requires extremely sophisticated processing techniques such as Frequency Modulation (FM) to provide a verifiable acoustic image of the target.

The processor group can accommodate seven 6U VME64 boards and incorporates the common torpedo processor cards for guidance functions, a custom interface card, a solid state recorder card and a spare slot for expansion.

The Mk 54 tracks, maps, classifies and calculates various target statistics, analyses them over multiple listening intervals to prioritise targets, eliminate false targets and home on to real targets.

Successful in-water tests conducted between January and November 1994 by Alliant Techsystems (now part of Hughes Aircraft Naval and Maritime Systems and subsequently Raytheon Systems Company) and the US Navy have validated the LHT concept. These trials, using a Control and Acoustic Test Vehicle (CATV), demonstrated the feasibility of integrating the Mk 50 nose array, Mk 46 propulsion system and ADCAP fuel valve. Mechanical electrical and software interface between the Mk 46 afterbody and the Mk 50 forebody were verified. Three CATV systems were delivered to the US Navy for in-water tests.

Operational status
FY05-08 - NAVSEA to purchase around 830 Mk 54.
FY04 - NAVSEA to order 36 Mk 54 Mod 0.
2004-05 - Mk 54 scheduled to enter service.
April 2003 - Series production of 24 × Mk 54 for the US Navy commences.
August 1999 - in water testing of Mk 54.
Mid-1998 - Development and operational testing of Mk 54 commences.
A total inventory of 1,000 warshots is projected.

Specifications
Length: 2,710 mm
Diameter: 324 mm
Weight: 275.8 kg
Warhead: 44.6 kg PBXN 103
Acquisition range (in deep water): 2,500 m
Sonar frequency: 25 kHz (approx)
Bandwidth: 10 kHz
Speed: 36 and 45 kt

Contractor
Raytheon Systems Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island. ***UPDATED***

NT 37 C/F

Type
Anti-surface vessel/anti-submarine torpedo.

Development
The NT 37 heavyweight torpedo is a total redesign of the original US Navy Mk 37 torpedo. Only the original torpedo hull remains common to both. The Mk 37 torpedo subsystems, including propulsion, sonar and guidance, have been completely replaced by new hardware and software.

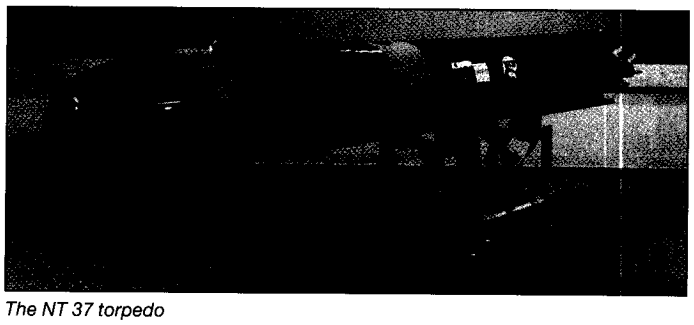
Additional performance enhancements include a new proximity fuze, two-speed engine and increased torpedo speed.

User navy exercises on the NT 37D model have demonstrated long-range active and passive homing attack on acoustic and live targets. The tests also demonstrated the following improvements: increased dynamic control and accuracy, complete wire guidance capability, ease of tactical software, low sonar background noise levels, low acoustic false alarm rate, long-range active and passive acoustic attacks on acoustic targets, increased torpedo reliability and reduced maintenance. A semi-automatic test set has been designed to replace manual test equipment.

Description
The NT 37 torpedo is a dual-purpose ASW and anti-ship torpedo that can be fired both from submarines and surface ships. Interfacing to a standard Mk 37 fire-control interface or a standard RS-422 bus digital fire control.

Complete NT 37 torpedoes are available as well as upgrades to earlier Mk 37 configurations. The design is modular, allowing the upgrade to be installed in various configurations. The upgrade consists of three major subsystems:

(a) an Otto fuelled thermochemical propulsion system. When compared to the performance of an unmodified Mk 37 silver/zinc oxide battery and electric motor, the new propulsion system demonstrates a 40 per cent increase in speed, a 150 per cent increase in range and an 80 per cent increase in endurance. The propulsion system is compatible with existing Mk 46 fuelling and engine maintenance facilities, engine tools and engine refurbishment kits. A fuel bag contained in a sealed hull provides double sealing protection for the Otto fuel;
(b) a solid-state acoustic system and a noise reduction laminar-flow nose assembly replaces the Mk 37's vacuum-tube acoustic panel and hemispherical nose. The new sonar substantially improves the passive detection range against high-speed surface targets and active detection range against small silhouette submarine targets; in most cases, target acquisition range has been doubled. The new self-noise reduction nose assembly increases transducer isolation while reducing flow noise effects, reducing the likelihood of self-decoying at all depths;



The NT 37 torpedo

(c) a computer-based control system upgrade eliminates the original relay logic, resulting in greater system stability, reliability and accuracy. The new system utilises an Intel 80186 embedded microprocessor, allowing fully programmable tactics. Should future naval tactics require modified torpedo command and control, changes can be implemented by revision of software and replacement of programmable read-only memory units (PROMs);
(d) Various running patterns are available including: (1) straight run/salvo anti-ship; (2) straight run with acoustic miss indicator to initiate acoustic re-attack; (3) active snake and circle – ASW; passive snake and circle – anti-ship.

Operational status
The US Navy Mk 37 family of torpedoes was purchased by at least 17 navies. The NT 37F version was delivered to the Egyptian Navy in 1994-95. The NT 37C is in service with Canadian maritime forces and the Norwegian Navy and will shortly enter service with the Polish Navy. The Netherlands Navy NT 37 (variants C/D/F) has been withdrawn from service although a number probably remain in the inventory.

Specifications
Length: 4,505 mm (Mod 2); 3,846 mm (Mod 3); 3,467 mm (NT 37E)
Diameter: 485 mm (fits 533 mm launch tubes)
Weight: 750 kg (Mod 2); 642 kg (Mod 3)
Warhead: 150 kg HBX HE
Fuze: contact and proximity
Propulsion: thermochemical rotary piston cam engine with Otto fuel
Speed: 32 kt (Mod 2); 35 kt (NT 37E)
Range: 13.5 n miles (Mod 2)

Contractor
Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

NT 37G Seahuntor

Type
Anti-surface vessel/anti-submarine heavyweight torpedo.

Development
The next-generation heavyweight torpedo to succeed the NT 37F is the NT37G Seahuntor, developed by Alliant Techsystems (subsequently Hughes Aircraft Naval and Maritime Systems and now Raytheon Systems Company) in 1992. The Seahuntor uses a two-speed Otto engine, programmable digital control logic, improved signal processing and an enlarged warhead with a new STN ATLAS Elektronik proximity fuze.

Description
The dual-role ASuW/ASW Seahuntor torpedo is designed to be deployed from the launch tubes of all known existing submarines. Being dual role eliminates the need for a submarine to carry two types of torpedo.

The torpedo consists of six main sections: nose assembly with seeker, fuze assembly, warhead, Otto fuel tank (near the centre of the weapon), processor and guidance system electronics, guidance wire dispenser (the guidance wire is dispensed through a tube at the rear of the weapon), and propulsion system.

The enlarged warhead with the advanced proximity fuze ensures a high kill probability against all known targets both surface and submerged.

The weapon is equipped with an improved thermal-chemical rotary piston cam two-speed engine driven by Otto fuel to provide the long range. The Seahuntor retains the self-noise reduction nose assembly of the NT-37F with solid-state ceramic acoustic panel (similar to the one used in earlier NT 37 and Mark 44 upgrades) for the active/passive seeker. The detection range in either active or passive mode is reported to be 200 per cent better than the Mark 37. The noise-reducing laminar-flow nose assembly reduces acoustic interference when operating at high speed or near the sea surface. The system includes adjustable detection sensitivity to compensate for high sea states and range gating and control logic to avoid decoys.

The modular software-controlled design featuring plug-in subassemblies is designed for easy and inexpensive maintenance. An automated test set can completely test the torpedo electronics in less than one day while a self-test capability ensures that the weapon is operable prior to launch.

Exercise torpedo operations are inexpensive using only Otto fuel as the propellant. A digital data recorder provides a complete record of the torpedo exercise operation.

Weapons control compatibility with existing and new submarines is ensured by the availability of both digital and analogue interfaces with the weapons control system. The torpedo interface was designed to be compatible with most versions of the German Type 209 submarines.

Operational status
Initial production deliveries were reported to have begun in 1996-97 but no further information is available about customers. The current situation regarding production is unclear.

Specifications:
Length: 4,763 mm
Diameter: 433 mm (fits 533 mm launch tubes)
Weight: 868 kg
Warhead: 150 kg HE (optional 250 kg HE)
Range: 15 n miles

Contractor
Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

SVTT Mk 32

Type
ASW torpedo launcher.

Development
The SVTT Mk 32 entered service in May 1960. The mounting also appears to be manufactured under licence in Japan as the Type 68. In mid-1994 the then GEC-Marconi Naval Systems, Underwater Weapons Division, received a licence to manufacture the Mark 32 in the UK.

Description
The SVTT (Surface Vessel Torpedo Tube) Mk 32 lightweight ASW torpedo launching system provides naval surface vessels with the capability to launch Mk 46 or similar lightweight torpedoes using local or remote control.

The system comprises a set of triple-barrelled, deck-mounted tubes with a removable breech mechanism that houses the high-pressure impulse air flask and associated air supply system.

The mounting is usually on the ship's weather deck and has a firing arc of up to 110°.

The most common mounting is the Mark 32 Mod 5 which consists of three 324 mm diameter glass fibre-reinforced polyester resin tubes arranged in a pyramid pattern with Barrel 1 (Mark 10 Mod 7) on top, Barrel 2 (Mark 10 Mod 8) below left and Barrel 3 (Mark 10 Mod 9) below right. The barrels are on the Mark 11 Mod 1 training gear and the mounting is moved manually with the aid of a training handle sited between Barrels 2 and 3.

On top of each tube is the breech access opening latch and a control box. On each side of the mounting is a junction box with moulded cable and connector assemblies, the heater switches for both tubes and training gear being below the left-hand junction box.

The weapons are launched using high-pressure air contained in the air flask that can be recharged.

The air in the flask is released through the control valve to the firing solenoid valve. Upon receiving the firing order, the operator (electrically or manually for air slugs) opens the firing solenoid valve and the air passes to the plug-puller mechanism that removes the torpedo-mating plug. The air then travels along the tube to the securing mechanism that is opened to release the torpedo. Simultaneously this actuates the flask-firing valve and the high-pressure air expands through this valve to eject the torpedo.

The system has been manufactured in a wide range of configurations with at least 10 separate modifications currently in service around the world. The in-service versions of the Mark 32 are:

Mod 5: Version to launch either the Mark 44 or the Mark 46 torpedo.
Mod 6/8: Exported Mod 0 or Mod 1 converted to operate the Mark 44 and Mark 46 torpedoes. This configuration is not used by the US Navy.
Mod 7: This version is designed to launch either the Mark 44 or the Mark 46 torpedoes.
Mod 9: A twin tube, fixed mounting that is accommodated in deckhouse installations. The Mod 9 consists of two Mark 10 tubes, one above the other, held together by two steel brackets. The tubes stick out some 0.97 m from the torpedo room at a 45° angle to the bow and each has a muzzle door mechanism.
Mod 10/11: Fixed single tube units for manual and remote operation respectively. These mountings are reported in official publications dating from June 1986 but it is unclear whether or not any entered service.
Mod 14: This triple tube mounting is installed in a deckhouse. It is similar to the Mod 5. There is a distinctive mount barrel junction box at the top of Barrel 1.
Mod 15: This is a similar system to the Mod 5/7 and is also installed on the weather deck but is intended for unmanned operation with remotely operated muzzle doors.
Mod 17: Mod 5 modified to operate the Mark 50 torpedo.
Mod 18: Mod 7 modified to operate the Mark 50 torpedo.

Operational status
In service with over 30 navies around the world.

Some 1,400 Mark 32 mountings have been produced or are on order. Of this figure about 800 were ordered by the US Navy and the remainder by foreign customers. In addition, about 150 Type 68 mountings appear to have been produced.

Specifications

	Mod 5/7	Mod 9	Mod 14
Length	3.43 m	3.56 m	3.43 m
Height	1.26 m	1.31 m	1.33 m
Width	0.94 m	0.70 m	0.94 m
Weight (unloaded)	1,012 kg	2,010 kg	1,080 kg

Contractor
United Defense, Armament Systems Division, Louisville.

UPDATED

MINES

Introduction

Mines

One of the most cost-effective forms of naval warfare is the mine. Mines are small, easily concealed, cheap to acquire, require virtually no maintenance, have a long shelf life, are easy to store in considerable numbers and can be laid easily and simply from almost any type of platform, which need not necessarily be a military platform. They can be used both strategically and tactically to deny waters to hostile forces and to defend high-value targets such as ports, anchorages and offshore structures from amphibious or seaborne attack, and can very quickly wipe out or very seriously impair the effectiveness of surface forces. To counter and neutralise the mine requires an effort out of all proportion to its size. In short, the mine is probably one of the most deadly weapons that any navy can deploy in its armoury.

Mine design has advanced significantly in the last decade or two, particularly with the introduction of low-cost signal processing electronics. Advanced intelligent mines of varying shapes and materials are now available, even to the smallest of navies. Furthermore, these modern technologies are not only incorporated into seabed mines, but are now being applied to moored mines as well.

Triggering mechanisms for mines are becoming even more sophisticated as mine designers seek to minimise the efforts of minehunting, minesweeping and mine clearance.

As the future maritime warfare scenario moves even closer to coastlines, the value of the mine as an offensive as well as defensive weapon will assumed even greater strategic significance. Environmental conditions in the very shallow water littoral region, together with the latest mine stealth technology will make it even more difficult to conduct effective mine countermeasures operations, and the mine may well prove to be the deciding factor in maritime warfare operations.

Moored mines

The moored mine has changed little from its forbears of the First and Second World Wars. Although a relatively unsophisticated weapon, it remains, nevertheless, an extremely effective one. Being simple to manufacture and relatively easy to lay (all that is necessary is a set of rails and a reasonably accurate navigation system which can be installed quickly on a wide variety of available ships), an extensive minefield will require a large force of minesweepers to sweep the field, an exercise which may take considerable time. The moored mine is therefore an ideal weapon for defensive purposes. A moored minefield can be used to protect extensive areas of vulnerable coastline and important port areas and anchorages. It can be used to create specified navigation channels leading to important areas such as ports; channels which can be rapidly closed using ground mines in face of impending attack.

Because of the nature of the weapon, the modern moored mine can be laid in much deeper waters than the ground mine (that is, beyond the limits of the continental shelf). The moored mine is therefore eminently suitable for use in a barrier system, denying passage in open waters. Although post-Second World War developments concentrated on the ground or influence mine, the moored mine has again come into prominence in new forms for use in submarine barriers in deep waters and to control choke points.

While many moored mines are of the older horned variety which are detonated by physical contact, the new moored mines for deep water barriers are detonated by magnetic or acoustic influence. These new types of moored mine can be countered using deep sweeps towed between two minesweepers. Naturally the mines incorporate anti-sweep devices such as time delays and snag lines.

The normal contact mine is usually triggered in one of three ways:

- Contact – hydrostatic
- Contact – mechanical
- Contact – chemical.

The moored mine comprises the mine itself coupled to an anchor box for laying. Mine and anchor are laid together by the minelaying ship. On reaching the seabed the mine is released from the anchor mechanism and rises on a cable attached to the anchor to a pre-selected height, determined in advance from operational requirements. The body of the mine is made of steel or GRP and contains the explosive charge, fuzes, detonators and other elements (such as influence devices, batteries and security devices) required for the correct functioning of the weapon.

Mines in a moored defensive minefield can be linked to a shore-based coastal defence station together with torpedoes, guns and coastal defence missiles, with overall command and control being exercised from the defence station. In other words, an integrated coastal defence system combining sensors (both underwater and above surface) and defensive weapons (underwater and above water).

Seabed mines

Seabed mines are detonated using one of three influences created by a target: acoustic, magnetic or pressure signature, or a combination of these influences. Influence mines are technologically the most sophisticated of all types of mine, and their reactivity to the specific type of influence on which they operate is infinitely variable. So sophisticated is the technology associated with these types of mine that they literally can be programmed to react not only to a specific class of ship, but, where sufficient data is available, even to a named ship within that specific class.

Unlike the moored mine, the seabed mine houses all its operating equipment within the steel or GRP casing, which is usually cylindrical in shape. A cylindrical shaped mine has obvious advantages in that it is compatible to laying from a wide variety of platforms, ranging from submarine torpedo tubes to surface vessels of all types and sizes to aircraft. However, cylindrical shaped objects reflect fairly definite sonar patterns or shadows which can be identified by a minehunter's sonar. To improve stealth capabilities and make the task of mine neutralisation more difficult, some seabed mines employ specific 'shaping' which diffuses the acoustic shadow or return to an indefinable pattern. Sonar patterns are further confused by the use of anechoic coatings.

For use on soft or sandy beds, some modern ground mines have the capability to bury themselves in the seabed, and are virtually undetectable to all but the most sophisticated sonars. Such mines, however, are small in size, with a small explosive charge and are better suited to very shallow water operation such as in estuarial areas or in areas where hostile submarine activity is anticipated fairly close to the coast or in specific navigable channels.

The two principal types of influence are the acoustic and magnetic.

The other principal type of influence used is the pressure influence. Because of the method of operation, mines incorporating this type of influence certainly cannot be swept using normal methods (as can some magnetic and acoustic influence mines) and have to be 'hunted' using sonar and neutralised using either clearance divers or remote-control submersibles.

In addition to the multitude of fuzing refinements available, triggering mechanisms can also be controlled with activate/deactivate devices, and various types of delay, counters and time responses.

Tethered mines

Tethered mines are specifically reactive to the approach of the target, which is principally the submarine, as distinct from the normal type of moored mine which remains completely passive until struck by the victim.

The most common form of tethered mine is known as the 'rising mine'. Both the US and the former Soviet Union have developed such weapons. Most tethered systems rely on passive detection of an approaching target to activate a powered, mobile homing system carrying the explosive charge.

Tethered mines are very much a barrier weapon to prevent passage of hostile shipping and to control major choke points.

The other major type of tethered system comprises a mobile homing system such as an acoustic torpedo tethered to the seabed in depths below 300 m. The system is linked to a static passive acoustic sensing system (such as the US SOSUS system) which detects, analyses and classifies underwater sounds, and in response to pre-programmed target signatures activates the release of the homing torpedo which then reacts in its normal way to the approach of the target.

Controlled mines

These were, in fact, the very earliest type of mine ever devised. They simply consisted of a series of large explosive charges laid on the seabed and connected by electric cables to a position on the shore overlooking the minefield. As the target was observed passing over the position of the mines they were detonated by an observer in the shore station.

Such systems using modern explosives and technology are still valid today and indeed some navies do operate such controlled minefields.

However, more sophisticated means are being developed to provide the remote activation of minefields. Experiments in this area have been geared towards the control of deep water minefields controlling principally acoustic influence mines. This is necessary due to the fact that while a mine remains in water its casing acts as home to a variety of marine life which affects the sensitivity of the acoustic transducers. Consequently, the longer a mine remains in water, the less sensitive the transducers.

Furthermore, there is a finite limit to the life of the batteries which power the mine's various electronic systems. If the mine can be remotely activated at intervals well beyond the capacity of any in-built timing device in the mine, then it could remain dormant in the water for considerable lengths of time, its onboard sensors all being activated by a simple remote command. Naturally any such remote activating system must be proved to be almost infallible before any system relying on this method is deployed. This is essential if any such system is to be deployed before active hostilities.

Remote control of such minefields will, in all probability, rely on coded VLF transmissions which are the only satisfactory means of long-range underwater communications at depth. Such a communications system, however, requires very high power and would most probably be shore-based.

Influence sensors

Traditionally, the main sensors used to detonate mines (apart from the contact variety) have been magnetic and acoustic with, to a lesser degree, pressure. The pressure sensor has not quite achieved the same prominence as the acoustic and magnetic sensors, as it is far more difficult to control and creates enormous problems in clearance, not only for hostile forces but for friendly forces too. However, as greater control is exercised over platform signatures through the incorporation of modern stealth techniques, so mine designers have sought to employ newer forms of sensor; both to make the mine more effective and to reduce the effectiveness of mine countermeasures forces. Hence the development of electric field (UEP and ELFE) and seismic sensors.

Influence design always has, and will continue to be, a compromise between the need to destroy the target and the need to embody some form of mine counter countermeasures capability. To achieve such a compromise involves introducing

tolerances in the mine logic for the acceptance of magnetic and acoustic signatures required for actuation.

If the tolerance is too narrow in order to achieve effective counter countermeasures, targets will not be detected. On the other hand, if the tolerance is too wide in order to ensure that all targets are detected, then the mine can be easily swept.

The introduction of microprocessor technology into mine mechanisms has allowed mine design to greatly reduce this tolerance. Not only does this technology largely overcome the problem of tolerance latitude, it also offers the ability to carry out sophisticated analysis and targeting logic, which has led to much more advanced mine capability such as identifying specific types of target.

However, development of software algorithms for mine logic is constrained by a number of factors including:

- The potential need to present a threat to a variety of targets
- The problems of a target's induced magnetic signature, which varies with heading and geographic position, while the permanent magnetic signature changes over time
- Variations in signature between ships of the same class
- The magnetic signature of a degaussed vessel, which varies with depth and offset range. It presents a complex structure in the near field, which evens out as the range from the target increases
- A vessel's magnetic signature is directly related to the status of its degaussing system and it's magnetic treatment history
- Magnetic and acoustic signatures can be deliberately varied in an effort to confuse the mine logic parameters
- Magnetic signatures, particularly of merchant ships, vary according to the payload
- Mechanical defects and other factors affect the acoustic signature
- Acoustic influence is subject to the same limitations that affect any underwater acoustic sensor

Acoustic

Acoustic signatures are notoriously unreliable influences to use in mine warfare for they are subject to the vagaries of multi-path interference and high ambient noise resulting from the existing sea state, marine life and the increasing volume of marine traffic now using the oceans; all of which mask the actual acoustic signature of the target. The sensor is also dependent on the propagation conditions existing in the area where the mine is laid. These factors create more of a problem for mine countermeasures forces than they do for the mine's sensor when used to detect an oncoming target. However, they do affect the effectiveness of the mine. This is usually overcome by combining the acoustic sensor with a magnetic sensor which is less susceptible to outside interference. Modern acoustic sensors for mines are usually constructed of piezoelectric materials which detect the acoustic signature which is then fed into a low noise amplifier with a response ranging from a few Hz up to several kHz. The problems associated with detecting ship acoustic signatures are overcome by the signal processing incorporated in the mine, in which the minute electric signals are changed into the frequency domain using a Fast Fourier Transform engine before undergoing processing from which tonal signal information can be extracted for analysis. The acoustic influence can be programmed to react to specific types of ship's signature such as propeller cavitation, engine noise, hull cavitation or shaft revolutions and even imperfections in this regular sound pattern, when these are known.

Magnetic

The traditional magnetic sensor is based on an induction coil (usually referred to as the coiled rod) which responds to the rate of change in the magnetic field surrounding the mine rather than the actual magnetic field. It usually operates in a single axis of detection with a low sensitivity. Modern ground mines, on the other hand, usually incorporate a three-axis fluxgate magnetometer which incorporates a filter which separates into several components the earth's static field, the target's static field and alternating fields in the immediate vicinity of operation. The magnetometer is much smaller and more highly sensitive than the induction coil, with a much lower self-noise signature. Unlike the acoustic sensor, the magnetic sensor is less influenced by outside interferences for their strength is less than the earth's magnetic field. This makes it easier to filter out the unwanted magnetic anomalies thus greatly assisting in the signal processing to reduce the effect of non-coherent signals. Magnetic influence mines react to changes in the ambient magnetic field and can be fuzed to react to magnetic polarity in either a vertical plane or fore and aft or athwartships in a horizontal plane on a target, and to specific fields and strengths, reacting to specific parts of a ship such as the machinery area or stern area.

Generally, static fields of targets are detected in the 5 MHz to 5 Hz band and for undegaussed platforms the signal-to-noise ratio is usually of sufficient strength for targets to be detected at medium range. However, with degaussed vessels the signal-to-noise ratio is lower and the form of the signature is very different, making it much more difficult to detect a target with consequent reduction in range of detection. With degaussed platforms, therefore, it is necessary to use a different type of magnetic field for detection, and this is usually the alternating magnetic field created by a target's onboard electric generating and other electrical systems. Other alternating fields are created through corrosion currents (that is, a rusty ship would exhibit a higher alternating field in this region than a newly built ship), eddy currents created by rotating machinery and magneto-hydrodynamic fields generated by the wake of the ship. These fields are all of low intensity, but at a frequency typically ranging from 5 to 500 Hz, the modern sensor with its high sensitivity is more easily able to detect them against the lower background magnetic noise.

Pressure

As a ship moves through the water an area of low pressure is created beneath the hull which varies according to the speed and draught of the vessel. This pressure change can be used in a number of ways to operate the pressure sensing device in the mine, the decrease in pressure opening and completing an electrical circuit to detonate the mine.

The modern pressure sensor is based on piezoelectric materials which are used to detect a reduction in pressure caused by the passage of a vessel over or near a mine. These signals are extremely small, but modern electronics used in signal conditioning are able to detect the small target signals against the much larger signal created by tidal movement and the static water head above the mine. Modern signal processing enables the system to compare short and long term averages of the signal and to measure the duration of pressure pulses created by the passage of the bow and stern of a target through the water, thus further enhancing target discrimination against other extraneous signals. Other pressure sensors operate on a strain gauge principle in which the deformation of a diaphragm exposed to pressure signals is measured. However, these latter demand higher power than the piezoelectric sensor and are lower in resolution resulting from hysterisis and non-linear problems.

Electric field

Two types of electric field can be used to detect a target, the Underwater Electric Potential (UEP) and the alternating field or Extra Low-Frequency Electric field (ELFE). Sensors used to detect these fields operate in the 5 MHz to 1 kHz band with a sensitivity of 10 nV per metre per root Hertz. The UEP static field of a platform is usually created by the platform's cathodic protection system. These fields propagate for some considerable distance beyond a vessel and with sufficiently sensitive sensors, such fields can be detected at reasonable ranges. The ELFE field results from the modulation of the target's static field by moving parts such as the propeller, machinery, generators, shafts and so on. The ELFE field is not so well defined as the UEP field, particularly in deep water and propagation falls off quickly as frequency increases. On the other hand, influence sensors have a higher sensitivity in the ELFE band compared to the UEP band, while the background noise in the ELFE field is much lower than that associated with UEP signals, which results in a much higher probability of detection in the ELFE band than the UEP band.

Seismic

When acoustic wave fronts emanating from a target at below 10 Hz strike the seabed, some of the energy is changed into velocity or seismic energy, which is then more easily retransmitted into the surrounding environment. It is this seismic energy which is used to detect the presence of a target. Because of the form of the energy it is not necessary for any part of the sensor to be in contact with the sea through which the energy passes. This means that seismic sensors are not unduly affected when mines become buried in sediment or mud on the seabed.

Seismic sensors are either based on the piezo-electric accelerometer, or on a pendulous mass which incorporates a permanent magnet and a fixed sensor coil. Both have advantages and disadvantages. The accelerometer uses electronic processing to derive a velocity signal, while the pendulous mass has to be mounted in such a way that the mechanism is maintained in the correct plane of operation using a gimbal-type mounting. This requires a certain delicacy of construction which is not required by the accelerometer. On the other hand, the pendulous mass provides a direct reading signal proportional to the velocity and does not require any signal processing.

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Table XVI

Operational mines*

Model	Manufacturer	Country	Type	Length (mm)	Diameter/ Width (mm)	Height/ depth (mm)	Weight (kg)	Charge (kg)	Explosive	Fuzing/ Sensor	Mooring depth (m)	Operating depth (m)	Operators
AMD-500		Russian Federation	Seabed					299	HE	Magnetic, Acoustic, Pressure, Combined		4-70 m	Bulgaria, China, Cuba, Egypt, North Korea, Poland, Russian Federation, Serbia & Montenegro, Syria, Ukraine, Vietnam
AMD-1000		Russian Federation	Seabed				987	782	HE	Magnetic, Acoustic, Pressure, Combined		4-200	Bulgaria, China, Cuba, Egypt, North Korea, Poland, Romania, Russian Federation, Syria, Ukraine, Vietnam
AMG-1		Russian Federation	Moored contact				1,034	262	HE	Impact chemical		13-100	Bulgaria, Cuba, North Korea, Russian Federation, Syria, Ukraine, Vietnam
BGM 100	Saab Bofors Dynamics AB	Sweden	Seabed	1,015	800	385	190	105		Magnetic, Acoustic		5-100	Sweden
BGM 600	Saab Bofors Dynamics AB	Sweden	Controlled	1,700	600	700	700 (app)	up to 400					Sweden
BGM 601	Saab Bofors Dynamics AB	Sweden	Seabed	2,000 (app)	750 (app)	750 (app)	800 (app)	80		Magnetic, Acoustic, Pressure	20-200	8-75 m	Sweden
BMM 80	Saab Bofors Dynamics AB	Sweden	Moored influence	1,125	660	1,125	450	80	Hexotonal		20-200	8-75 m	Sweden
Cluster Bay		Russian Federation	Rising					230	HE	Acoustic		80-200	Russian Federation, Ukraine
Cluster Gulf		Russian Federation	Rising					230	HE	Acoustic		80-2,000	Russian Federation, Ukraine
DM 51	ATLAS Elektronik	Germany	Anti-invasion	750	300		110	60	HE	Acoustic			Denmark, Germany
DM 61	ATLAS Elektronik	Germany	Seabed	2000 (app)	600 (app)		750 (app)			Magnetic, Acoustic, Pressure, Combined			Denmark, Germany
EM-52	Dalian Warship Institute	China	Rising rocket	3,700	450		620	140	RS-211	Magnetic, Acoustic		down to 200	China, Iran (?)
EM-55	Dalian Warship Institute	China	Rising	3,500/ 3,350	450/533			130	RS-211	Magnetic, Acoustic		down to 200	China, Iran (?)
KMD-500		Russian Federation	Seabed			500	300					4-70 m	Bulgaria, China, Egypt, North Korea, Poland, Russian Federation
KMD-1000		Russian Federation	Seabed			987	782					4-200	Bulgaria, China, Egypt, North Korea, Poland, Russian Federation
Limpet	C-TEC	India	Limpet	310		135	6	1	RDX/TNT				India
LSM		USA	Littoral										
M-08		Russian Federation	Moored contact							Impact chemical			China, Egypt, Iran, North Korea, Russian Federation
M-12		Russian Federation	Moored contact							Impact chemical			China, North Korea, Russian Federation
M-16		Russian Federation	Moored contact							Impact chemical			China, Russian Federation

Model	Manufacturer	Country	Type	Length (mm)	Diameter/ Width (mm)	Height/ depth (mm)	Weight (kg)	Charge (kg)	Explosive	Fuzing/ Sensor	Mooring depth (m)	Operating depth (m)	Operators
M-26		Russian Federation	Moored contact							Impact inertial			China, Iran (?)
M66		Serbia	Diversionary	670	320	430	50	27 (app)	TNT			30	Serbia
M70		Serbia	Seabed	2,823		245							Serbia
M71		Serbia	Limpet		345	245	14	3	pressed TNT			30	Serbia
MAS	Marine Air Systems	New Zealand	Limpet		300	170	6.5						New Zealand
MAD-1		Romania	Moored contact										
M-AG		Russian Federation	Antenna							Antenna			
Matrix	Northbend Underwater Systems	South Africa	Seabed										
MCF-100	DSND Consub SA	Brazil	Moored contact	1,400	1,020	1,500	770	160	Trotyl	Magnetic, Acoustic	10-100	Mar-50	Brazil
MCT	DSND Consub SA	Brazil	Limpet	428	375	70.5	15	6	Plastex			30	Brazil
MDM-1	Dvigatel	Russian Federation	Seabed	2,860	533		1,120	960		Magnetic, Acoustic		12-120	
MDM-2	Dvigatel	Russian Federation	Seabed	2,300	790		1,413	950		Magnetic, Acoustic		12-125	
MDM-3	Dvigatel	Russian Federation	Seabed	1,580/ 1,530	450		525/635	300		Magnetic, Acoustic		15-35 m	
MDM-4	Dvigatel	Russian Federation	Seabed	2,790/ 2,300	650		1,370/ 1,420	950		Magnetic, Acoustic, Pressure		15-125	
MDM-5	Dvigatel	Russian Federation	Seabed	3,060/ 2,400	630		1,500/ 1,470	1,350		Magnetic, Acoustic, Pressure		15-300	
MDM-6	Dvigatel	Russian Federation	Seabed	2,860	533		1,120	960		Magnetic, Acoustic, Pressure		12-120	
MDS		Russian Federation	Seabed	7,900	533		1,380					8- ?	
MFI	DSND Consub SA	Brazil	Moored influence	1,400	1,020	1,500	680	160	Trotyl	Magnetic, Acoustic	10-50 m	15-100	Brazil
MILA-6B	SAES	Spain	Limpet		350	150	7					40	Spain
Mirab		Russian Federation	Seabed				279	64		Magnetic		2	
Mk 31	COSMOS	Italy	Seabed	2,000	470		290	220					
Mk 41	COSMOS	Italy	Seabed	995	470		147	105					
Mk 56		USA	Seabed	2,900	570		909	164	HBX-3	Magnetic, Magnetic/ Acoustic		366	USA
Mk 62	Frequency Engineering	USA	Seabed	2,200 (app)	273		227	89	H6	Magnetic, Pressure, Seismic		100	USA
Mk 63	Frequency Engineering	USA	Seabed	3,000 (app)	350		454	202	H6	Magnetic, Pressure, Seismic		100	USA
Mk 64	Frequency Engineering	USA	Seabed	3,800	460		908	429	H6	Magnetic, Magnetic/ Pressure		100	USA
Mk 65	Frequency Engineering	USA	Seabed	3,250	740		1,086	908	PBX 103	Magnetic, Pressure, combined		100	USA
Mk 414/ 430	COSMOS	Italy	Limpet		350	200		7					
M-KB		Russian Federation	Moored contact							Impact chemical			China, Egypt, North Korea, Russian Federation
M-KB-3		Russian Federation	Moored contact							Impact chemical			
MMA		Romania	Seabed										
MMMCA	Romtehnica	Romania	Moored contact	2,200	925	1,250	1,125	240	Trotyl		2-175	12-390	
MN 102	SEI	Italy	Seabed	2,096	533		780	630	HBX-3	Magnetic, Acoustic, Pressure		6-300	Italy
MN 103	SEI	Italy	Anti-invasion		980	440	220	130	HBX-3/ TNT	Magnetic, Acoustic		3-100	Italy
MN 105	SEI	Italy	Moored influence	1,560	533		870	200	HBX-3	Magnetic, Acoustic		20-300	Italy
Mobile		Russian Federation	Mobile										
MO-90	SAES	Spain	Moored influence	1,180	1,090	1,690	1,060	300	HBX-3	Magnetic, Acoustic + ?	5-340		Spain
MP-2	Romtehnica	Romania	Limpet				18	10				50	

Model	Manufacturer	Country	Type	Length (mm)	Diameter/ Width (mm)	Height/ depth (mm)	Weight (kg)	Charge (kg)	Explosive	Fuzing/ Sensor	Mooring depth (m)	Operating depth (m)	Operators
MP-80	SEI	Italy	Seabed	2,096	533		780 (app)	620	HBX-3	Magnetic, Acoustic, Pressure		6-300	India, Italy
MR-80 Mod A	SEI	Italy	Seabed	2,750	533		1,035	870	HBX-3/ TNT	Magnetic, Acoustic, Pressure		5-300	Greece, Italy, Norway, Turkey
MR-80 Mod B	SEI	Italy	Seabed	2,096	533		760	630	HBX-3/ TNT	Magnetic, Acoustic, Pressure		5-300	Greece, Italy, Norway, Turkey
MR-80 Mod C	SEI	Italy	Seabed	1,646	533		565	460	HBX-3/ TNT	Magnetic, Acoustic, Pressure		5-300	Greece, Italy, Norway, Turkey
MSHM		Russian Federation	Rising continental	4,000	533		1,500	250		Acoustic		60-300	
MYaM		Russian Federation	Moored contact							Impact chemical			Libya
MYaRM		Russian Federation	Moored contact							Impact chemical			China, Egypt, Iran, North Korea, Libya, Russian Federation
MZ-26		Russian Federation	Obstructor				413	1				24-46	
PDM-2H		Bulgaria	Anti-invasion									5-15 m	
PLT		Russian Federation	Moored contact							Impact inertial			
PLT-3		Russian Federation	Moored contact										China, North Korea, Russian Federation
PMK-1		Russian Federation	Rising	7,830	533		1,850	350	HE	Influence, contact, time, combination		200-400	
RMK-1		Russian Federation	Moored	7,830	533		1,850	350				200-400	
RM-2		Russian Federation	Moored rocket	3,850	533		870					down to 450	
Samcon 600	IMT	South Africa	Seabed		533			600/400/ 200		Acoustic, Magnetic, Pressure, Seismic		60-150	
SMDM (type 1)	Dvigatel	Russian Federation	Rising	7,900	533		1,980	480		Magnetic, Acoustic		4-120	
SMDM (type 2)	Dvigatel	Russian Federation	Rising	11,000	650		5,500	800		Magnetic, Acoustic		8-150	
Stonefish	BAE Systems	United Kingdom	Seabed	2,500	533		990	up to 600	B2211D PBX	Magnetic, Acoustic, Pressure		10-200	Finland, Pakistan, United Kingdom
Stonefish Mk III	BAE Systems	United Kingdom	Seabed	1,821	533		755	500	PBX	Magnetic, Acoustic, Pressure			
UDM		Russian Federation	Seabed	2,400	790		1,470						
UDM-2		Russian Federation	Seabed	2,400	630		1,470						
UDM-500		Russian Federation	Seabed	1,525	600		635						
UEP		Russian Federation	UEP					227		Electrical		490	

*Details provided where available. Operators listed only where confirmed.

NEW ENTRY

Brazil

MCF-100

Type
Moored contact mine.

Development
The MCF-100 moored contact mine was developed in the 1980's.

Description
The MCF-100 moored contact mine is designed for use against submarines and surface ships at depths between 3 and 50 m in strong currents. It can be laid at bottom depths between 10 and 100 m. The mine can be programmed to remain inert on the bottom for a fixed period of time and then to self-release and anchor itself at the desired depth.

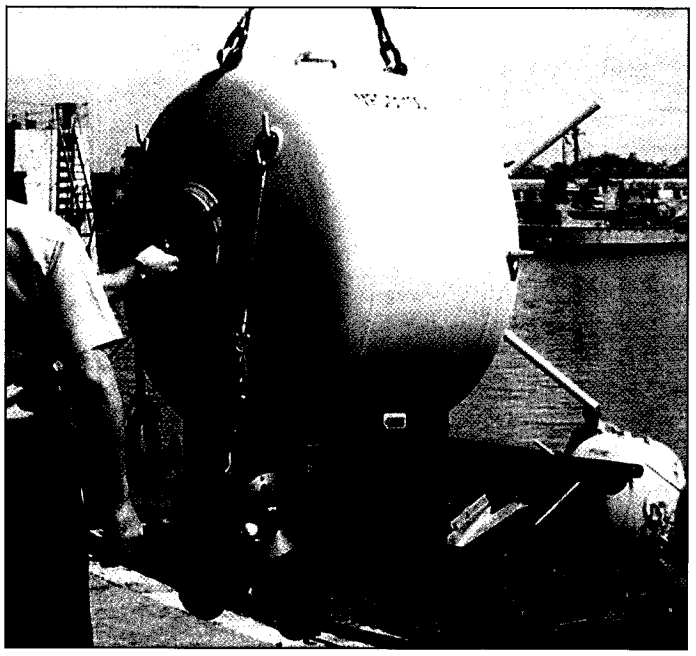
The newly developed installation procedure allows the mine to be moored with an accuracy in anchoring level of 0.50 m independently of currents and surface waves.

During 1992, Consub, in co-operation with the Brazilian Navy Research Institute, completed development of an influence (magnetic and acoustic) sensor which will increase the efficiency of the MCF-100. The sensor replaces the contact head assembly in the mine. This sensor can also be used in combination with up to three explosive modules, a priming charge and fuze, resulting in a powerful ground influence mine which could also be deployed from submarine torpedo tubes.

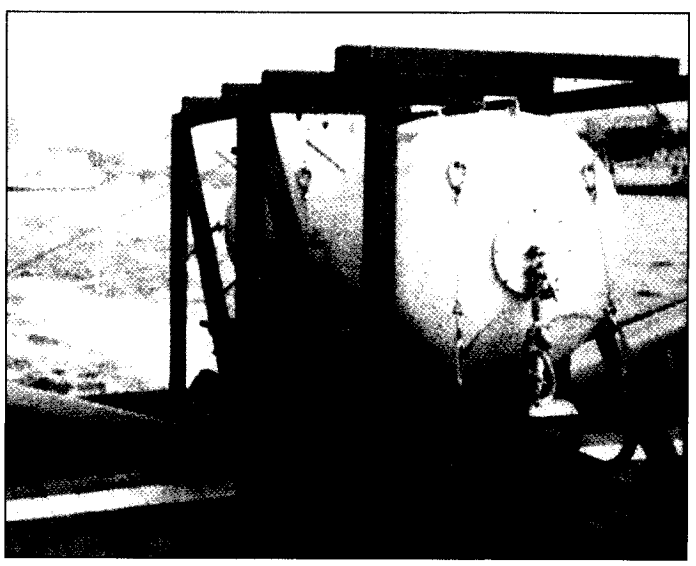
Three different versions of this mine are available: combat (MCF-100C), exercise (MCF-100E) and handling simulation (MCF-100M).

The MCF-100 can also be supplied with modular skids allowing:

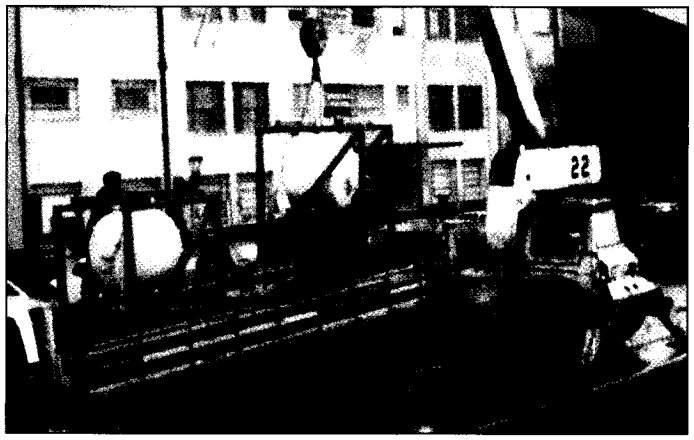
- smaller storage area
- easier and safer transportation
- the skids can also be mounted and aligned on almost any COOP vessel to create a modular rail deployment system.



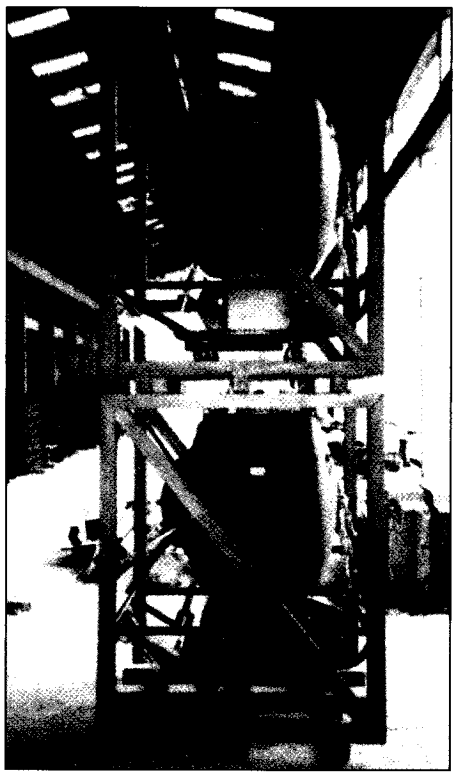
MCF-100 mine on launching rail



Skid mounted on COOP to form minelaying rail



MCF-100 in skid facilitating handling



MCF-100 stored in modular skids reducing storage space requirements

Operational status
The mine has been exhaustively tested by the Brazilian Navy. It has also been designed to meet US Navy military standards. A contract for 100 mines was placed by the Brazilian Navy in August 1991. Since then the Brazilian Navy has purchased the MCF-100 on a regular basis. The submarine *Tikuna* carries 32 of these mines.

Specifications
Length: 1,400 mm
Width: 1,020 mm
Height: 1,500 mm
Weight: 770 kg
Charge: 160 kg Trotyl
Operating depth: 3-50 m
Mooring depth: 10-100 m

Contractor
DSND Consub SA, Rio de Janeiro.

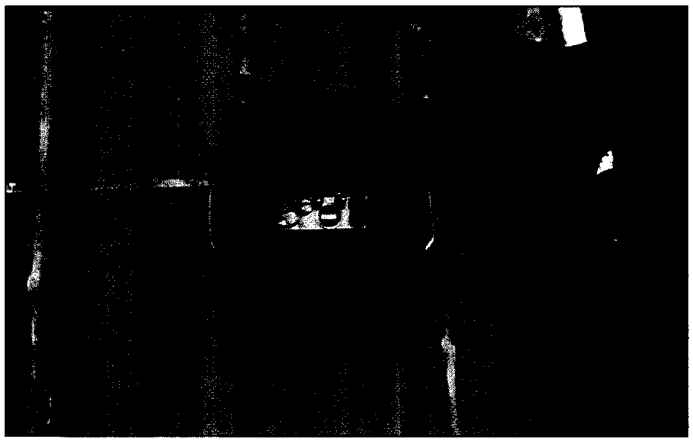
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MCT

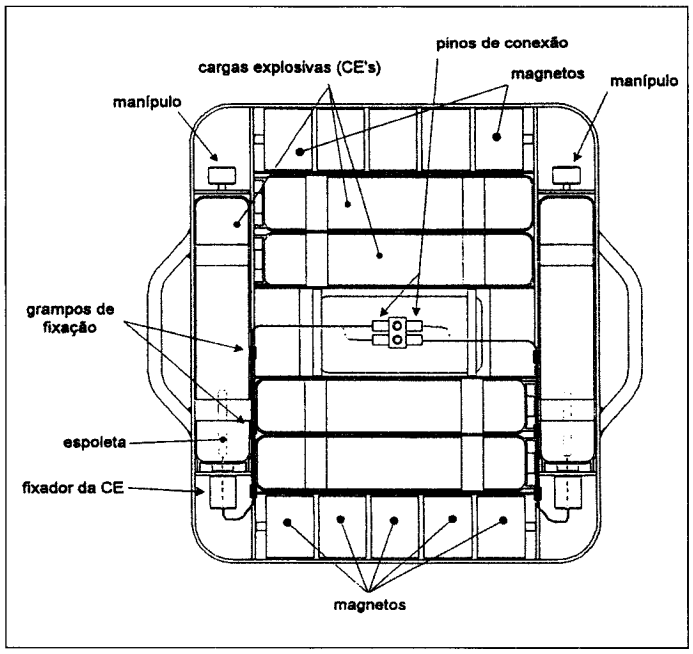
Type
Limpet mine.

Description
The MCT limpet mine consists of four modules: a casing, explosive charge, set of magnets and programming and firing module.

The mine is designed to allow explosives to be placed on ferromagnetic naval structures in locations down to depths of 30 m. The programming and firing module is fitted with a switch panel, through which the operator can adjust the timing of detonation between 25 minutes and 24 hours.



MCT limpet mine with typical damage caused to ferromagnetic material (DSND Consub SA) 0077633



Block schematic of the MCT (DSND Consub SA) 0077635

Specifications
Length: 428 mm
Width: 375 mm
Height: 70.5 mm
Weight
(in water) 1 kg
(in air) 15 kg
Charge: 6 kg Plastex
Operating depth: 30 m
Power source: 3 × 3.6 V lithium batteries

Contractor
DSND Consub SA, Rio de Janeiro.

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MFI

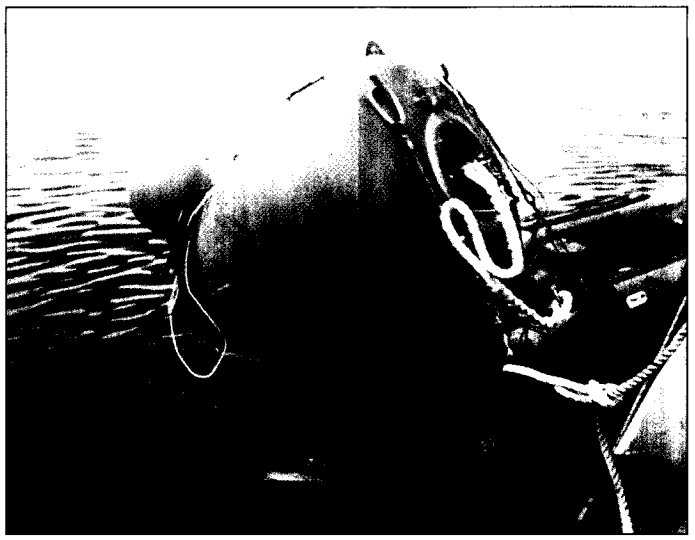
Type
Moored influence mine.

Description
The MFI intelligent acoustic/magnetic moored influence mine is designed for operations against both surface ships and submarines.

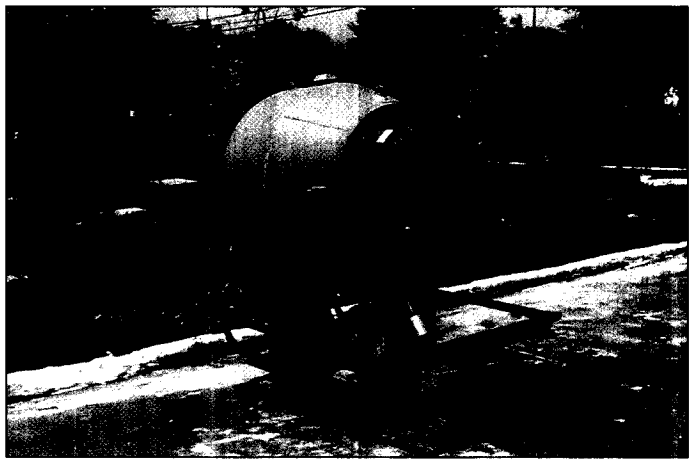
It is intended for laying at depths between 10 and 90 m and the mooring device is precise offering accuracy of ±1.0 m.

The mine casing is structural aluminium protected with a corrosion resistance material allowing the mine to remain in an aggressive environment for long periods of time.

Two different and independent mechanical locks assure maximum safety. The influence mechanism is equipped with a highly sensitive triaxial magnetometer and hydrophone and a ruggedised control unit. The control unit detects magnetic and acoustic signals, feeding them to a preselected detonation algorithm. The unit also maintains a housekeeping algorithm which measures power saving, detonation and sterilisation parameters in addition to target validation.



MFI influence mine ready for laying (DSND Consub SA) 0077589



MFI influence mine on portable skid (DSND Consub SA) 0077588

Specific parameters (insulation depth, sterilisation time and so on) can be programmed immediately prior to laying using a portable field test and programmer unit. The mine can be set to activate from 1 to 72 hours in 1 hour steps.

The MFI mine family incorporates a dual purpose skid suitable for transporation and minelaying.

Operational status
Developed and in service.

Specifications
Length: 1,400 mm
Width: 1,020 mm
Height: 1,500 mm
Weight: 680 kg
Charge: 160 kg Trotyl
Operating depth: 15 to 100 m
Mooring depth: 10 to 50 m

Contractor
DSND Consub SA, Rio de Janiero.

VERIFIED

Bulgaria

PDM-2H

Type
Anti-invasion mine.

Description
The PDM-2H, developed from the earlier PDM-2C-2, is a microprocessor-controlled anti-invasion mine. The battery powered spherical mine is designed for laying in fields configured for the protection of vital shore installations and areas susceptible to amphibious assault. The minefields can be remotely controlled either from a shore station or from a surface vessel.

The PDM-2H is designed for an operating environment of between –15 to +55°C at depths of 5 to 15 m. The mine is suspended on a pole above a large base braced by four tensioned wire stays. A tilt rod fuze is mounted on the top surface. It can be

programmed with a lifetime ranging from 30 minutes up to 24 hours. On reaching its pre-programmed lifetime the mine deactivates, when it can be raised for reprogramming. All programming of the mine is carried out prior to laying.

The battery is supplied by Germanos of Greece while Pyrkal supplies the power management system.

Operational status
Currently being assembled by Pyrkal in Greece.

Contractor
Bulgarian Academy of Sciences' Institute of Metal Science, Sofia.

UPDATED

China

EM 52

Type
Rocket propelled rising mine.

Description
The Chinese Navy, which largely relies upon former Soviet-designed naval mines, has developed an 'intelligent' sea mine actuation system for what are described as 'large' and 'medium' moored mines.

The rocket propelled rising mine, EM 52, developed around 1981, closely resembles the first Russian Cluster rising mine. It features a programmable central processor that can accept inputs from acoustic and magnetic sensors and, optionally, pressure sensors as well. It incorporates a ship counter system (up to a count of 99) which can permit up to 15 actuations before detonation, a delay mechanism of up to 250 days before arming and a self-destruction timer for up to 500 days. There are eight operating modes, which are believed to be mixtures of fuze and logic settings to meet different operational or environmental conditions. The EM 55 can operate in one of three modes: straight rising, vectoring or homing.

Operational status
In service. Reports indicate it may be in service with Iranian forces.

Specifications
Length: 3,700 mm
Diameter: 450 mm
Weight: 620 kg
Charge: 140 kg RS-211
Operating depth: 200 m

Contractor
Dalian Warship Institute, Dalian.

VERIFIED

EM 55

Type
Rocket propelled rising mine.

Description
The rocket propelled rising mine EM 55, closely resembles the first Russian Cluster rising mine. It features a programmable central processor which can accept inputs from acoustic and magnetic sensors and, optionally, pressure sensors as well. It incorporates a ship counter system (up to a count of 99) which can permit up to 15 actuations before detonation, a delay mechanism of up to 20 days before arming and a self-destruction timer for up to 360 days. Activation is either active or passive acoustic or magnetic, or a combination of any of the three influences. The EM 55 can operate in one of three modes: straight rising, vectoring or homing. The weapon is manufactured in two sizes for deployment by both submarines (533 mm version) and surface ships (450 mm version).

Operational status
In service. Reports indicate it may be in service with Iranian forces.

Specifications
Length: 3,500 or 3,350 mm
Diameter: 450 or 533 mm
Weight: 620 or 840 kg
Charge: 130 kg RS-211
Operating depth: 200 m

Contractor
Dalian Warship Institute, Dalian.

VERIFIED

Germany

DM 51 (SAI)

Type
Anti-invasion mine.

Development
STN ATLAS Elektronik has developed the DM 51 SAI (Seemine Anti-Invasion) mine under a bilateral programme in conjunction with the German MoD and Denmark. Designed to counter shallow draft amphibious vessels, the mine is fitted with an active acoustic fuze. The weapon can also be remotely detonated.

Operational status
SAI was produced for the German Navy and Denmark between 1982-90.

Specifications
Length: 750 mm
Diameter: 300 mm
Weight: 110 kg
Charge: 60 kg HE

Contractor
ATLAS Elektronik GmbH, Bremen/Wedel.

VERIFIED

DM 61

Type
Seabed influence mine.

Development
Development commenced in 1980 and was completed in 1986.

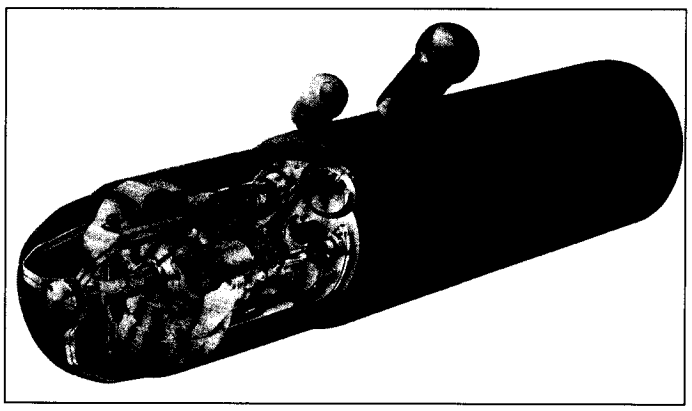
Description
The DM 61 (SM G2) heavyweight, non-magnetic seabed mine is designed for blocking shipping lanes, and for laying defensive minefields in coastal waters and sea areas.

The mine comprises an equipment section incorporating acoustic, magnetic and pressure influence sensors, which can operate individually or in combination and signal processing electronics and an explosive charge section with detonator and safety devices.

The sensors detect target signatures (acoustic LF or audio, magnetic and pressure) which are then analysed by the signal processor and compared with preprogrammed data held in the computer's programmable library of ship signatures. When certain preset parameters are recognised with unwanted local environmental factors filtered out, range to the target estimated and at the optimum range for that target, the detonator is actuated and the mine explodes. The analysis programs and parameters are fed into the onboard computer via the testing and programming units; particular tactical parameters can still be programmed into the weapon just before laying.

Operational status
Serial production has been authorised under a MoU between Denmark and Germany and assembly was carried out in German and Danish naval arsenals. For training purposes an exercise mine is available, and for data acquisition of ships' signatures a special version is also available.

A total of 1,058 units were manufactured for the German Navy by 1994 with further deliveries planned. An unknown number have been purchased by the Danish Navy.



Cutaway of DM 61

Specifications
Length: 2,000 mm (approx)
Diameter: 600 mm (approx)
Weight: 750 kg (approx)
Operating temperature range: –2.5 to +38°C

Contractor
ATLAS Elektronik GmbH, Bremen/Wedel

VERIFIED

India

Limpet Mine

Type
Anti-ship mine.

Description
Developed in 1994 and designed specifically for use by divers and frogmen, the mine is completely self-contained within a glass fibre shell. The device is attached to the target either by six powerful magnets or, in the case of a non-magnetic target, by a system of straps. Once fixed to the target, the frogman sets the timing device and starts a mechanical timer by removing the safety-arming pin. After a period of 20 minutes the mine is armed and exploded at the preset time by an electronic detonator. The mine incorporates countermeasure devices to prevent removal and disarming. The explosive is capable of blasting a hole 240 mm in diameter through 20 mm thick steel plate.

Specifications
Diameter: 310 mm
Depth: 135 mm
Weight: 6 kg
Explosive: 1 kg RDX/TNT

Operational status
In production.

Contractor
C-TEC, New Delhi.

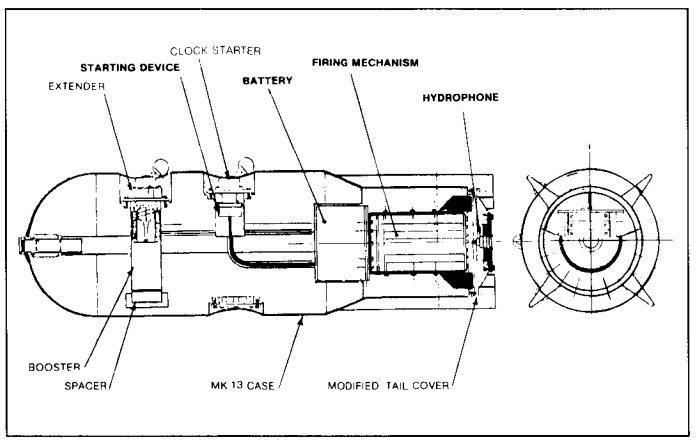
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Italy

Mine Target Detection Device

Type
Influence package for updating mines.

Description
Large quantities of old sea mines, manufactured shortly after the end of the Second World War, still remain in many inventories around the world. Both technically and operationally, these mines are now considered obsolete and are unable to comply with the modern requirements of naval mine warfare. In addition, their firing devices, designed and using technology of 40 years ago, are no longer reliable and are thus often unusable. Modern targets present operational, constructional and passive countermeasure techniques completely different from those extant when these mines were designed. To be effective, such mines require a modern, sophisticated and intelligent firing mechanism.



Typical elements incorporated in an updated Mk 13 Mod 6 mine

To meet these requirements a refit package, based on the Target Detection Device (TDD) which can be fitted inside the original mine casing and allowing the mine to retain its main charge, was developed in 1985. The TDD can operate over a wide range of pressure and magnetic sensors, as well as different acoustic frequencies. TDD can be used to update any type of mine, both ground and moored. The refit TDD package is also available in exercise versions.

Operational status
The TDD is currently in production. Incorporated in the MO-90 mine of Spain.

Contractor
SEI SpA, Ghedi (Brescia).

VERIFIED

Mk 31

Type
Underwater charge.

Description
The Mk 31 is designed to be carried by a Chariot (one per Chariot) to attack ships at anchor or alongside a pier, or for attacking oil rigs and pipelines. On arrival at the target, the charge is released from the Chariot and towed by the combat divers to the position where it is to be laid.

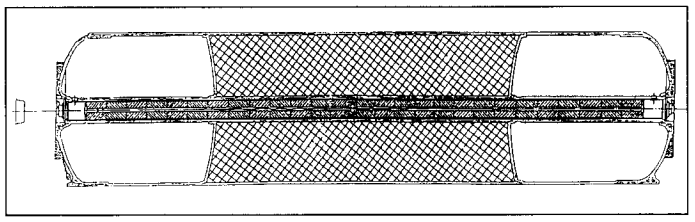
The charge is armed by two electronic fuzes.

Operational status
Developed.

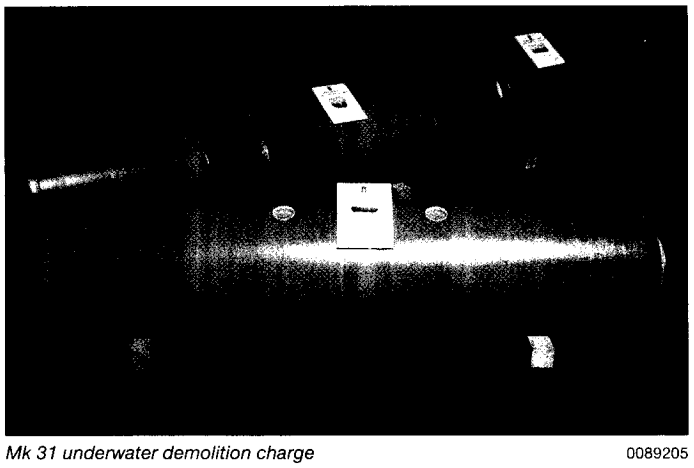
Specifications
Length: 2,000 mm
Diameter: 470 mm
Weight: 290 kg (in air)
Charge: 220 kg

Contractor
Cosmos SpA, Livorno.

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Schematic of Mk 31 charge (Cosmos) 0089220



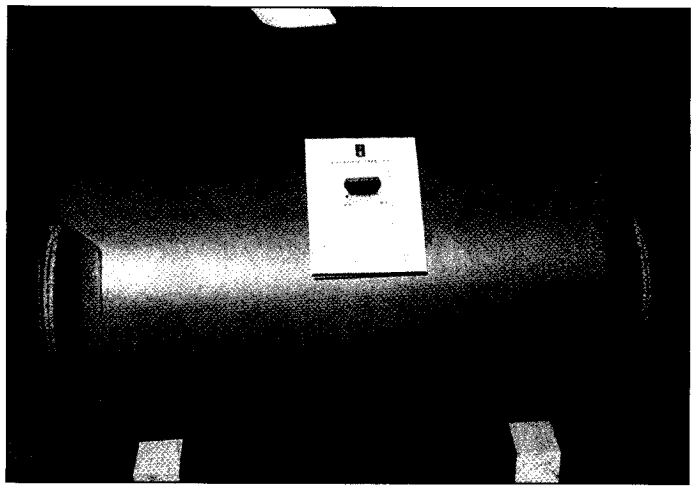
Mk 31 underwater demolition charge 0089205

Mk 41

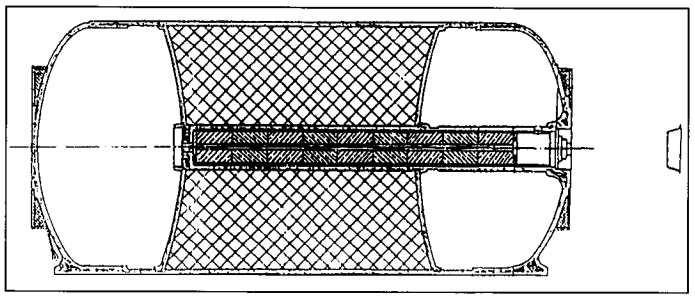
Type
Underwater charge.

Description
The Mk 41 is designed to be carried by a Chariot (two per Chariot) to attack ships at anchor or alongside a pier, or for attacking oil rigs and pipelines. On arrival at the target, the charge is released from the Chariot and towed by the combat divers to the position where it is to be laid.

The charge is armed by an electronic fuze.



Mk 41 underwater demolition charge 0089211



Schematic of Mk 41 charge (Cosmos) 0089219

Operational status
Developed.

Specifications
Length: 995 mm
Diameter: 470 mm
Weight: 147 kg (in air)
Charge: 105 kg

Contractor
Cosmos SpA, Livorno.

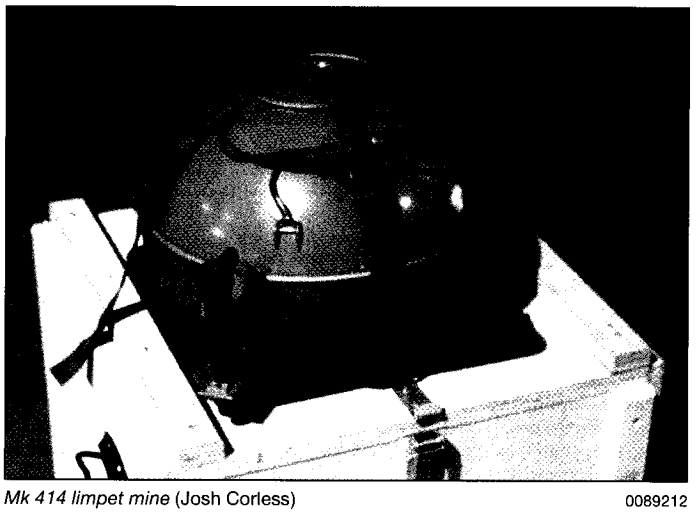
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Mk 414/430

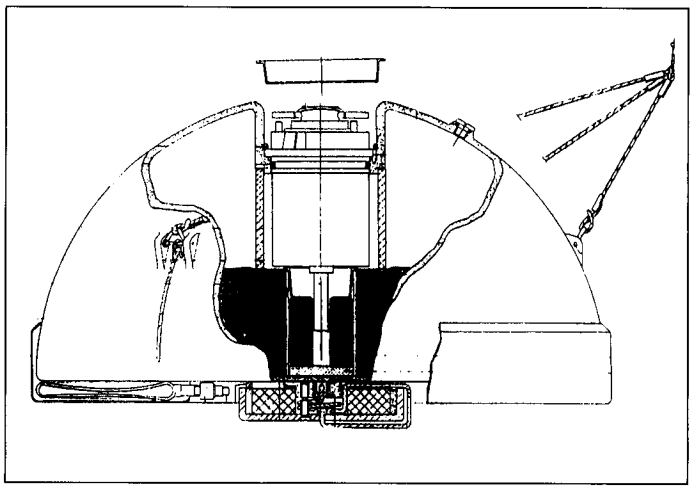
Type
Limpet mines.

Description
These light underwater charges are designed for attacking ships at anchor or alongside port installations, oil rigs and pipelines. They are carried by Chariots in the equipment containers used by commandos. The charges are easily transported and secured to a target by the combat divers.

Operational status
Developed.



Mk 414 limpet mine (Josh Corless) 0089212



Schematic of Mk 414 limpet mine (Cosmos) 0089218

Specifications
Mk 414
Height: 200 mm
Diameter (base): 350 mm
Weight: <0.5 kg (in sea water)
Charge: 7 kg

Mk 430
Height: 230 mm
Diameter (base): 420 mm
Weight: <0.5 kg (in sea water)
Charge: 15 kg

Contractor
Cosmos SpA, Livorno.

VERIFIED

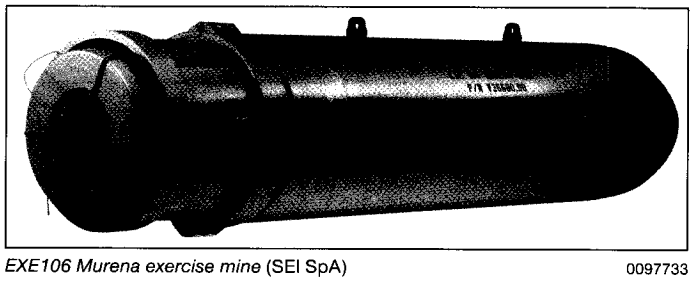
MN 102 – Murena

Type
Multi-influence seabed mine.

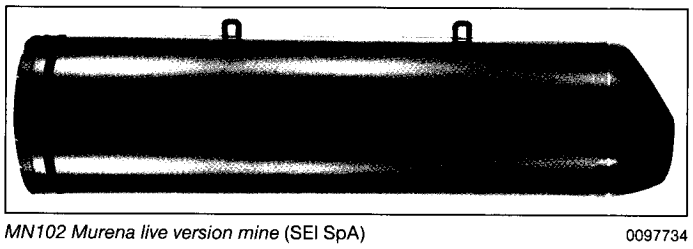
Development
Murena, currently in production, is the third generation of SEI mines and results from the upgrading of the MR-80 and MP-80/MRP mines. The weapon is a general-purpose advanced influence mine developed for the Italian Navy and is currently in service with several navies throughout the world.

Description
Murena is a multi-influence seabed mine designed to be effective against a wide range of targets.

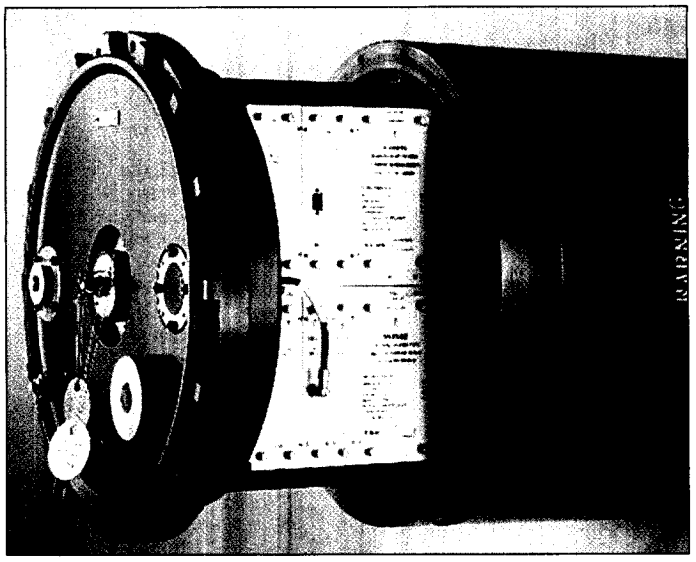
The mine logic is based on a unique analysis of target acoustic, magnetic and pressure signatures and provides the operator with a high degree of flexibility. The precision reached in target classification and localisation makes Murena extremely effective against a wide range of targets and resistant to mine countermeasures. Special background noise, depth and tide compensation guarantees the best 'kill' probability in any environmental scenario. The option of remote cable control



EXE106 Murena exercise mine (SEI SpA) 0097733



MN102 Murena live version mine (SEI SpA) 0097734



Murena target detection device (TDD) (SEI SpA) 1020471

increases the flexibility, enabling the mine to be used in harbour, strait and port defences.

The mine consists of a cylindrical shaped casing constructed of glass fibre impregnated with epoxy resin, which houses the explosive, target detection device (TDD) and safety and arming device. The TDD can be easily extracted from the casing for maintenance. TDD safety against removal or flooding is verified during operating life by anti-tampering and anti-flooding devices. The mine is shaped so as to provide it with the best in water trajectory during laying.

The mine can be laid by surface vessels, aircraft and clandestinely delivered from submarine torpedo tubes.

Murena is also available in exercise and dummy variants suitable for training simulation, target data acquisition and sea trials. The exercise variant can be used in the SEI mine warfare ranges (MWR).

Operational status
In production and in service with the Italian Navy and many other navies.

Specifications
Length: 2,096 mm
Diameter: 533 mm
Weight: 780 kg
Charge: 630 kg HBX-3
Operational depth: 6-300 m

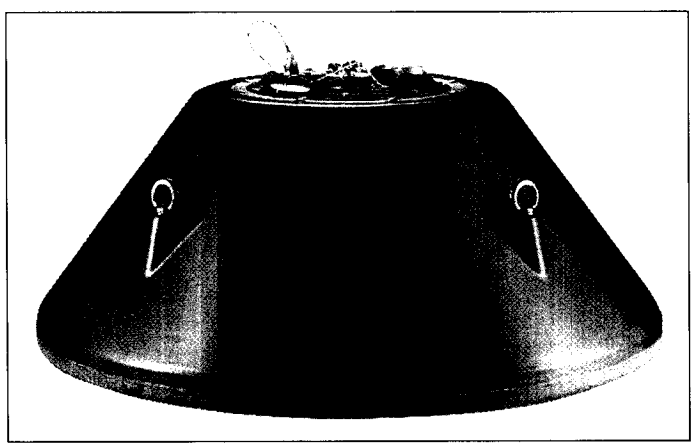
Contractor
SEI SpA, Ghedi (Brescia).

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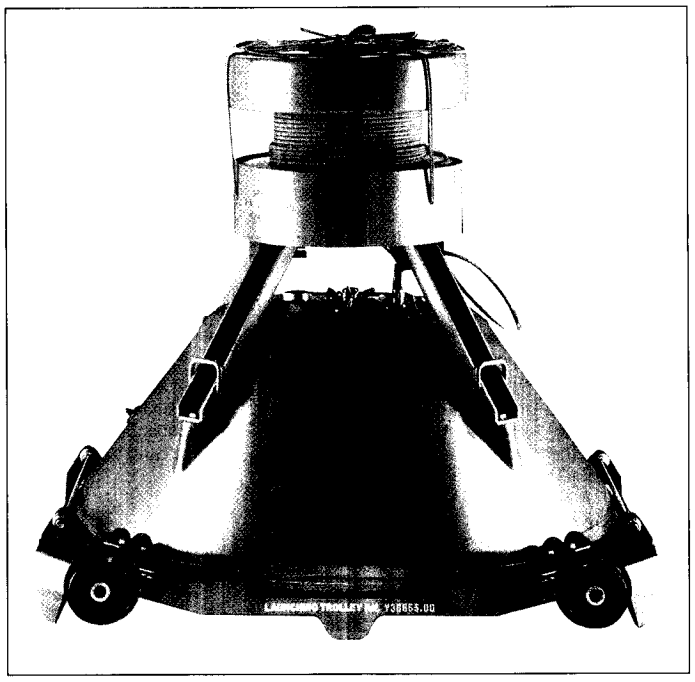
MN 103 Manta

Type
Stealth shallow water anti-invasion mine.

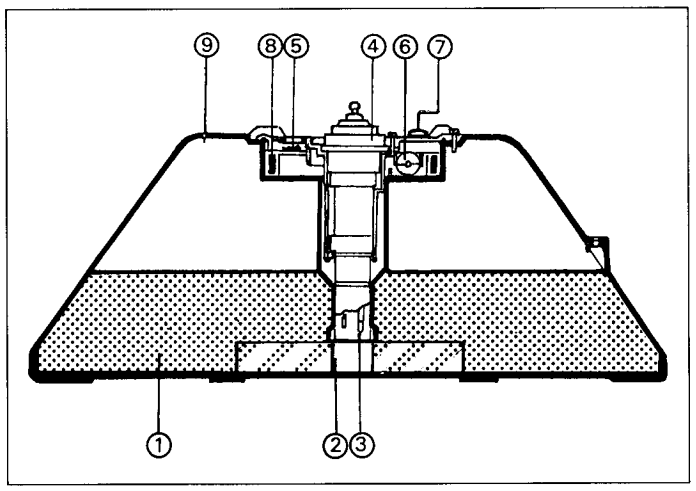
Description
The MN 103 Manta is a multi-influence sea mine designed to be effective against landing craft and small to medium tonnage vessels. It's unique shape, low target strength and low magnetic signature make the mine very difficult to detect. Its shape and in water weight make it remarkably stable on the bottom, even in rivers, channels and in the presence of currents.



A live version of Manta (SEI SpA) 1020468



EXE105 Manta exercise mine (SEI SpA) 0097732



MN 103 Manta shallow water anti-invasion influence mine. Key to diagram: ***(1)*** *main charge* ***(2)*** *booster* ***(3)*** *detonator* ***(4)*** *priming device* ***(5)*** *firing mechanism* ***(6)*** *battery* ***(7)*** *acoustic transducer* ***(8)*** *magnetic sensor* ***(9)*** *calibrated holes*



A Manta mine after a week on the seabed (SEI SpA) 1020467

The mine's logic is based on state-of-the-art analysis of the target's acoustic and magnetic influences. The option of cable remote control increases the flexibility of use in harbour, strait or port defence.

The mine, which can be laid by surface vessels, helicopters and aircraft, is available in warshot, exercise and dummy variants for training, simulation and target data acquisition and sea trials.

Operational status
The mine is in production and service with the Italian and many other navies. It has been combat proven in a number of situations and a number of Manta mines were cleared from Kuwaiti waters after the 1990-91 Gulf War.

Specifications
Diameter: 980 mm
Height: 440 mm
Weight: 220 kg (in air)
Charge: 130 kg TNT or HBX-3
Operational depth: 3-100 m

Contractor
SEI SpA, Ghedi.

VERIFIED

MN 105 Seppia

Type
Multi-influence moored mine.

Description
Seppia is a multi-influence moored mine which offers high flexibility, operating capability, effectiveness and reliability that assures a successful mining strategy in any naval scenario. The mine can be laid by surface vessels and aircraft and can operate in any type of sea against both surface and submerged targets according to the laying depth.

The mine's logic is based on a state-of-the-art analysis of the target's acoustic and magnetic influences.

The mine comprises a cylindrical shaped casing of glass fibre impregnated with epoxy resin which houses the explosive, TDD and safety and arming device mooring system (SADMS), which allows the mine to be laid at the required depth. The TDD can easily be extracted from the casing for maintenance.

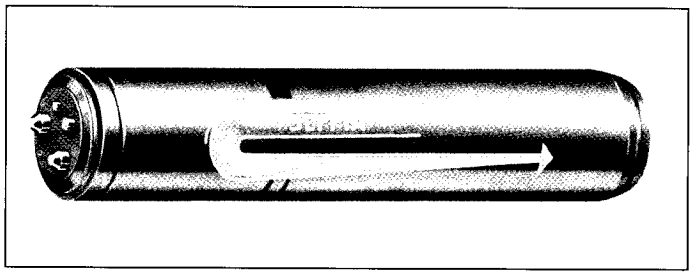
Seppia is also available in exercise and dummy variants suitable for training, simulation, target data acquisition and sea trials. The exercise variant can be used in the SEI MWR.

Operational status
In production and in service with the Italian and other navies.

Specifications
Length: 1,560 mm
Diameter: 533 mm
Weight: 870 kg (in air)
Charge: 200 kg HBX-3
Operational depth: 20-300 m

Contractor
SEI SpA, Ghedi.

VERIFIED



MN 105 Seppia moored mine (SEI SpA) 1020473

MP-80

Type
Seabed influence mine.

Development
Designed in co-operation with the Italian Navy to meet a requirement for an influence seabed mine capable of meeting the latest concepts on mining doctrine.

Description
The MP-80 uses the same general mechanical structure as the previous MR-80, but with an updated firing mechanism and the addition of sophisticated data processing to improve performance. The target detection device uses four microprocessors to provide digital processing of target signatures (magnetic, pressure and/or acoustic) and comparison with an onboard threat library. The system can discriminate between targets and countermeasures and, when presented with multiple choice targets, selects the most suitable.

Activation is by combined magnetic, acoustic and pressure sensors controlled by the programmable microprocessor. Arming and neutralisation delay time is also programmable.

Operational status
No longer in production. Remains in service with the Italian, Indian and other navies. Replaced by MN 102 Murena.

Specifications
Length: 2,096 mm
Diameter: 533 mm
Weight: 780 kg (approx)
Charge: 620 kg HBX-3
Operational depth: 6-300 m

Contractor
SEI SpA, Ghedi (Brescia).

VERIFIED

MR-80

Type
Seabed influence mine.

Description
Developed in the early 1960s, the MR-80 cylindrical seabed mine can be laid from any type of platform and is actuated by a combination of influences (magnetic, pressure, low-frequency acoustic, audio high-frequency acoustic) from the target and is able to damage or sink surface vessels and submarines of all types either conventional or nuclear powered. The cylindrical body is of epoxy resin and glass fibre, which renders the mine resistant to sea corrosion and makes it lighter than previous generation mines. The main body contains the explosive charge, while the tail section contains all the actuation, priming and operating devices. It is closed by means of a cover, which houses the acoustic, magnetic and pressure sensors together with the safety and arming device.

All influence devices are connected to a central unit, where all delay functions, safety intervals, sterilisation, influence combinations, ship counting, anti-removal and firing control are located.

The sole plate supporting all the electronic modules and the magnetic sensor is linked to the cover by slides that run inside the tail section. By unscrewing the bolts of the crown, the tail cover is easily removed with all the devices linked to it; in this way every part of the mine is accessible for assembly and adjustment operations.

Operational status
Entered service in the early 1960s with the Italian Navy. No longer in production, but remains in service with the Italian Navy. Reportedly sold to Greece, Norway and Turkey. Iraq developed a mine which was very similar to the MR-80. Replaced by MN 102 Murena.

Specifications
Length: 2,750 mm (Mod A); 2,096 mm (Mod B); 1,646 mm (Mod C)
Diameter: 533 mm
Weight: 565-1,035 kg (according to model and type of explosive)
Charge: TNT, HBX-3 or similar HE; 460, 630, 870 kg (Mod C, Mod B, Mod A)
Operational depth: 5-300 m (for surface targets and for submerged submarines)

Contractor
SEI SpA, Ghedi (Brescia).

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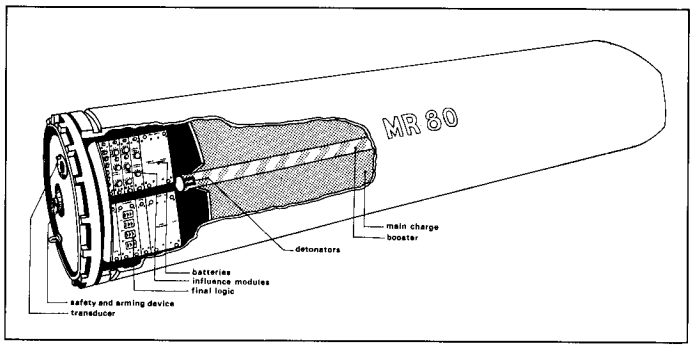


Diagram of MR-80 general purpose seabed influence mine

MWR

Type
Exercise Mine Warfare Range (MWR).

Development
The MWR has been developed to provide a realistic mine warfare training environment for naval forces in which ship safety condition and MCM equipment are efficiently tested against mine threats in various seabed conditions, and which allows the collection of signatures from co-operative vessels.

Description
The MWR architecture is fully scalable, allowing a wide range of configurations. These range from a fast short-term operation deploying a single mine, to a long-term activity with numbers of mines in different areas according to the different logistic and environmental constraints of the operative scenario and environment, the threat type and the types of mine available.

The key feature of the MWR is its real-time mine influence data acquisition and ship position tracking on the range. This allows the effective evaluation of mine and vessel performance and the supervision of the operation. The tracking system is based on GPS or transponder systems. Other tracking systems can be integrated if requested.

The main function during MCM evaluation and training operations are:
- simulation of combat scenarios
- performance assessment and risk estimation of MCM missions
- evaluation of the effectiveness of MCM
- determination of the best minesweeping techniques to counter the threat

- assessment of MCM techniques (ships, drones, ROVs, divers, sweep gear) during MCM operations
- assessment of vulnerability of friendly vessels
- measurement of the damage from a simulated mine explosion.

The main function of the MWR during mine evaluation and training operations are:

- acoustic/magnetic/pressure signature acquisition
- collection of underwater influences from co-operative vessels
- evaluation of the effectiveness of mines against different naval targets
- determination of the optimum mine settings against various targets
- evaluation of the capability of mines to be resistant to minesweeping techniques
- mine setting activation probability and configuration effectiveness.

MWR is designed to operate with the exercise variants of Murena, Manta and Seppia. The old MR-80, MP-80 and MRP and customer's own mines can be easily integrated on the range.

The MWR can be equipped with a special sea laboratory, which allows the collection of multiple underwater influences (including ELFE and EUP signatures) from co-operative vessels to give comprehensive information on mine and countermining operations.

Operational status
In production.

Specifications
Operational area: 30 miles
Water depth: up to and in excess of 100 m
Operating area of communication buoy: 10 km²

Contractor
SEI SpA, Ghedi (Brescia).

VERIFIED

New Zealand

MAS

Type
Exercise limpet mine.

Description
The MAS exercise limpet mine, developed in 1998, is an inert device used to train navy divers in mine removal techniques. The device was originally developed to meet New Zealand Navy requirements, but export variants are also available with alternative configurations and performance characteristics.

The device simulates the appearance, method of attachment, arming and activation characteristics of real limpet mines that are available internationally. The device is hemispherical in shape with a flat baseplate fitted with four magnets used to attach the device to a target. The base supports the sealed electronics chamber that is housed in a thick-walled PVC casing. The entire device is protected by a rugged PVC outer casing.

The device is fitted with a time delay counter which can be preset up to 24 hours using a 10-position selector switch which is programmable to customer requirements. Once the device is attached to the target using the magnets, the arming pin is withdrawn which allows the anti-lift plunger to make contact with the hull.

The device is actuated when the time delay is reached, or if any attempt is made to remove the device. Detonation is indicated by a flashing Xenon strobe light. The strobe light is turned off by pressing the anti-lift plunger home and installing a replacement-arming pin. An event counter provides a permanent record of activation. Power is provided by eight size 'C' cells.

An anti-lift device with incremental encoding is fitted which enhances the discrimination of the detector. When the mine is placed on the hull and the arming pin removed, the anti-lift plunger moves under spring pressure against the hull. After a few seconds, the circuitry records the datum position of the plunger and thereafter its position is monitored by the electronics. When a change of more than the preset amount (for example ±1 mm) is detected, the strobe is actuated.

A proximity detector, mounted on the innermost end of the anti-lift plunger housing, senses when the plunger is home (that is, the device is not armed). This proximity detector is fitted with contacts so that only when the plunger moves to the target's hull is the circuitry powered.

A unit without the electronics chamber is available for use with limpet mine disposal equipment.

Operational status
In service with the New Zealand Navy and a number of other navies.

Specifications
Diameter: 300 mm
Depth: 170 mm
Weight: 6.5 kg

Contractor
Marine Air Systems, Wellington.

VERIFIED

Romania

MAD-1

Type
Moored contact anti-invasion mine.

Development
The MAD-1 has been developed to provide coastal protection against amphibious assault landings against landing craft operating in areas of water depth between 5 and 35 m.

Description
The moored contact mine is designed for laying in shallow waters off the coast and is effective against landing craft and small- and medium-size surface vessels. The weapon consists of two parts: the body, containing the explosive, safety and arming devices and self-destruct mechanism; and the sinker, holding the mechanism for automatic anchoring and depth-setting.

The MAD-1 is fitted with four contact horns set at 45° from the top of the mine and at 90° from each other.

The mine can be laid in water depths of between 5 and 35 m with an operating depth between 0.6 and 2.4 m, adjustable in steps of 0.3 m.

The mine is fitted with an inertial galvanic-contact firing mechanism, automatically anchored from surface to bottom.

Operational status
In production and service.

Specification
Length: 700 mm
Diameter: 734 mm
Height: 1,160 kg
Weight: 220 kg
Charge: 30 kg TGAF
Operational depth: 5-35 m (mine depth 0.6-2.4 m)

Contractor
Romtehnica, Bucharest.

VERIFIED

MMA

Type
Shallow water seabed influence mine.

Description
The MMA shallow water influence mine, developed from the Russian ADM-500 influence mine of which a number are held in the Romanian inventory, is designed for deployment in water depths between 6 and 50 m. Two variants of the mine are available, the MMA-1 designed for use in rivers and the MMA-2 for use in shallow coastal waters. The mines differ in the content of the explosive charge – the MMA-1 being filled with TNT and the MM-2 with TGAG-5 explosive.

The cylindrical seabed mine is fitted with both magnetic and acoustic influence fuzes for use against surface ships and submarines. The acoustic influence is sensitive against both LF and NF noise and the magnetic fuze uses the intensity of either the horizontal or vertical component of the target's magnetic field.

The mine is equipped with a timer that activates the mine after a predetermined delay time and with a ship counter.

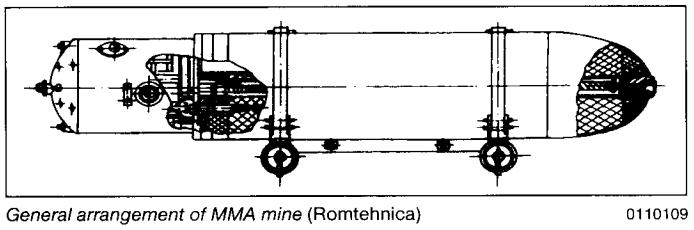
The mine is powered by alkaline-manganese/zinc batteries (MnO_2-ZN).

Operational status
In production and service.

Specifications
Length: 1,967 mm
Diameter: 452 mm
Weight: 572 kg
Charge: 300 kg
Operational depth: 6-50 m

Contractor
Romtehnica, Bucharest.

VERIFIED



General arrangement of MMA mine (Romtehnica) 0110109

MMMCA

Type
Contact mine.

Description
Developed from the Russian KB-KRAB mine, of which a number are held in the Romanian inventory, the MMMCA contact mine is designed for use against submarines and surface vessels in depths of 2 to 175 m with the sinker at depths between 12 and 390 m. The weapon is designed to operate like a limpet mine.

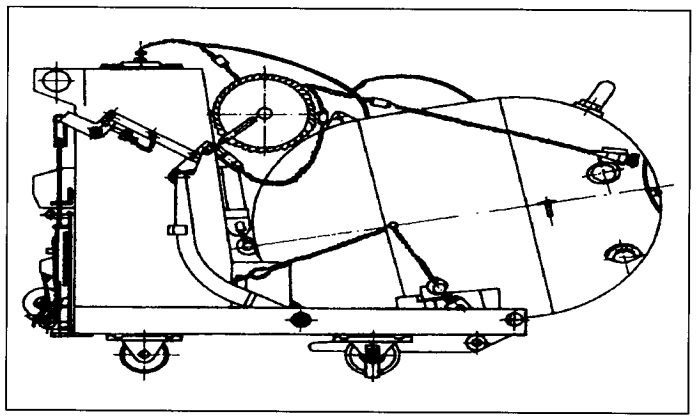
The mine can be programmed to remain inert for a fixed period of time.

Operational status
In production and service.

Specifications
Length: 2,200 m
Diameter: 925 m
Height: 1,250 m
Weight: 1,125 kg
Charge: 240 kg trotyl
Operational depth: 12-390 m (mine depth 2-175 m)

Contractor
Romtehnica, Bucharest.

VERIFIED



Outline of MMMCA contact mine (Romtehnica) 0110110

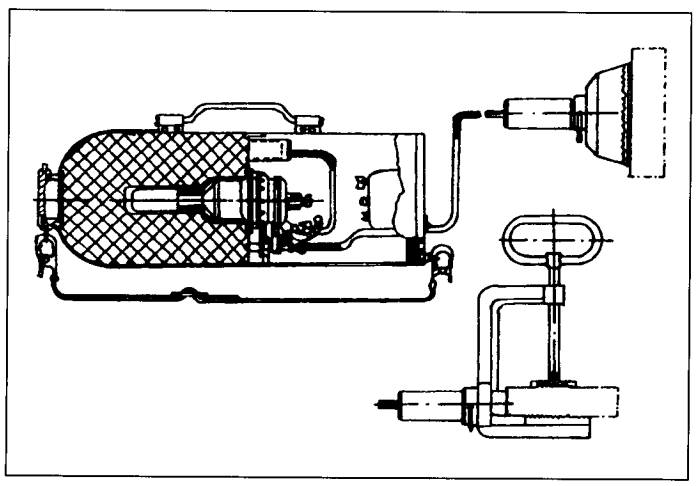
MP-2

Type
Limpet mine.

Development
The MP-2 limpet mine has been developed from the earlier MP-2 variant.

Description
The MP-2 limpet mine is designed for use against ships and underwater platforms. It features improved security against removal from the target through the incorporation of a modernised electric panel. The mine is fixed to the target by means of magnets and with special screws provided on the mine.

The weapon is fitted with a time fuze and clock mechanism with time settings ranging from 10 minutes to 3 hours. Fuze activation is performed after the mine has been fixed to the target.



Block schematic of MP-2 mine 0110108

Operational status
In production and service.

Specifications
Width: 18 kg
Charge: 10 kg
Operating depth: 50 m

Contractor
Romtehnica, Bucharest.

VERIFIED

Russian Federation

Introduction

In 1987, the US DoD estimated that the former Soviet Union possessed an inventory of 300,000 naval mines. According to US intelligence, the inventory includes about 100,000 moored contact mines. In addition, mines have been provided to other former Warsaw Pact navies and also exported to many other countries. Among countries outside the Warsaw Pact that are believed to have received stocks of former Soviet mines are China, Egypt, Finland, Iran, Iraq, North Korea, Libya and Syria. It is also likely that other Third World navies possess mines of former Soviet design. At least, some of these countries have set up production lines to manufacture mines based on these designs.

Moored mines
The RFAS is known to have at least 11 different types of contact mine. Some of these are no longer in production, but many of them could be encountered.

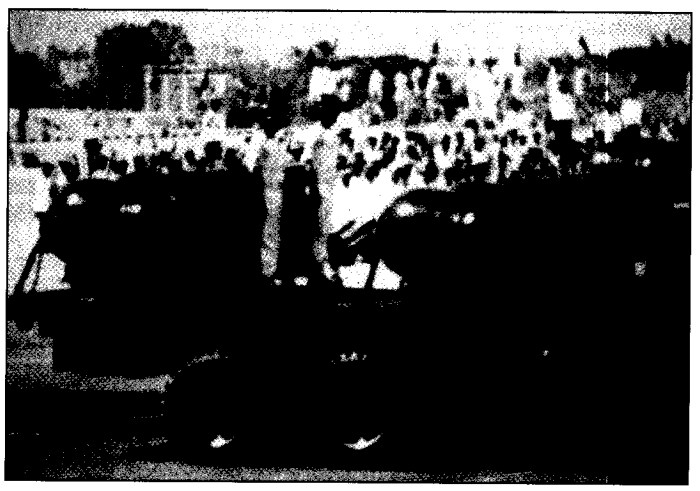
The main type is the basic contact moored mine using an inertia type firing mechanism which can be either galvano-contact, mechanico-contact or electrico-contact.

The two smallest mines are designated MYaRM and MYaM. Both have a conventional spherical shape with horns and small sinker units. The MYaRM has an explosive charge of 3 kg and is used in rivers and lakes. The MYaM has an explosive charge of 20 kg and is used in lakes and shallow coastal areas to protect them from small boats and landing craft. The MYaM is thought to have entered service immediately after the Second World War and was first encountered in 1952 by the US Navy. It has been used by both the Iranians and Iraqis in the Persian Gulf.

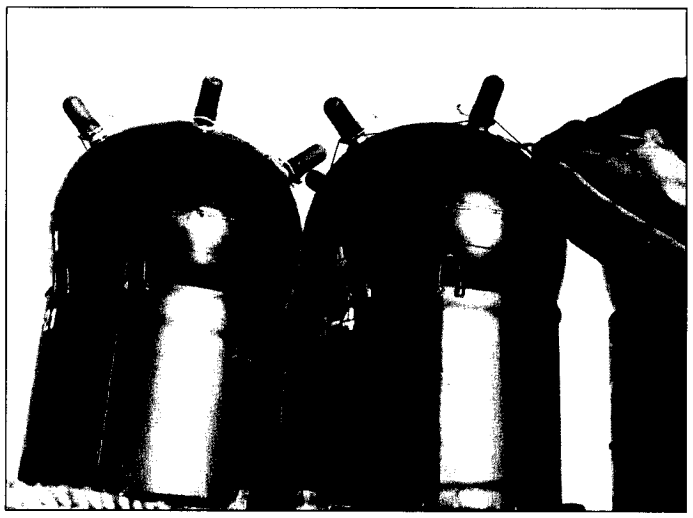
The medium-sized moored contact mine is largely confined to the extensive stocks of the M-08 series used for coastal defence barriers. The M-08 was developed in 1908 and remains in widespread service in various navies. The robust, reliable, spherical mine is filled with 115 kg of explosive and the firing mechanism consists of 5 Hz horns. Intended for use against surface ships, the M-08 can be laid in up to 110 m of water. The M-08 mines used in the Persian Gulf were, according to US intelligence reports, assembled by the Iranians, probably from components supplied by the North Koreans, who apparently manufacture the M-08 themselves.

There are two improved versions of the M-08: the M-12 and M-16, which are identical to the M-08 except that they have longer cables connecting the mine case to the anchor, enabling them to be laid in deeper waters. In addition, the RFAS has devised a version of the M-16 in which two of them are linked together in tandem, with only one mine case being released at a time. If the first mine is swept or detonates, the second mine is released.

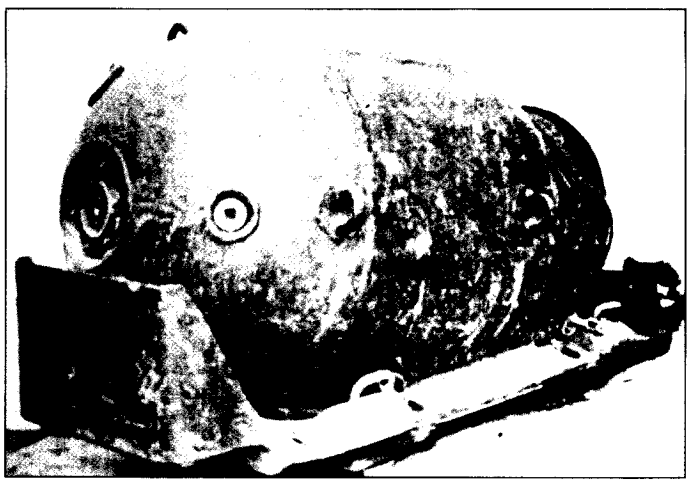
The M-26 is totally different from the M-08, using a PLT inertial firing mechanism. When armed, a shock causes the trigger shaft to move out of position, thus allowing the trigger to strike percussion caps that detonate the main charge. The entire mine comes to rest on the bottom before the mine case is released from the anchor. Although this makes it possible to use a simple anchor, it also makes it impossible to use the M-26 in deep water, where the case might be crushed by high pressures. The M-26 has been used by the North Koreans.



Egyptian KMD mines on display in 1977



Iranian M-08 mines captured by the US Navy in the Persian Gulf



An Egyptian KMD mine. The AMD mine is similar

The M-KB is a large mine with a 230 kg explosive charge intended for use in deep waters down to 300 m. It operates in much the same way as the M-08 and even uses some of the M-08's components. The M-KB is known to have been supplied to a number of countries including Egypt and North Korea.

Several variants of the M-KB mine have appeared. The case of the M-KB-3 is 6 in shorter with a corresponding reduction in the size of its explosive charge. The M-AG is almost identical to the M-KB except that it also has an antenna firing device and can be laid in considerably deeper water. The mine has a 35 m long upper antenna and a 24 m long lower antenna. The antenna operates by generating an electric current when the copper wire of the antenna comes into contact with the steel hull of a surface ship or submarine. The mine is intended primarily for use as an ASW weapon as it increases the vertical area covered by the mine. Antenna mines tend to be unreliable, however, and most countries now use influence mines for ASW.

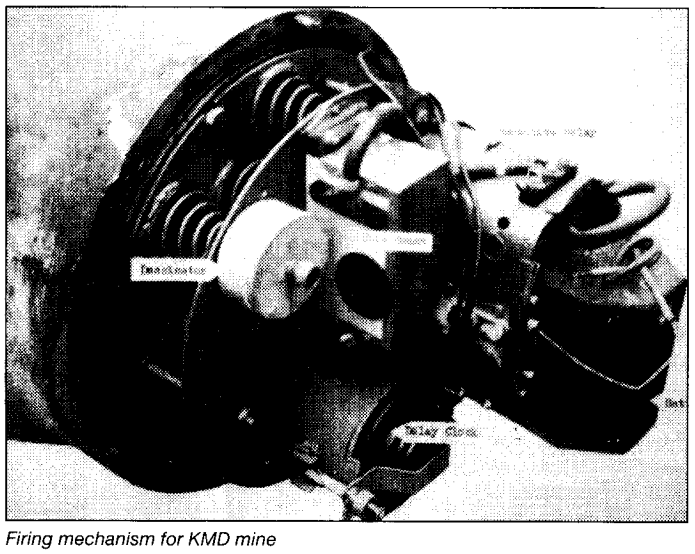
The AMG-1 is a version of the M-KB adapted for air delivery. Not being fitted with a parachute, it must be laid at low altitudes and slow speeds. However, because of its high-impact velocity it can penetrate several inches of ice. Because of this feature it is possible that this otherwise obsolescent mine might still be used operationally by the RFAS.

Two contact mines exist which can be laid by submarines, the PLT and PLT-3. The large PLT can only be laid by specially designed submarines fitted with an internal minelaying mechanism. As there are no such submarines operational, the PLT is likely to be encountered only if laid by surface ships. The newer PLT-3, however, can be laid through submarine torpedo tubes.

It is likely that the RFAS has additional types of moored mines in her inventory. According to one report there is an acoustic moored mine, and it would seem probable that a magnetic influence moored mine has also been developed. These could be versions of existing moored mines fitted with influence sensors. It is also probable that the RFAS has developed a new aircraft-delivered moored mine. The AMG-1 is a primitive weapon not suited for deployment from modern high-speed aircraft. Hence, the appearance of a new moored mine fitted with either a contact or an influence firing mechanism would not be surprising.

Mine protectors

Because of the ease with which moored mines can be swept, the RFAS has developed the MZ-26 mine protector. Attached by a cable to an anchor is a magazine with a buoyancy chamber and four floats. The magazine is normally set to float at a depth of 18 m, but it can be up to 46 m deep. Each of the floats is attached to the chamber by a cable usually 12 m long. The floats contain a small explosive charge which is detonated when a sweep cable comes into contact with it, cutting the sweep cable, and halting minesweeping operations. Although the float is destroyed, a replacement float is automatically released when one is destroyed. Thus each MZ-26 has the potential for cutting up to four sweep wires. The protectors can be used in conjunction with M-16 tandem mines.



Firing mechanism for KMD mine

Seabed mines

Relatively little is known about Russian influence mines. The first seabed mine available in any quantity was the KMD developed in the late 1940s. The AMD is an aircraft-delivered version of the KMD. It was first identified in the late 1950s but early variants first entered service in 1942. The first variants (AMD-1) featured a single channel, two-pulse magnetic influence exploder while the AMD-2 variants noted in the 1950s carried a combined acoustic/magnetic influence exploder. Subsequent variants were fitted with one of four different types of sensor: acoustic (using either or both low-frequency and high-frequency noise generated by the target), magnetic (relying on either the intensity of the horizontal or vertical component of the target's magnetic field or the rate of change of its field), pressure, or a combination firing mechanism using two or all three different influences in conjunction. The KMD mine is fitted with a timer that can be set to activate the mine after a delay of up to 10 days, and it can also be fitted with a ship counter that requires up to 11 activations before the mine actually detonates. Both mines can carry either 500 kg or 1,000 kg of explosives, and both have been exported to other former Warsaw Pact navies and to countries in the Third World.

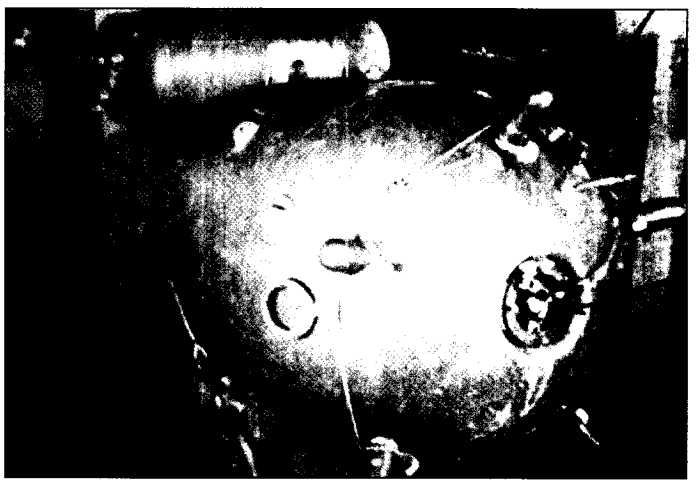
The former Soviet Union is known to have developed additional influence mines in the past 30 years. The first of these was identified in 1985 after being used by the Libyans in the Red Sea. According to published reports the mine was 533 mm in diameter, suggesting it was designed for submarine deployment. The mine is believed to have been of modular design with replaceable circuit boards, which enabled the sensitivity to be altered according to the type of target to be countered. The mine carried an explosive charge of 680 kg.

It is probable that several different types of ground mine are available, including an air-deployed version of the submarine-launched mine. As that particular mine was large, it is probable that smaller anti-invasion ground mines also exist. The latest types of ground mine probably follow Western practice in that they are programmable microprocessor-controlled types, whose mechanisms can also be retrofitted into existing warstocks.

While the RFAS has exported its newer mines to countries as diverse as Libya and Finland, it is unlikely that they will incorporate firing devices as sophisticated as those fitted in the former Soviet Navy's inventory.

Specialised mines

Several special purpose mines intended for a deep water ASW role have been developed. Two such weapons are the torpedo shaped, rocket-propelled, tethered rising mines, NATO designation 'Cluster Bay' (operating in water 80 to 200 m deep) and 'Cluster Gulf' (which can be laid in 2,000 m of water) which first entered service



M-AG antenna mine

Specifications

Type	Mine designation	Firing mechanism	Overall weight	Explosive charge	Minelaying depth Min	Minelaying depth Max	Case depth Min	Case depth Max
Bottom	AMD-1000	Influence	987 kg	782 kg	4 m	200 m	0 m	54.9 m
	AMD-500	Influence	-	299 kg	4 m	70 m	0 m	24.4 m
	KMD-1000	Influence	987 kg	782 kg	4 m	200 m	0 m	54.9 m
	KMD-500	Influence	500 kg	300 kg	4 m	70 m	0 m	24.4 m
	Mirab	Influence - magnetic	279 kg	64 kg	2 m	-	0 m	9.1 m
Mobile	?	Influence	-	-	40 m	70 m	0 m	-
Moored	AMG-1	Contact - chemical horn	1,034 kg	262 kg	13 m	100 m	2 m	9 m
	M-08	Contact - chemical horn	-	115 kg	6 m	110 m	0 m	6 m
	M-12	Contact - chemical horn	-	115 kg	6 m	147 m	0 m	6 m
	M-16	Contact - chemical horn	-	116 kg	6 m	366 m	0 m	6 m
	M-26	Contact - inertial	-	240 kg	6 m	139 m	1 m	6 m
	M-AG	Antenna	1,089 kg	230 kg	80 m	454 m	0 m	91 m
	M-KB	Contact - chemical horn	1,089 kg	230 kg	0 m	300 m	6 m	9 m
	M-KB-3	Contact - chemical horn	1,061 kg	200 kg	0 m	273 m	0 m	9 m
	MYaM	Contact - chemical horn	175 kg	20 kg	3 m	50 m	1 m	3 m
	MYaRM	Contact - chemical horn	-	3 kg	3/4 m	50 m	-	2 m
	PLT	Contact - impact-inertial	839 kg	230 kg	9 m	139 m	0 m	9 m
	PLT-3	Contact - chemical horn	998 kg	100 kg	0 m	128 m	0 m	9 m
	UEP ?	Influence - electrical	-	227 kg	0 m	490 m	0 m	-
Obstructor	MZ-26		413 kg	1 kg	24 m	46 m	0 m	34 m
Rising	'Cluster Bay'	Influence - acoustic	-	230 kg	80 m	200 m	0 m	609.6 m
	'Cluster Gulf'	Influence - acoustic	-	230 kg	80 m	2,000 m	0 m	-

during the 1970s. The speed of rise of this rocket-propelled mine is understood to be about 155 kt.

Targets are initially detected by a passive acoustic sensor and located by transmissions from an active acoustic sensor. If the target is confirmed as being within the vertical attack zone, the tether is cut and the rocket ignited. The fast upward speed allows very little time for the target to evade the device if its launch has been detected.

The RFAS also developed an Underwater Electric Potential (UEP) mine. Nothing is known about this mine, except that the firing mechanism operates by detecting the electrical field generated by a target.

It is possible also that the RFAS has developed a mobile mine similar to those used by the US Navy. Mobile mines are attached to torpedoes, making it possible for a submarine to lay a mine at a distance from the location where the mine is released into the water.

Nuclear mines

The RFAS is believed to have a small stockpile of nuclear mines with yields ranging between 5 and 20 kT for use against high-value surface units and base targets. Laying of these mines is almost certainly assigned to specially selected SSK/SSN units.

Operational Status

The following list is considered to typify inventories of some navies with whom the former Soviet Union was in close contact. However, many of these mines are obsolescent and may no longer be retained in inventories.
China: MYaM, M-08, M-12, M-16, M-26, M-KB, PLT-3, KMD, AMD
Egypt: MYaM, M-08, M-KB, KMD, AMD
Iran: MYaM, M-08, M-26(?),
Iraq: MYaM
North Korea: MYaM, M-08, M-12, M-26, M-KB, PLT-3, KMD, AMD
Libya: MYaM
Poland: KMD, AMD
Russia: MYaM, M-08, M-12, M-16, M-KB, M-AG, PLT-3, KMD, AMD, VEP, Cluster Bay, Cluster Gulf
Bulgaria: KMD, AMD

VERIFIED

MDM/UDM series

Type

Seabed mines.

Description

This family of seabed influence mines is designed for delivery from a wide range of platforms. The MDM-1 and MDM-6 variants are designed for laying from the torpedo tubes of submarines and surface ships, while the MDM-2 is designed for launching from surface ships. MDM-3 and MDM-5 are designed to be laid by aircraft. These mines differ from most normal air-launched mines in that the parachute is dispensed with, enabling the mine to be laid much more covertly and from a much lower altitude. While this is advantageous from the tactical point of view, it does give rise to severe technical design problems with regard to damage resulting from high-speed impact with the water, the possibility of ricochet, and the possibility of deep penetration of soft seabed. This is overcome by the use of soft stabilisers, which also help to ensure accuracy of placement.

The mines can either be fitted, or retrofitted with a remote control capability.

The MDM-1 features a two-channel influence exploder of the acoustic-magnetic type and conventional devices, a timing device and ship counter. It can be laid from surface ships with rails and stern ramps or from submarine torpedo tubes. Laying speed from surface ships is between 4 and 15 kt and from submarines 4 to 8 kt.

The MDM-2 is laid from surface ships at speeds of between 4 and 10 kt. It features a three-channel acoustic influence fuze and a set of protective and functional devices including a time delay, ship counter and self-destruct unit.

The MDM-3/5 are fitted with a three-channel fuze using acoustic, magnetic and pressure influences and carries a set of protective and functional devices as the MDM-2. All three mines are laid from air or surface vessel platforms and the MDM-3 is designed for use against surface vessels, while the MDM-4 and MDM-5 also have an anti-submarine capability down to depths of 125 m and 300 m respectively for which they are equipped with fin stablisers. The MDM-3 has a braking parachute.

The MDM 6 is basically an MDM-1 with a pressure sensor added to the acoustic/magnetic sensor combination.

The influence exploder in all versions has an operating radius of 50 to 60 m.

The MDM-3/4/5 were developed for export.

The variants for the Russian Navy are designated UDM-500 (MDM-3), UDM (MDM-4) and UDM-2 (MDM-5).

Operational status

According to unconfirmed reports the MDM-6 is to be deployed by the new Yasen class from its torpedo tubes.

Contractor

Dvigatel, St Petersburg.

UPDATED

Specifications MDM/UDM series

	MDM-1	MDM-2	MDM-3	MDM-4	MDM-5	MDM-6
Diameter	533 mm	790 mm	450 mm	630 mm	630 mm	533 mm
Length	2,860 mm	2,300 mm	1,580/1,530 mm	2,790/2,300 mm	3,060/2,400 mm	2,860 mm
Weight	1,120 kg	1,413 kg	525/635 kg	1,370/1,420 kg	1,500/1,470 kg	1,120 kg
Charge	960 kg	950 kg	300 kg	950 kg	1,350 kg	960 kg
Operating depth	12-120 m	12-125 m	15-35 m	15-125 m	15-300 m	12-120 m

MSHM

Type

Continental shelf mine.

Description

The MSHM is designed for use against submarines and surface ships in continental shelf waters at depths between 60 and 300 m. The weapon is fitted with an acoustic sensor which detects and identifies the target, establishes the course

and speed and computes the required intercept trajectory before the underwater rocket is fired. The rocket then homes on to the target using its acoustic homing device.

The mine is constructed with a double-casing with a large air gap in between. This effectively reduces the impact velocity performance of a penetrator by some 25 per cent. The mine can remain on the seabed for up to a year.

Specifications
Diameter: 533 mm
Length: 4,000 mm
Weight: 1,500 kg
Charge: 250 kg
Operating depth: 60-300 m

Contractor
Rosoboronexport, Moscow.

VERIFIED

PMK-1

Type
Underwater rocket-powered torpedo.

Description
Developed in the mid-1970s, the PMK-1 features a combined launcher and tethered rising mine based on a rocket-powered torpedo. Designed for attacking submarines, the onboard sensor and computer detects and identifies the target, establishes the course, depth and speed and computes the required intercept trajectory before activating the rocket motor. Detonation is achieved using a combined influence, contact and time fuze which operates either independently or in combination.

Specifications
Diameter: 533 mm
Length: 4,500 mm (torpedo)
7,830 mm (overall)
Weight: 1,850 kg
Warhead: 324 mm diameter
Charge: 350 kg HE
Speed: 30 or 60 kt
Operating depth: 200-400 m
Radius of action: 1,000-1,500 m

Contractor
Rosoboronexport, Moscow.

VERIFIED

SMDM series

Type
Self-propelled seabed mines.

Description
Developed in the 1970s from the MDS-1 self-propelled seabed mine, these mines are a development of the basic MDM seabed influence mine incorporating a dual magnetic/acoustic sensor, combining a mine into the body of a 53-65 KE torpedo. They are designed to be laid from submarines as defensive mine barriers in the entrances to naval bases, harbours and restricted waterways, forming part of an integrated defensive system with other weapons such as coastal defence guns, missiles and torpedoes.

The SMDM-1, after covert launch, travels up to a distance of about 10 n miles before descending to the seabed. The trajectory and distance are preset before launch and the weapon is believed to incorporate various devices such as timing circuits for activation/deactivation, counters, target identifying algorithms and so on. The mine module incorporates either a 3-channel (acoustic/magnetic/pressure) or 2-channel (acoustic/magnetic) influence exploder.

The SMDM-2 variant prototype is believed to have an extended range in the region of about 25 n miles based on the propulsion plant of a 650 mm torpedo.

Standard torpedoes can be adapted into SMDM.

Operational status
It is conjectured that Russia possesses a stock of up to hundreds of thousands of mines of various types.

Specifications
SMDM-1
Diameter: 533 mm
Length: 7,900 mm
Weight: 1,980 kg
Charge: 480 kg
Operating depth: 4-120 m

SMDM-2
Diameter: 650 mm
Length: 11,000 mm
Weight: 5,500 kg
Charge: 800 kg
Operating depth: 8-150 m

Contractor
Dvigatel, St Petersburg.

UPDATED

Serbia and Montenegro

M66

Type
Diversionary underwater mine.

Description
This virtually non-magnetic mine is designed for the destruction of vessels, harbour installations and other fixed offshore installations and in rivers and lakes. The weapon incorporates a pyrotechnical safety device which enables full safety in handling and preparation of the mine. Various clockwork fuze settings from a minimum of 20 minutes up to a maximum of 10 hours are possible. Fuze timing is set during weapon preparation. Once the mine has been attached to its target and the mine safety and pyrotechnical safety elements removed, the weapon cannot be removed from the target without risking detonation.

Specifications
Length: 670 mm
Diameter: 320 mm
Width: 430 mm
Weight: 50 kg
Charge: 27 kg TNT (approx)
Operating depth: 30 m

Contractor
Yugoimport SDPR, Belgrade.

VERIFIED

M70

Type
Influence seabed mine.

Description
The M70 acoustic/magnetic influence seabed mine is designed to destroy or seriously damage warships up to 5,000 tonnes and merchant ships up to 20,000 tonnes and over. Highly sensitive sensors and a large explosive charge make the weapon extremely effective and applicable for either offensive or defensive roles.

The mine can be laid from submarine torpedo tubes in depths suitable for anti-submarine (150 m) and anti-surface vessel (50 m) targets. Targets and laying depths can be preselected.

The detonating system comprises both mechanical and fully transistorised electrical devices using printed circuit board technology. The detonation system is compact, robust and resistant to vibration/shock and stable under any climatic conditions for long periods of time.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

Operational status
Held in inventories of Croatia and Yugoslavia, and possibly also Libya.

Specifications
Length: 2,823 mm
Diameter: 534.4 mm
Weight: 1,000 kg
Charge: 700 kg
Operating depth: 50-150 m

Contractor
Yugoimport SDPR, Belgrade.

VERIFIED

M71

Type
Limpet mine.

Description
The M71 limpet mine is designed for use against both ships and submarines. Detonation of the weapon is designed to rupture the underwater part of the hull plating. It is attached to the target by means of magnets and, to wooden structures, by special screws fitted on the mine.

The weapon is fitted with a time fuze and clockwork mechanism with time settings ranging from 0.5 to 10 hours and with anti-removal devices. Fuze activation is performed after the mine has been fixed to the target.

Specifications
Diameter: 345 mm
Height: 245 mm
Weight: 14 kg
Charge: 3 kg pressed TNT
Operating depth: 30 m

Contractor
Yugoimport SDPR, Belgrade.

VERIFIED

South Africa

Matrix

Type
Family of modular mines.

Description
The Matrix mine system, developed in the early 1980s, is a family of eight different multi-influence moored and seabed mines. Different configurations of mines can be made up using various combinations from a total of 13 available modules which include sensors (magnetic, acoustic, pressure and other sensors), warhead, sinkers, microprocessors and chain. The mines are said to incorporate a high level of intelligence and can be deployed from a variety of platforms including aircraft and helicopters. The mines are suitable for use against both submarines and surface vessels.

An air-launched version is fitted with a double parachute retarding system which pulls the weapon sharply into a near vertical descent just after release ensuring very accurate placement.

Operational status
The Matrix mines have been in production since 1987 and have been sold to a number of export customers. The Matrix 3S arms submarines of the South African Navy while an air-launched version arms Mirage F.1s of an overseas force.

Contractors
Northbend Underwater Systems (Pty) Ltd, Capetown.

VERIFIED

Samcon 600

Type
Multi-influence mine.

Description
The Samcon 600 mine has been developed by a consortium of South African defence companies primarily for deployment in defensive barrier fields once a situation begins to rapidly deteriorate towards hostilities. The mine can be laid by a variety of platforms including aircraft, surface vessel, submarine (from 533 and 555 mm diameter torpedo tubes) or from midget submarine using an external launch system and requires less than 20 minutes to prepare for launching.

The complete system comprises a multi-influence mine (acoustic/magnetic/pressure with optional seismic sensor) that can accommodate three sizes of underwater charge (600, 400 or 200 kg), a computerised maintenance and support system and an optional underwater intelligence centre. The mine is effective against surface targets in water depths of 60 m and against submarine targets to a depth of 150 m.

The mines are fitted with programmable intelligent on-board computers that can analyse all the parameters that characterise the signature of naval vessels.

The firing algorithms are software programmable, and can be adapted by the user navy to suit its changing needs.

The underwater intelligence centre provides full analysis of all the strategic, operational and tactical options, facilitates the planning of mine barriers, and is used to control the deployment of the mines when necessary.

The complete technical history of each individual mine can be tracked using the computerised maintenance system.

The total system comprises: combat, exercise and drill mines, maintenance test system and special tools.

Operational status
Developed in 1997.

Contractors
Denel (Naschem) (main contractor), Centurion.
Institute of Maritime Technology (IMT), Simons' Town (subcontractor).
Laingsdale Engineering (subcontractor).
Stelkon (subcontractor).

UPDATED

Spain

MILA-6B

Type
Naval limpet mine.

Description
MILA is a time-fuzed tactical underwater limpet mine that can also be used as a demolition charge.

The limpet mine can be attached to all kinds of underwater structures using either a method of magnetic or mechanical attachment.

The main features of the limpet mine are safe transport and handling, simple operating procedures, countermeasures to prevent removal from the target, enhanced robustness and high reliability and low maintenance.

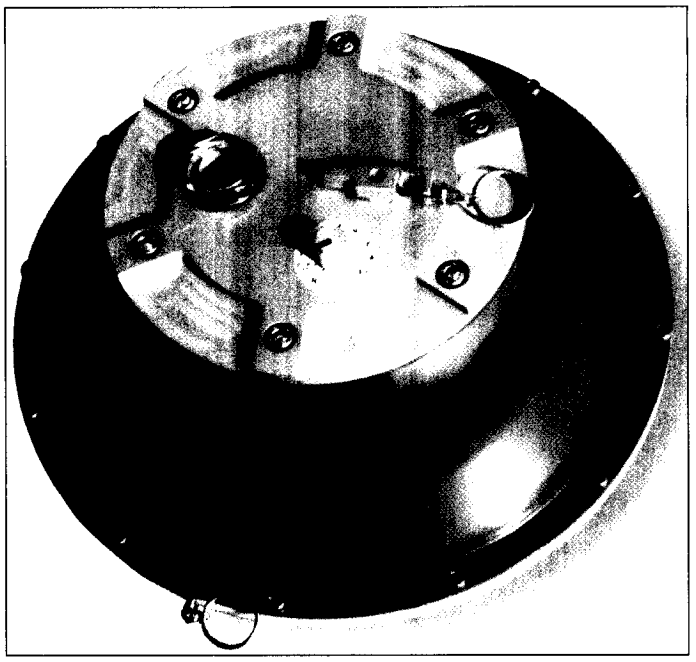
The device consists of two main subassemblies. The upper assembly houses the electronic fuze and arming device, while the main section contains the relevant hardware for attaching the mine to its target, the explosive charge and an anti-removal device.

MILA incorporates a large number of safety devices covering transportation and arming. Arming safety methods include explosive train out of line, unpowered firing circuit and detonator short circuit.

A built-in test function enables testing the mine without requiring disassembly. A MILA Exercise Version (MEV) is available for operator training (above and underwater).



A Mila-6B limpet mine (SAES) 0097503



A Mila-6B limpet mine (SAES) 0024774

Operational status
In production and in service with the Spanish Navy since 2000.

Specifications
Height: 150 mm
Diameter: 350 mm
Weight: 6.5 kg (air) 0.5 kg (water)
Fuze delay: up to 72 h (programmable)
Operating depth: down to 40 m

Contractor
SAES, Cartagena.

VERIFIED

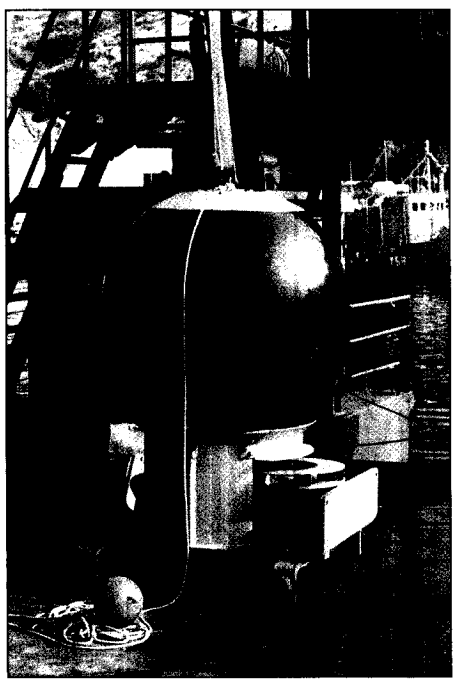
MO-90

Type
Moored influence mine.

Description
Developed by SAES in close co-operation with the Spanish Navy, the MO-90 moored mine is an intelligent, multi-influence mine designed for use against submarines or surface ships. It is designed for 25 years' shelf life with up to two years in-water life.

The mine consists of a GRP buoy which contains the sensors, target detection device, safety and arming device, and the explosive charge. The sinker and reel containing Kevlar mooring rope also form part of the mine. More than 10 parameters of the mine can be programmed into the weapon's computer just before launch without opening the casing. Among the features incorporated in the design are anti-minesweeping countermeasures. The depth setting mechanism of the buoy is claimed to be extremely accurate, being in the region of ±1 m.

Said to have a lethal range of 40 m.



Moored mine MO-90

Operational status
In production and in service with the Spanish Navy since 1992.

Specifications
Length: 1,180 mm
Width: 1,090 mm
Height: 1,690 mm
Weight: 1,060 kg
Charge: 300 kg HBX-3
Buoy depth setting: 5-340 m

Contractor
SAES, Cartagena.

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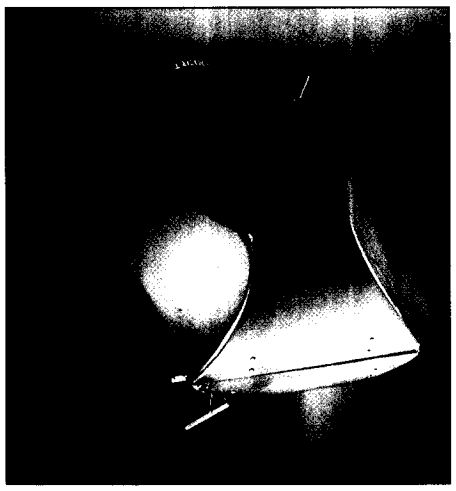
Sweden

BGM 100 (Rockan)

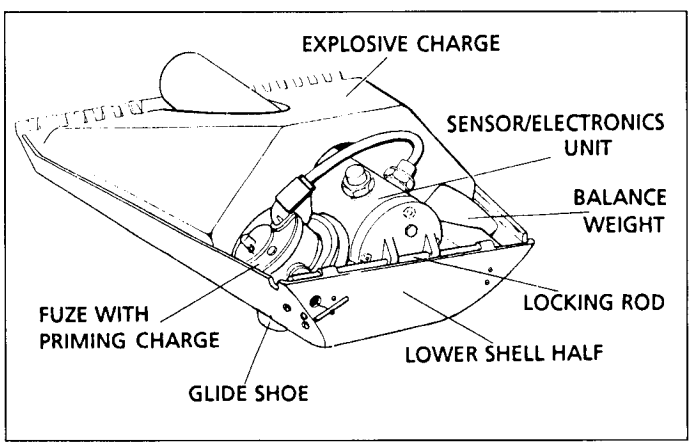
Type
Anti-invasion ground influence mine.

Description
Developed early in the 1980s this ground influence (magnetic/acoustic) mine is intended for use as an anti-invasion deterrent against small and medium tonnage vessels in coastal waters, inlets, and confined waters such as harbours. It may also be deployed in deeper waters against submarines to protect friendly routes and bases. A feature of the design is a shape which enables minelaying over a wide area while the minelayer covers the minimum distance. This is achieved by shaping the mine in a casing that enables it to plane or glide in the water for a distance of up to twice the depth of the water it is being laid in. This also enables mines to be planted in pairs from each side of the ship, or for mines to be spread out directly from the quay.

Another advantage of this wedge shape is its low profile, which makes it difficult to detect by minehunting sonars and other anti-mine techniques. The mine is



After resting on the seabed for a time the Rockan ground mine becomes very difficult to detect both visually and by minehunting sonar



Schematic of BGM100 (Bofors Underwater Systems AB) 0099759

constructed of an outer shell of reinforced plastic coated with anechoic coatings and containing an explosive charge, a magnetic/acoustic fuze with arming unit, and a sensor/electronic unit. The outer shell has sliding runners to enable the mine to be moved on a mine rail, orientated either along or across the rails. The shell can be opened easily for maintenance or for adjustments and so on. New multisensors and SAI units have been developed.

Operational status
Production completed.

Specifications
Length: 1,015 mm
Width: 800 mm
Height: 385 mm
Weight: 190 kg
Charge: 105 kg
Operating depth: 5-100 m
Glide coefficient: 2
Glide speed: 2 m/s (approx)
Min distance between mines: 25 m

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED

BGM 600

Type
Cable controlled multi-influence mine.

Development
The BGM 600 advanced cable controlled mine was developed in the 1980s for the Swedish Coastal Artillery's amphibious battalions to provide an efficient and rapid means of deploying a controlled minefield, featuring on/off arming capabilities which enable a navy's own forces to pass over the minefield in safety for rapid deployment.

Description
The BGM 600 is designed for remote control using a slim, flexible cable and the entire mine and cable system can be deployed at high speed. When required it may also be used in autonomous mode without cables.

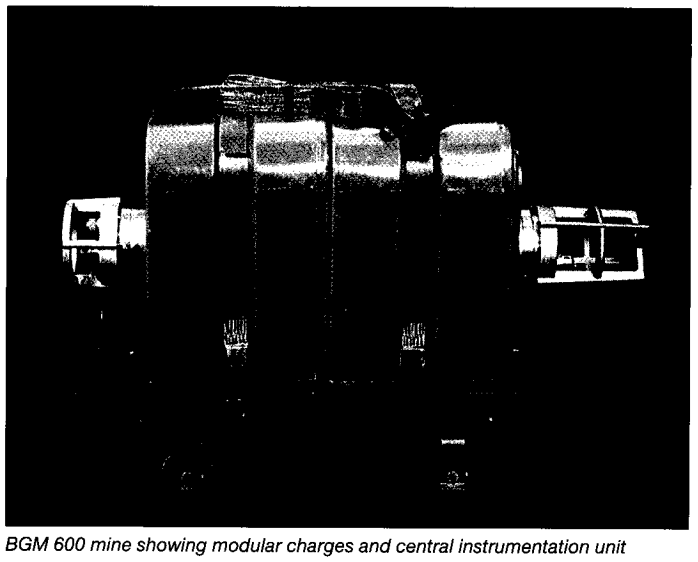
The mine features a modular main charge consisting of two, three or four charge modules each containing over 100 kg of high explosive and a central instrumentation tube containing the sensors and control electronics. The sensor package can be programmed for a specific target. The micro-processor controlled sensors include autonomous or controlled detonator modes, with input from mulitple sensors in either a stand-alone mode or a combination of both. The bottom plate may optionally be fitted with wheels to enable it to be handled on mine rails. The electronics include a multisensor system and advanced signal processors which are programmable for different targets, the sensitivity being changed from the shore base. The mine is capable of operating in different environments and against different target characteristics, and can be upgraded and reprogrammed.

Operational status
Developed for the Swedish Coastal Artillery and in full production.

Specifications
Length: 1,700 mm (max)
Width: 600 mm (max)
Height: 700 mm (max)
Weight: 700 kg (max) (approx)
Charge: 2, 3 or 4 modules each containing over 100 kg explosive
Sensors: multiple sensors defined by customer

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED



BGM 600 mine showing modular charges and central instrumentation unit

BGM 601 (Bunny)

Type
Ground influence mine.

Development
Development ended in May 1990 and was followed by a production contract.

Description
The BGM 601 ground influence mine has been developed as part of a new submarine weapon which will be carried in a mine girdle attached to the outer hull of submarines. The mine will also be able to be launched from any type of surface ship.

The mine incorporates a buoyant upper section which gives the weapon an underwater weight of 200 kg. Against surface targets the mine will have an operating range of 40 to 50 m but can be laid in deeper water down to 150 m for deployment against submarines.

The mine is fitted with the CelsiusTech 9SP 180 programmable naval mine sensor unit, which incorporates multiple sensors using sophisticated logic, making it resistant to countermeasures. It will be able to discriminate specific types of target and initiate detonation at the lethal range for that particular target. The sensor unit is powered by a lithium battery pack and/or external power source. The sensor unit can remain in water for up to 12 months. The PCHS-1 combined hydro-sensor unit senses depth, dynamic pressure and sound in separate channels, while the three-axis magnetometer measures variations from the locally determined magnetic field. The measured signals are filtered and evaluated against preprogrammed criteria by the microprocessor. The logics unit reports the evaluation result through a standard electrical interface to the firing device or corresponding unit in non-mine applications. The sensor unit can also be retrofitted to existing mines.

The volume of explosive carried is 400 litres.

A moored version of the mine has been successfully tested for submarine deployment.

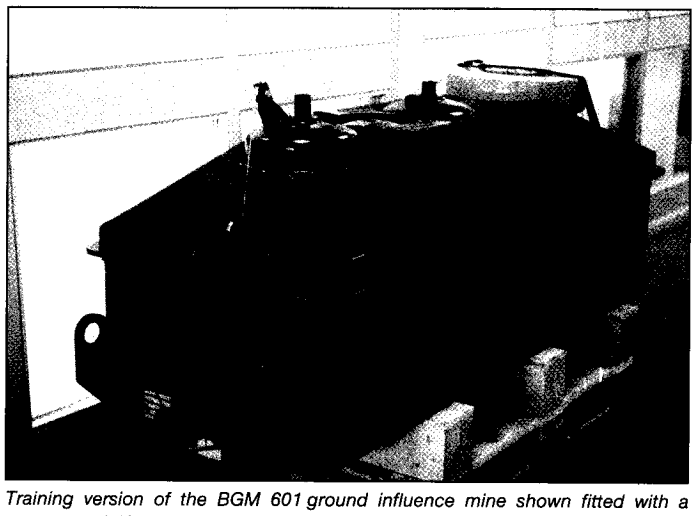
The exercise variant VEM 90 can be both active and passive and is equipped for all types of training from laying to simulation of hostile attack.

Operational status
Production completed.

Specifications
Length: 2,000 mm (approx)
Width: 750 mm (approx)
Height: 750 mm (approx)
Total weight: 800 kg (approx)
Sinker weight: 240 kg
Charge: 80 kg
Bottom depth range: 20-200 m
Mine depth range: 8-75 m
Min distance between mines: 25 m

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED



Training version of the BGM 601 ground influence mine shown fitted with a recovery unit (Anchor Consultancy Photo Library)

BMM 80

Type
Moored influence mine.

Description
Developed in the early 1980s, this influence mine is designed for use against small and medium tonnage surface ships and submarines. It is suitable for laying in water 20 to 200 m deep. The mine itself consists of a buoyancy section of cellular plastic, which also contains the explosive charge, the fuze and the sensor/electronics package (which is similar to that of the BGM 100, but adapted to the moored mine role).

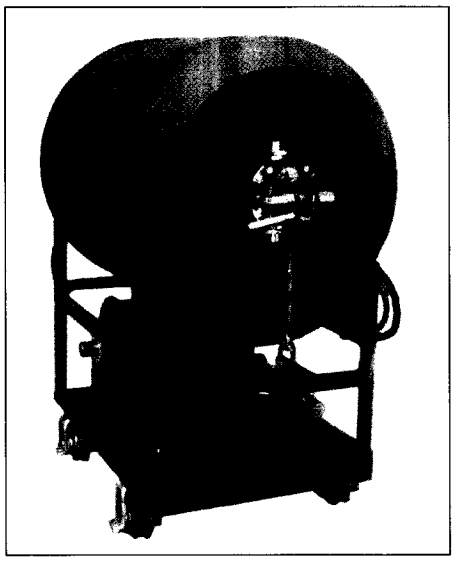
The BMM 80 is programmed to anchor itself automatically at the desired depth, which can be set before sinking. A sinker unit is employed with the BMM 80 and the mine can be laid from rails.

Operational status
Production completed.

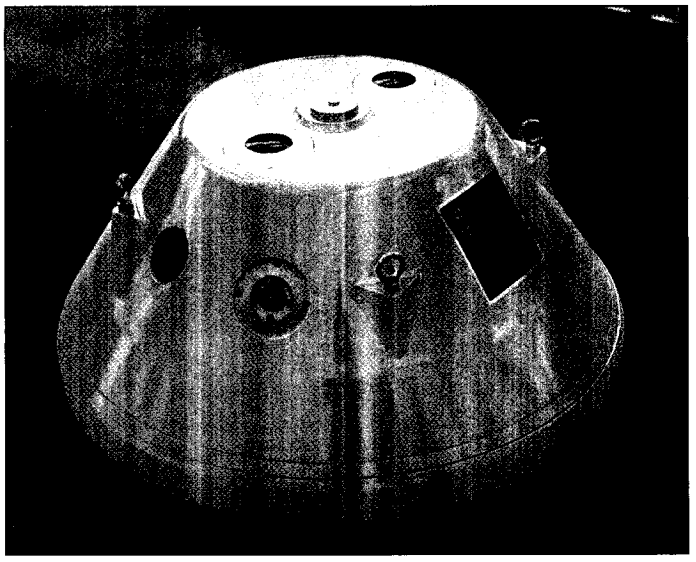
Specifications
Length: 1,125 mm
Width: 660 mm
Height: 1,125 mm
Total weight: 450 kg
Sinker weight: 240 kg
Charge: 80 kg Hexotonal
Operating depth : 20-200 m
Mine depth range: 8-75 m
Min distance between mines: 25 m

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED



BMM 80 mine on launching trolley



VEM Type S – the low-profile VEM (Anchor Consultancy Photo Library)

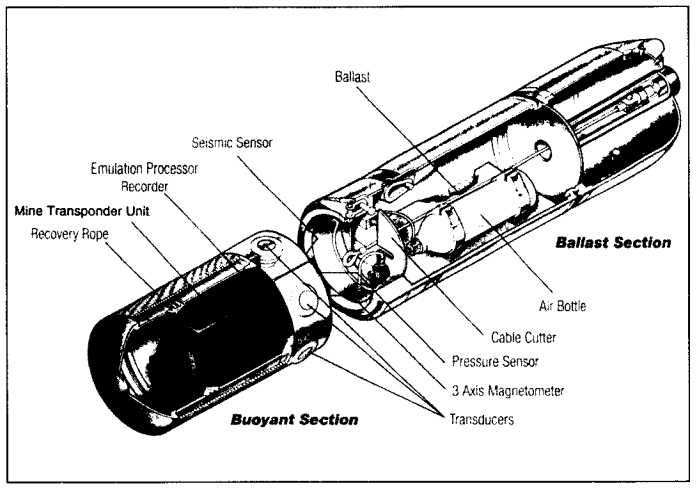


Diagram of the standard Versatile Exercise Mine System (VEMS) ground mine variant

United Kingdom

Advanced Versatile Exercise Mine System (VEMS)

Type
Exercise ground and buoyant mines.

Description
The Advanced Versatile Exercise Mine System (Advanced VEMS) is designed for training and for assessment of the effectiveness of mine countermeasures equipment and tactics. The Advanced version has much greater capability than the original system with a wider range of sensors, improved processing capability and a much larger data recording capacity. With its improved sensors and signal processor, it provides a system which can emulate the firing characteristics of the most sophisticated ground mines currently available. The enhanced underwater acoustic link is used to signal mine fires, to measure ship to VEM range and to command release. The Advanced version can also transmit recorded data while laid and permits change of emulations during exercises.

The VEM is available in a variety of forms: the standard generic ground mine, moored buoyant mine and in stealth mine shapes. It is capable of processing target acoustic and seismic influences, three independent magnetic axes (plus rate of change and total field) and pressure influences. An electric field sensor, capable of detecting static and alternating fields is also available. The processor uses digital signal processing techniques to implement spectral analysis of acoustic and seismic signals. This permits accurate programming of frequency response to emulate all threat mine types including those which have a resonant response. Raw spectral data is also recorded for detailed analysis. The system can store and execute multiple emulations and these can be selected during an exercise by means of the acoustic link system. The incorporation of improved memory devices has led to a major increase in stored data capacity during exercise and the use of a low power design has led to a longer operational life.

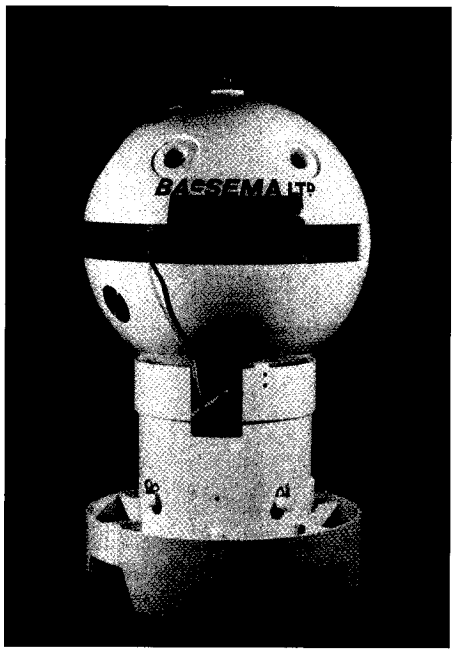
The VEMs can be programmed with up to 30 mine emulation programs simultaneously. Programs can be selected either according to preprogrammed times or by acoustic command.

The ship transponder system is used on the exercise vessel for two-way communication between the ship and exercise mines. When a mine 'fires', coded acoustic signals are transmitted which are detected by the shipborne transducer. This transmits the information to the Exercise Support Unit (ESU) in the ship's Operations Room which signals an alarm and displays mine identity and range. Data recorded in the mine during the exercise can be transmitted back to the ship to permit 'quick look' analysis during the exercise. The acoustic link system can interrogate mine status and is also capable of surveying VEM positions and of acoustically tracking the ship relative to the VEMS. Each VEM can also be programmed to signal additional events, such as individual influence channel detections and ship counts.

The ESU is a ruggedised laptop computer which can be used on shore, on the deck of the vessel or in the ship's Operations Room. It is used to prepare mine programs and to download those programs into the VEM before laying. During an exercise the ESU is connected to the shipborne transducer via a ship transponder unit in the Operations Room and is used to control the VEMS acoustic link. After the mine has been recovered the ESU is used to download data recorded in the mine via an umbilical cable. The analysis facility of the ESU allows an MCM exercise to be analysed in detail in order to provide an assessment of the MCM performance and risk, and threat to target vessels.

Improvements for applications in the minehunting role currently in development include: fitting of a Sonar Insonification Detector (SID); provision of anechoic jackets to vary the target strength of VEMS; and reconfiguration of VEM sensors, processor and transponder into threat mine shapes to provide more realistic sonar targets during classification and identification operations.

The SID is used to detect minehunting sonars. It records the amplitude, frequency and duration of insonification for subsequent exercise analysis. The mine response simulation software package predicts the actuation envelope of a mine against a specified ship's signature. This allows the exercise planner to adjust the sensitivity so as to match the actuation envelope to the damage range for an exercise target.



Buoyant VEM Type B

Enhancements can also be provided to allow use of the system as a mobile multi-influence range. These include an item umbilical cable, additional sensors and a full suite of influence analysis and modelling software. In this role, VEMS can provide many influence range configurations, from a fixed semi-permanent range to an onboard self-check facility. Advanced VEM can also be fitted with an Electric Field Sensor (EFS). This is a broadband three-axis sensor capable of detecting the static and alternating electric field signatures of vessels. The unit is fitted to the end of the buoyant section of the VEM.

Displayed for the first time in October 1994 was a stealth variant, designed to have a low sonar signature representative of a number of currently available warshot mines. Known as VEM Type S (low-profile VEM) it features a 'dumb' shape for use in simple minehunting sonar exercises or as a fully equipped variant with a full range of influence sensors and VEM electronics. Standard sensors include acoustic and magnetic, while seismic, pressure and electric field sensors are available as options. The case consists of two sections: a ballast section containing release units and a recovery line, and a buoyant section with sensors and electronics.

Mines supplied to the Canadian Navy are provided with innovative anechoic jackets which enable the target strength of the mines to be varied. Also incorporated are modifications to allow the recording of diver influences coupled with a diver warning device which further enhances the training provided to explosive ordnance disposal divers.

Operational status
VEMS is currently in production and in service with the Royal Navy, the US Navy and the Royal Thai Navy. Current orders will make the US Navy the largest operator of the VEM. VEMS is also operated by the Royal Saudi Navy the Belgian and Canadian navies.

The UK MoD has also acquired 11 VEMS in two variants. One is the VEMS Mk II for simulation of deep-water threats, and the other the VEMS Type S to simulate low-profile seabed mines typically found in shallow water conditions.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

Limpet mines and Underwater Timers

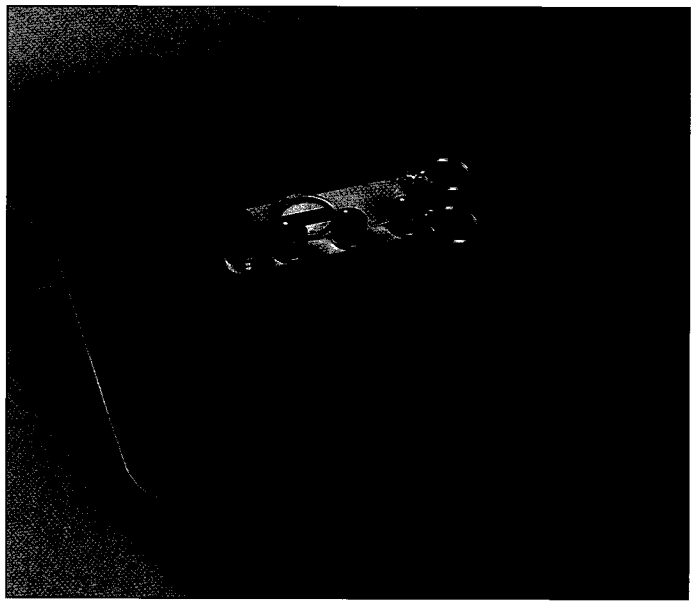
Type
Underwater demolition devices and exercise/training variants.

Description
British Aerospace Defence Systems produce a family of naval limpet mines which includes live mines and training mines which are in service with naval, army and special forces throughout the world.

The live limpet mine contains a modular plastic explosive charge and is equipped with electronic timer, manual override and anti-tamper features, a safety and arming system, built into a modular self-contained timer unit. A firing delay of up to 24 hours can be set. Explosive charge options range from 1 to 6 kg. Slave explosive units, attached by special couplers, are available to increase explosive power.

Magnetic and strap attachment methods are standard and other options are available. Inbuilt buoyancy is standard. The training mine is equipped with a high-intensity light to simulate detonation.

The electronic timer is also available separately for underwater demolition operations.



Limpet mine variant 0007237



Limpet mine 0007236

Operational status
Range of variants in service with navies worldwide, including the UK Royal Navy.

Contractors
AMS, New Malden, Surrey.

UPDATED

LNS4-3 magnetic sensor

Type
Three-axis magnetic anomaly detector.

Description
The LNS4-3 is a three-axis fluxgate magnetic sensor which detects small magnetic anomalies or measures low-frequency magnetic fields. Although designed primarily for use in sea mines, other applications include geophysical surveys, surveillance, security screening, and monitoring for unwanted ferrous matter. The salient feature of the LNS4-3 is that it incorporates a reset facility, which provides a fast setting time of the magnetometer directly after the detection of a magnetic anomaly, thus enabling multiple target detection.

LNS4-3 can detect magnetic anomalies as low as 2.4 nT in the earth's static field and requires less than 5 mW of power from a ±5 V DC supply. Two low-impedance outputs are provided for each axis; one is AC coupled and the other is DC coupled. Both outputs are suitable for interfacing directly to a multiplexer and an analogue to digital converter. The device is compact (100 × 690 × 46 mm), robust, totally self-contained and encapsulated. Reliability is quoted as 300,000 h MTBF.

Operational status
In service.

Contractor
Ultra Electronics, PMES Hednesford, Cannock, Staffordshire.

UPDATED

Mk 5 Enclosed Mine Lift Bag

Type
Automated enclosed mine lift bag.

Development
In mine clearance operations it is not always possible to dispose of unexploded ordnance in the position where it is found. For safety reasons, therefore, it is essential that a means of remotely lifting ordnance from the seabed for removal to a suitable area, together with means of lowering the ordnance in a controlled manner for disposal is available.

Standard lifting bags are a lightweight low cost means of lifting unexploded underwater ordnance. The ability to inflate a bag on site from an integral compressed air supply provides a versatile method of lifting that is widely accepted in EOD diving operations. However, a limitation of standard lifting bags is the tendency to accelerate towards the surface out of control. This can result in the dumping of gas at the surface and the unexploded ordnance rapidly descending to the seabed with potentially disastrous consequences. Conversely, if an air filled lifting bag starts to sink its volume decreases with increasing hydrostatic pressure, the lift forces reduce and the rate of descent rapidly increases resulting in unexploded ordnance landing uncontrolled onto the seabed, again with potentially serious consequences.

The Mk 5 Automated Enclosed Mine Lift Bag (EMLB) is a further development of the operationally proven Mk 4 system that is in-service with various NATO Navies,

Description
The function of the Mk 5 EMLB is to provide a safe and reliable means of remotely lifting ordnance up to 1,000 kg from depths down to 80 m by providing a programmable inflation delay of up to 45 days and a unique microprocessor controlled ascent and descent rate capability.

Encompassing all the unique capabilities of the earlier Mk 4 EMLB, the new Mk 5 version incorporates lightweight 300 bar composite cylinders resulting in significant savings in both weight and size. Two versions of the Mk 5 EMLB are available, one with a lifting bag of 500 kg capacity and one with a lifting bag of 1,000 kg capacity.

Each consists of two main assemblies:
- Lifting bag assembly with integral valise
- Cylinder pack and time control unit

Operation of the EMLB requires the cylinder pack (with charged cylinders suitably configured for the proposed lift) and the timer/controller unit to be attached to the lifting bag assembly. Once the actuation delay period has been set on the surface using the remote setting control box, the assembly is deployed in the water and positioned for attachment to the item to be lifted.

When the EMLB has been attached by the two lifting straps, or if preferred rearranging the two straps to form a single point, the two quick release plastic buckles on the lifting bag that secure the valise are released and the ascent arming pin is removed from the timer/controller unit. Actuation then occurs after the preset delay period. The lifting bag is inflated by the opening of the solenoid valve in 10 kg bursts in conjunction with a microprocessor controlled pneumatically operated dump valve to give a controlled ascent rate of 2 ±0.5 m per second.

Similarly, when the EMLB is on the surface, it may be used to lower an item at a controlled rate of descent. This is achieved by removing the descent-arming pin adjacent to the pneumatic dump valve at the top of the inflated lifting bag. Actuation then occurs after a five-minute delay period; the pneumatic dump valve is opened to deflate the lifting bag to give a controlled decent rate of 2 ±0.5 m per second.

The 500 kg and 1,000 kg versions of EMLB are essentially the same, the differences being in the size of the lifting bag and the number of cylinders in the cylinder pack.

The optional Tidal Lift Kit may be used with the 500 kg EMLB, or with the 1,000 kg EMLB in two cylinder configuration, to enable the delayed inflation unit to be separated from the lifting bag assembly enabling remote lifting from a beach on a rising tide. The Tidal Lift Kit consists of the following:

1. A 5 m long sheathed 'umbilical' containing:
- 'Intelligent' six pin electrical cable
- Inflate air hose
- Dump valve air hose

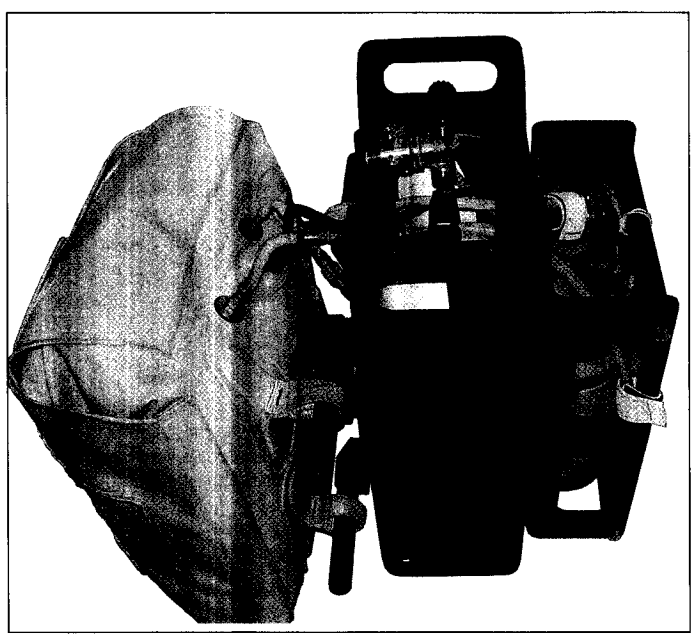
2. Pair of buoyancy blocks for attachment to the carrier frame of the delayed inflation unit

3. Pair of webbing straps to attach the buoyancy blocks to the carrier frame of the delayed inflation unit

Operational status
The EMLB is a thoroughly proven system that is in service with the UK Royal Navy Mine Clearance Diving Branch and other NATO Navies.

Contractor
Divex Ltd, Aberdeen.

NEW ENTRY



Two cylinder pack with 500 kg lift bag (stowed) and microprocessor module (Divex)
NEW/1067193

Stonefish

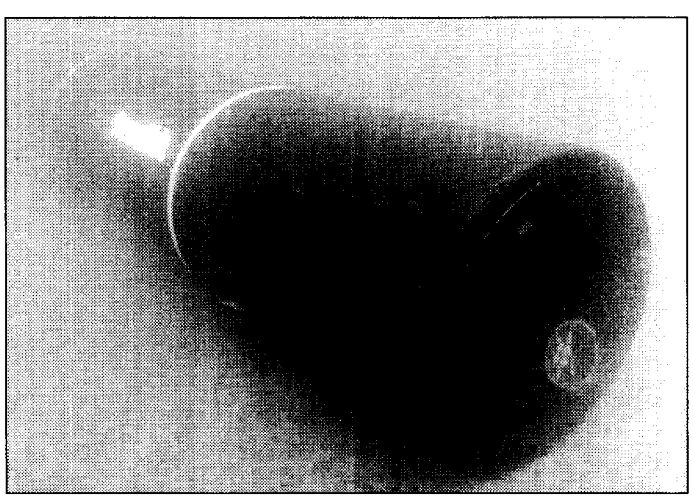
Type
Surface, air, submarine-launched ground influence mine.

Description
The modular Stonefish mine is composed of three sections: warhead (live or inert), launching system and electronics pack. The cylindrical device features a flat nose cap and bell-shaped tail assembly. The warstock variants are provided with an advanced design polymer bonded explosive (PBX) warhead. Two sizes of warhead are available (100 kg and 300 kg) and these are coupled together in various combinations to form a complete warhead unit of 100, 200, 300, 400, 500 or 600 kg. The warhead, together with the appropriate launch kit and a standard tail unit containing the sensors, signal conditioning and processor package, can be configured to cover the range of launch vehicles, depths and targets available. The basic sensor pack comprises acoustic, magnetic and pressure sensors. The signal processing includes signal conditioning and information processing, the setting of thresholds, mine logic and sterilisation delay times. The mine programme can be modified by means of a portable presetter, changing threat and operational conditions before the mine is deployed. Different sizes of warhead can be fitted according to water depths, minefield pattern and expected target size.

The Stonefish warstock versions have a storage life of over 20 years and an in-water or laid life of over 700 days. They are intended to be laid at depths of between 10 and 90 m for surface targets and down to depths of 200 m for submarine targets. The refurbishment life for stored warstock weapons is nominally six years. To provide training in mine countermeasures, Stonefish is available as an exercise variant.

The B2211D explosive charge in the mine was developed by SNPE of France. The explosive is claimed to have a 15-20 per cent increase in shock wave energy and 20-35 per cent greater bubble energy compared with conventional explosives.

The exercise variant is capable of assessing minehunting and minesweeping effectiveness in its true environment. When laid it is available for data gathering relevant for target selection, together with a facility to emulate known mine characteristics. The main features are:
- command activated recovery system
- acoustic command system, enabling mine states to be interrogated or changed
- digital signal processing and large solid-state data store
- it is available as cable controlled or a seabed test platform for sensor/processing development.



Stonefish mine

Specifications Stonefish

	Mk II Warstock mine	Exercise mine	Assessment mine
Length	2,500 mm	1,912 mm	506 mm
Diameter	533 mm	520 mm	530 mm
Weight	990 kg	440 kg	120 kg
Warhead	600 kg B22IID PBX (max)	inert	
Operating depth	10-200 m	10-200 m	

Using the command link the exercise variant can accurately measure target range, change its operational status and recover itself, even if buried in deep mud on the seabed, by means of an inflatable flotation collar.

It can be refurbished at sea and recharged within 4 hours ready for relaunch.

The assessment variant is used to gather mine and target data for use by the tactical planner so that the optimum minefield can be planned. The variant uses a modified version of the warstock version's electronics system and is connected by underwater cable to a shore-based computer.

The training variant is inert but can accept all the available equipment options to facilitate classroom instruction, handling, programming and test trials.

Mines of the Stonefish family are up to 2.5 m in length, with a diameter of 533 mm and all-up weight varying up to 770 kg depending on configuration.

The Stonefish presetter, designed as a self-contained unit, employs a microprocessor and incorporates built-in data checking during input and automatic test facilities.

The air launching equipment comprises a frangible housing covering a hydrodynamic shaped slanted nose which ensures the mine maintains trajectory as it sinks to the seabed. The tail unit incorporates the parachute descent retarding device.

The modular concept enables variants to be assembled to meet any tactical, exercise or training requirement.

Operational status
In production and in service with UK forces. Orders for the exercise variant of Stonefish have been received from the Royal Australian Navy and warstock units have been sold to Finland and Pakistan. Assessment mines are in service with six countries. A Mk III variant was offered to the Commonwealth of Australia under Joint Project 2045 (see Stonefish Mk III entry).

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

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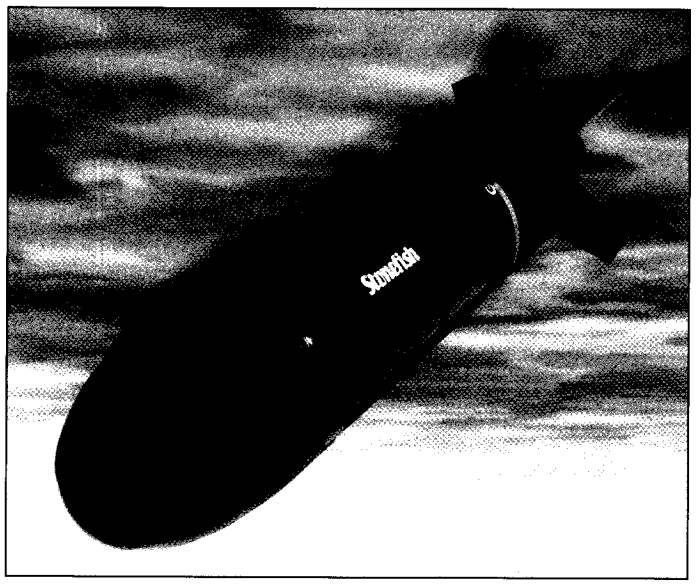
Stonefish Mk III

Type
Surface-, air-, submarine-launched ground influence mine.

Development
The Mk III Stonefish mine was developed to meet Australian requirements for Project 2045.

Description
The Stonefish Mk III mining system features a single mine type for air, surface and submarine deployment and role kits are used to readily adapt the warshot variant to each laying platform.

The fully digital Stonefish Mk III retains only the body casing and warhead of the earlier version. The air-launched version incorporates a frangible housing to cover the hydrodynamically shaped slanted nose to achieve the correct attitude angle for water entry and descent to the seabed. The tail unit ensures aerodynamic stability and incorporates a retarding parachute. The mine incorporates a universal Target Detection Device (TDD), Safety and Arming Unit (SAU) and Programming and Analysis Unit (PAU) for all three deployments. Its multisensor TDD allows programming flexibility that will cater for the widest range of mine warfare scenarios.



Air-launched version of the Stonefish MK III (BAE Systems) 0089551

The Stonefish Mk III open architecture TDD incorporates advanced sensor conditioning functions for the acoustic, magnetic and pressure sensors which allows the weapon to discriminate between targets and other contacts. A single warshot mine can simultaneously target several vessel types, thus increasing minefield effectiveness.

Use of frequency domain analysis techniques enables the Stonefish Mk III TDD to discriminate between target and non-target signatures, making it highly resistant to mine countermeasures.

The lethality of the warshot variant's sensitive munition warhead provides an increase of 15 to 20 per cent in shock wave and 20 to 35 per cent in bubble energy compared with conventional explosives.

The training variant can be programmed to simulate the performance of many different mine types and its physical characteristics are closely matched to the warshot variant to ensure identical carriage, release and trajectory behaviours.

Essentially similar role kits for air, submarine and surface launch offer significant operational and logistical benefits in addition to exercise realism.

The low-cost Stonefish Mk III exercise variant is a single inert store designed to be used for training in handling, transportation and preparation of the warshot variant. In conjunction with the training mine it ensures the best operational effectiveness from the Stonefish system.

Key features of the Stonefish Mk III mining system are:

- Deployable by submarine, surface and air.
- Training mine can be remotely programmed through the water using an acoustic communication system.
- Safety and Arming Unit (SAU) is designed to be fail-safe and employs the latest fuze technology with an exploding foil initiator.
- System commonality offers major operational, logistical and cost benefits to operators.
- Twenty-year shelf life with a design target for preventative maintenance of 12-15 years.

Operational status
Selected to meet requirement for Project 2045 for the Australian defence forces, but the project has been cancelled.

Specifications
Length: 1,821 mm
Diameter: 533 mm
Weight: 755 kg
Charge: 500 kg PBX

Contractor
BAE Systems, Underwater Weapons Division, Waterlooville, Hampshire.

UPDATED

United States

LSM

Type
Littoral sea mine.

Development
The Naval and Maritime Integrated Systems division of the Raytheon Company and the US Naval Coastal Systems Station, Panama City, Florida, under a technology demonstration project sponsored by the US Office of Naval Research, is jointly developing the LSM. The project is being run under a three-year programme that began in March 1999.

The aim of the LSM project is to develop a weapon that will achieve battlespace dominance in the littoral region, project power and provide crisis response via a controllable wide-area littoral sea denial system.

Description
The LSM, which can be delivered by air, surface or submarine platform, is a wide-area mine concept comprising three elements:

- a target detection system
- an encapsulated mobile homing warhead based on the Mk 54 homing torpedo
- a remote control subsystem.

The target detection system will provide detection, localisation and tracking of targets in the littoral until they come within lethal range of the Mk 54 torpedo. Passive LF acoustic and non-acoustic sensor arrays in the bottom of the mine will process target signature data and initiate transition to the active acoustic verification mode. The HF active transmit/receive sonar in the top of the mine will transmit low probability of target alertment pulses to make multiple range and bearing measurements until a target track converges with sufficient quality to verify that the target is within the mine's lethal range. Initial tests have shown that it is possible to detect slow, quiet surface ships and submarines out to ranges of 700 m.

The target detection system will then activate the encapsulated mobile homing warhead, pass targeting information to the vehicle and prepare it for launch.

The primary function of the encapsulated mobile homing warhead, is to deliver a bulk charge warhead from the mine's vertically deployed position, to within the mission abort damage range of the target and to detonate the warhead at the appropriate time. On emerging from its capsule the torpedo pitches over on to the target bearing and carries out a conventional torpedo engagement.

The remote control subsystem will provide the capability to control an LSM field from the surface, air or submarine platform. By using communication links between mines to pass targeting data, the minefield can use far fewer weapons than a standard minefield.

An underwater acoustic modem that communicates with low probability of intercept transmissions to either buoyed surface modems with RF uplink receiver/transmitters, submarines or UUVs with underwater modems, will be incorporated into the top of the LSM. The functions of the remote control subsystem will include turn on/off with confirmation, auto turn off after preset time delay and command sterilisation for recovery, or to allow the passage of friendly forces.

The weapon will operate in depths between 45 and 182 m and rests on the seabed with the encapsulated torpedo in the vertical position.

Operational status
Science and technology demonstration programme ongoing.

Contractors
Raytheon Company, Naval & Maritime Integrated Systems , Portsmouth, Rhode Island.
Naval Coastal Systems Station, Panama City, Florida.

UPDATED

Mk 56

Type
Seabed mine.

Description
The current stock of sea mines consists of the Mk 56 (the Mk 52, 55, and 57 having been withdrawn from service). The sensitivity enables the mine to react to a submarine proceeding at 3 kt. The Mk 56 embodies a target counter (up to 30) and a preset arming delay ranging from one hour to 90 days. The Mk 56 features a stainless steel casing and was specifically designed for use against high-speed, deep diving submarines. The mine is fitted with a nose fairing and box fins to ensure a stable attitude during flight.

Operational status
Developed in 1948, these mines were used extensively in the Vietnam War and this family of mines is now obsolete, although a number may still remain in the US inventory. The Mk 52 was also manufactured in Germany.

The Mk 56 first became operational in 1966. All mines in these categories except the Mk 56 have been completely removed from the inventory but some may remain in storage for emergency use. The Mk 56 is also being removed from the operational inventory.

Specifications
Type: Mk 56 Mod 0, aircraft-laid moored mine
Length: 2,900 mm
Diameter: 570 mm
Weight: 909 kg
Charge: 164 kg HBX-3
Operating depth: 366 m
Actuation: total field, dual-channel magnetic, acoustic/magnetic

UPDATED

Mk 62, 63, 64 and 65 Quickstrike series

Type
Air-launched seabed mines.

Description
The Quickstrike seabed mine development programme, initiated in the early 1970s, embraced a family of mines based on modified general purpose bombs using different size cases but with common target detection and classification mechanisms. The four members of the Quickstrike family are the Mks 62, 63, 64 and 65. The last of these (Mk 65 Mod 0) is in the 2,000 lb (900 kg) class and is in full production by Aerojet TechSystems in Sacramento, California. The Mk 64 is also in the 2,000 lb (900 kg) class, based on a Mk 84 2,000 lb bomb.

Quickstrike mines are for shallow water deployment (to approximately 100 m) and targets have to approach to within a few hundred feet for it to act. The mines use existing Mk 80 series GP bomb cases as well as a new mine case. Quickstrike mines are deployed primarily by aircraft, but surface ships or submarines can also launch the weapons. Four types of Target Detection Device (TDD) are used: the TDD Mk 70 (magnetic/seismic fuze); TDD Mk 71 (pressure/magnetic/seismic fuze); and TDD Mk 57 (magnetic/seismic fuze) and TDD Mk 58 (magnetic/seismic/pressure fuze).

This family of mines is based primarily on conversion of existing ordnance (bombs and torpedoes). An exception is the Mk 65 mine (approved for service in 1983) which is not a bomb conversion. It has a thinner case than the equivalent bomb and contains the effective underwater PBX explosive. It is now available in a long-range version equipped with an on-board digital flight control and GPS navigation system. The Mk 65 has now been deployed with the US Navy and is in service with the Italian Navy being marketed by SEI.

Operational status
In service with US forces. It is reported that over 4,800 of these types of mine have been supplied to the US forces, in excess of 3,000 being of the Mk 65 type.

Specifications
Type: Mk 62, aircraft-laid seabed mine
Length: c 2,200 mm
Diameter: 273 mm
Weight: 227 kg
Charge: 89 kg H6 explosive
Fuze: TDD Mks 57, 58, 70 or 71
Operating Depth: 100 m
Actuation: magnetic and pressure

Type: Mk 63, aircraft-laid seabed mine
Length: c 3,000 mm
Diameter: 350 mm
Weight: 454 kg
Charge: 202 kg H6 explosive
Fuze: TDD Mks 57, 58, 70 or 71
Operating depth: 100 m
Actuation: magnetic and pressure

Type: Mk 64, aircraft-laid seabed mine
Length: 3,800 mm
Diameter: 460 mm
Weight: 908 kg
Charge: 429 kg H6 explosive
Fuze: TDD Mks 57, 48, 70 or 71
Operating depth: 100 m
Actuation: magnetic or magnetic/pressure

Type: Mk 65, submarine/aircraft-laid seabed mine
Length: 3,300 mm
Diameter: 740 mm
Weight: 1,177 kg
Charge: 908 kg PBX 103
Fuze: TDD Mk 57 or 58
Operating depth: 100 m
Stand-off range: >50 n miles (max)
Actuation: magnetic and pressure and combined magnetic/pressure

Contractor
Sensytech Inc, Newington, Virginia.

UPDATED

ASW ROCKETS AND DEPTH CHARGES

Introduction

Medium-range rocket launchers
One of the most widely adopted developments in the years since the Second World War was the medium-range anti-submarine rocket launcher. Brief details of the French system, and Swedish system on which the French system is based, are given. Although it differs in some important respects from the French and Swedish systems described below, the Norwegian Terne system is also in this general weapon category. Many similar developments have also taken place in the former USSR.

Depth charge mortars
Towards the end of the Second World War a more streamlined type of depth charge with a higher rate of sinking was introduced by the RN and subsequently by other navies. The intention was to project charges ahead of an attacking ship so that they could be fired more accurately while still in sonar contact, which was otherwise lost when the attacking ship ran over the submarine to deliver conventional depth charges. Such mortars have been developed in several countries, Squid and Limbo in the UK were two examples, the Italian Menon being a third.

Another weapon in this category is the French four-barrelled mortar. This is mounted in a turret and is automatically loaded. It fires a heavier projectile and has a longer range (about 2,750 m) than any of the others. All these mortars fire 12 in (305 mm) depth charges. Sweden has developed the small grenade launcher ELMA which is now operational in some Scandinavian navies.

It is believed that the Russian Navy has not adopted the streamlined form of depth charge. It does, however, use depth charge mortars, but it is thought possible that they use compressed air to propel the charge whereas other countries use an explosive cartridge.

The PLA Navy also uses depth charge mortars and ASW rocket launchers based on Russian designs.

Depth charges
Relatively simple cylindrical depth charges that can be rolled or catapulted into the sea or dropped from aircraft are the longest established anti-submarine weapons; they were first used by the Royal Navy in the First World War. They are generally depth-fuzed and have a low sinking rate to give the launching vessel time to get clear. They are still extensively used by many navies: a typical weight is 150 kg and a launcher can project the charge up to about 150 m.

Nuclear depth charges
Also introduced by the US Navy is the nuclear depth charge. To take this clear of the launch vessel a rocket is required, and these depth charges have so far been associated only with ASROC and SUBROC. In the UK, it is understood that Royal Navy Sea King helicopters can be equipped with 'Bomb 600 lb special ordnance'. Based on the US B-57 depth charge, this is intended to attack deep-diving submarines, which are running too deep or too fast for homing torpedoes. These nuclear devices are of UK manufacture. It is believed that nuclear depth charges have been removed from the inventory of NATO navies.

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Chile

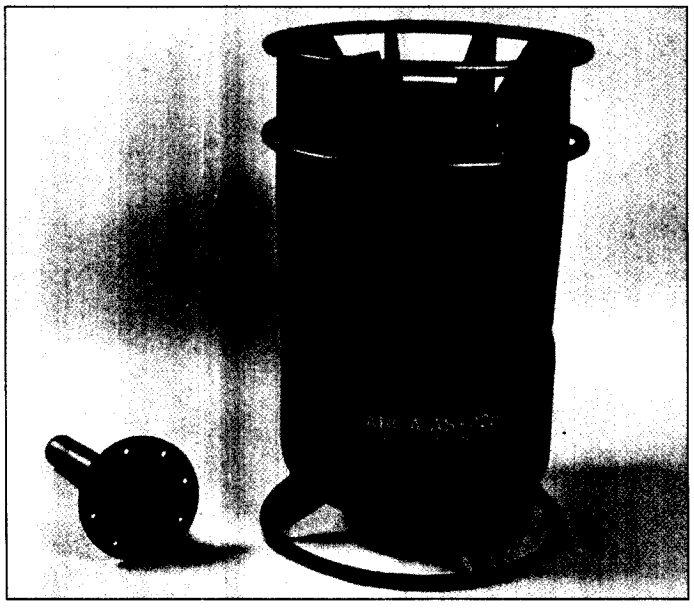
AS-228

Type
Air/surface-launched depth charge.

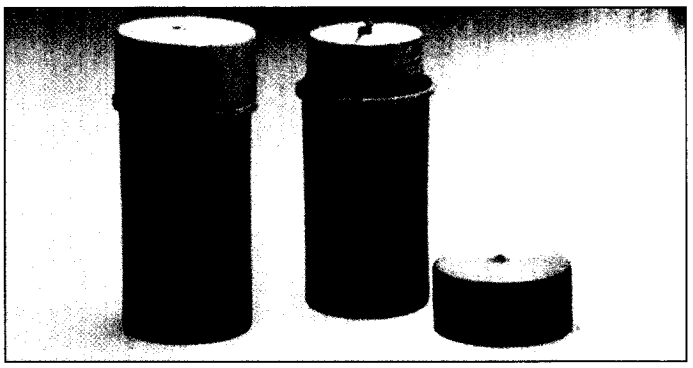
Description
The AS-228 fast-sinking depth charge is an anti-submarine weapon with a hydrostatic pressure-activated fuze that permits its use against targets at depths from 30 to 490 m. The detonation depth can be preset to any one of 19 depths between these limits. The detonator also incorporates three safety measures for handling and transportation, inertia, and submarine action. The charge itself can be launched by conventional methods from naval vessels or from aircraft, including helicopters. The fuze, manufactured by Industries Cardoen, is also supplied as a separate unit as a replacement for outdated fuzes in depth charges and bombs of other manufacture. The weapon is formed of a shallow cylindrical steel drum with a truncated cone at its base and to which seven stabilising fins are attached.

This company also manufactures underwater hand grenades for use as an anti-diver weapon for the protection of ships moored or anchored in insecure waters. These are operated by hydrostatic fuzes and can be set to explode at depths between 4 and 12 m. Thrown overboard at intervals alongside warships they offer a defence against the attentions of frogmen.

Operational status
In service with Brazilian and Chilean armed forces.



Cardoen AS-228 anti-submarine depth charge



Cardoen anti-frogman underwater grenades

Contractor
Industrias Cardoen Ltda, Santiago.

UPDATED

France

Mk 54

Type
Surface-to-subsurface anti-submarine rocket.

Description
This system comprises an anti-submarine rocket launcher associated with a sonar and a computer. The rocket launcher is remotely controlled, aiming and rocket fuzing being determined by the computer, which in turn receives input data from the sonar.

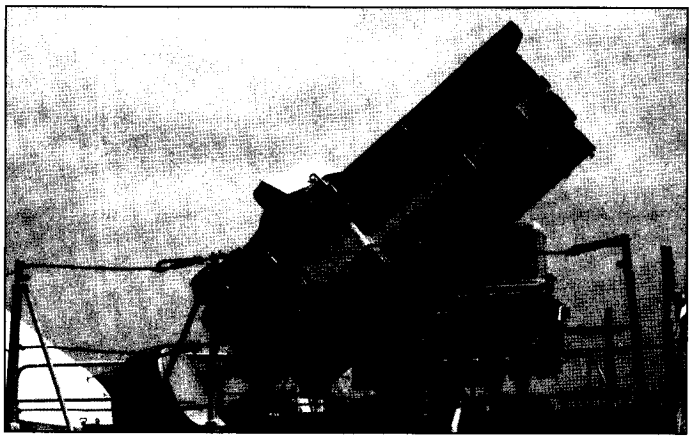
The launcher was made by Mécanique Creusot-Loire under licence from Bofors and is a six-tube device with automatic reloading from a magazine. It fires single rockets or salvos as required and will accept any of the range of Swedish Ordnance 375 mm rockets, thereby giving a choice of ranges from approximately 655 to 3,625 m. Rate of fire can be up to one round per second.

The computer calculates ballistic data for initial velocities of 100, 130, 165 and 205 m/s for the different rockets that may be used with the systems.

Input data from the sonar comprise the location and rate of change of position of the target.

Mécanique Creusot-Loire is also licensed for the manufacture of the twin-tube rocket launcher.

Operational status
No longer in production. The rocket system equips three Type A69 frigates of the French Navy and six of the Turkish Navy and three Wielingen class escorts of the Belgian Navy. The system is currently being removed from the French frigates.



The French Bofors ASW rocket launcher on the frigate Lieutenant de Vaisseau le Hénaff (Stefan Terzibaschitsch)

Specifications
Warhead: 107 kg
Range: 1,600 m

Contractor
Mécanique Creusot-Loire, Immeuble Ile de France, Paris La Défense (launcher).

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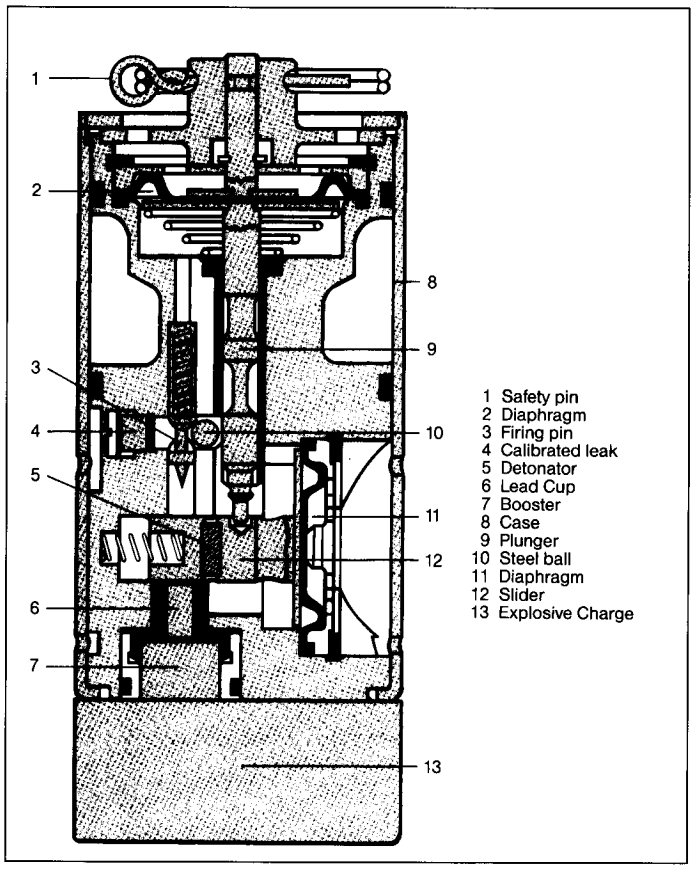
Germany

DM 211 and DM 221

Type
Anti-frogman depth charge and underwater signal charge.

Development
The anti-frogman depth charge is designed to provide an effective weapon for the protection of ships and harbour installations against frogmen. The underwater signal charge is used for encoded submarine-to-surface ship communications. Both charges incorporate safety features providing for safe handling and use by untrained personnel.

Operational status
In production and used by the German, Canadian and other navies.



DM 211 and DM 221

Specifications
DM 211
Length: 268 mm
Diameter: 60 mm
Weight: 1,400 g
Charge: 500 g
Operating depth: 6 m
Throwing distance: 15 m

DM 221
Length: 145 mm
Diameter: 60 mm
Weight: 800 g
Charge: 50 g
Operating depth: 6 m
Throwing distance: 20 m

Contractor
Rheinmetall W & M GmbH, Unterluss.

VERIFIED

Italy

DC 101-MS500

Type
Smart anti-submarine depth charge.

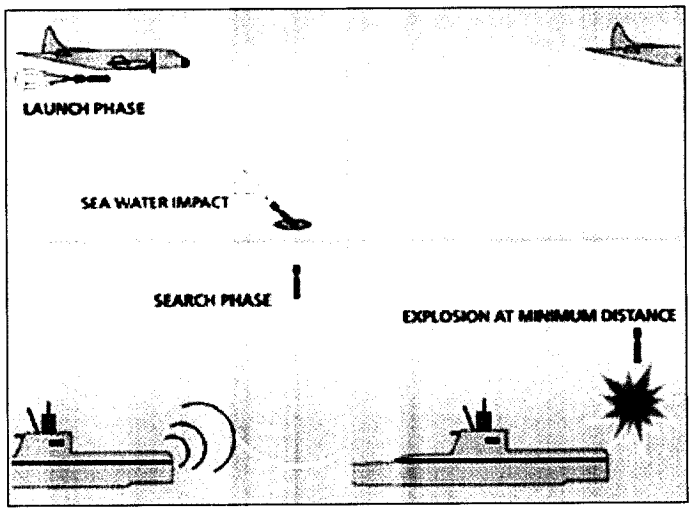
Development
The SDC101-MS500 has been developed for the Italian Navy to replace the obsolete Mk 54 anti-submarine depth charge and overcome the need to set a detonation depth.

Description
The weapon is a 500 lb anti-submarine depth charge designed to be effective against double hull submarines and maximise the abort mission and target kill probability.

The depth charge is equipped with a state-of-the-art active sonar that enables detonation at the minimum distance from the target (the optimum



DC101 depth charge
(SEI SpA)
0097735



The operational scenario of the DC101-MS500 (SEI SpA) 1020469

detonation point). If a target is not acquired the MS500 detonates at a pre-set depth (300 m) or as soon as it reaches the seabed.

The depth charge can be carried by any kind of launch platform equipped with standard pylons for 500 lb class bombs; no electrical interface with the launch platform is required. The in-air trajectory of the charge is stabilised by a dedicated parachute, which allows the correct impact angle and velocity.

The depth charge is also available in a dummy version suitable for training and simulation.

Operational status
In production for the Italian Navy.

Specifications
Length: 2,170 mm
Diameter: 324 mm
Weight: 226 kg (in air)
Charge: 100 kg desensitised CBX101
Operational depth: 300 m

Contractor
SEI SpA, Ghedi.

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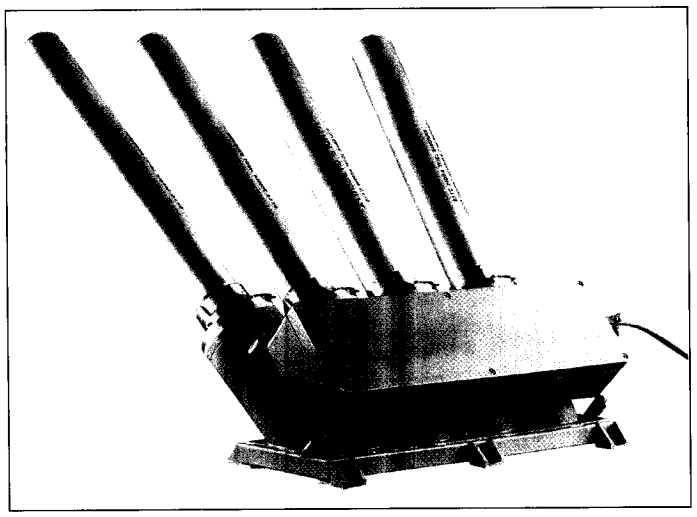
SLD 302 Airone and DC 103

Type
Anti-intruder defence system.

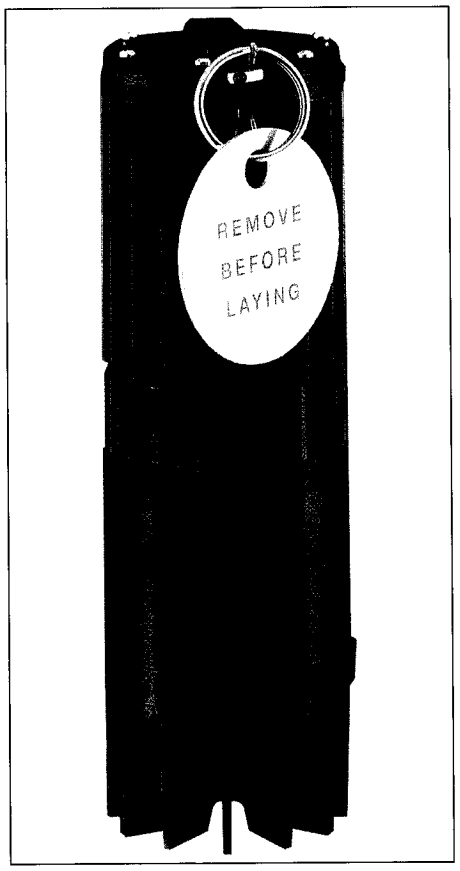
Description
The SLD 302 Airone anti-intruder defence system has been developed to protect the area surrounding ships or strategic locations against underwater intruders (frogmen or divers) by means of DC 103 depth charges.

Airone can be supplied as a stand alone unit (Mod 2) or integrated unit (Mod 1) with a command and control unit able to manage up to 10 launchers simultaneously with the maximum flexibility.

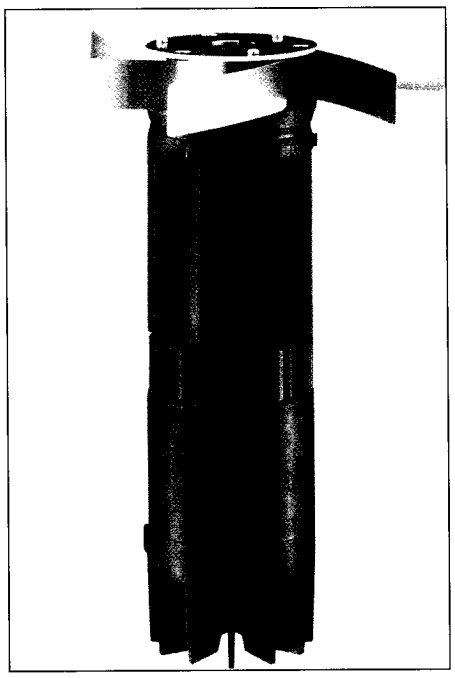
Each launcher comprises a stationary launching unit equipped with four launching tubes, each housing two DC 103 Mod 1 depth charges. The tubes are



SLD 302 – airone with ammunition barrels (SEI SpA) 0097731



DC 103 Mod 0 launch-by-hand (SEI SpA)
0097730



DC 103 Mod 1
(SEI SpA)
0097729

fitted on the launching unit with different orientations to cover a wide sector with a range of up to 100 m from the launch site. The pressure wave generated by the charges detonating is sufficient to cause severe damage to underwater intruders.

The launch range and direction is independent of human factors, and is the fundamental characteristic of the system. Other features are the simplicity and rapidity of ammunition tube replacement after use, which allows a firing ratio of one salvo per minute.

Airone can be integrated with underwater systems able to detect the presence of intruders.

The DC 103 Mod 4 is a hand launched depth charge variant. The hydrostatic safety ensures the security of personnel responsible for the protection of vessels and maritime installations against underwater attacks.

Operational status
In production and in service with several navies.

Specifications
(launch unit with ammunition tube)
Length: 650 mm
Width: 360 mm
Height: 660 mm
Weight: 23 kg and 4 kg (each ammunition barrel)

Charge (DC 103)
Length: 216 mm
Diameter: 66 mm
Weight: 1 kg (approx)
Charge: 0.25 kg T4

Contractor
SEI SpA, Ghedi.

VERIFIED

Norway

Terne III

Type
Anti-submarine rocket-propelled depth charge.

Description
Terne III is a short- to medium-range anti-submarine weapon system, ripple-firing rocket-propelled depth charges, in salvos of six, against submarine targets. The rockets are fired in a line, each charge being separated by 18 m. Salvo patterns can be formed up to the moment of firing according to the tactical situation. Recoverable practice missiles are available. The remote power-controlled six-tube launcher is automatically loaded within 30 seconds from a manually loaded magazine hopper. The launcher is specially protected against arctic conditions.

The main features of Terne III are:

(a) a unified and balanced design;
(b) low weapons weight and small space requirements. A complete installation weighs less than 10 tonnes;
(c) the weapon part can be interfaced with existing sonars and other target data sources. Norwegian frigates have a new modular fire-control unit to which the Terne III system is interfaced via databus STANAG 4156;
(d) freedom of choice in the position on board;
(e) remote-control firing at elevation angles between 47 and 77°, giving variable ranges throughout 360° of bearing;
(f) depth charge is fitted with proximity (range 6 m)/time (0.35)/percussion fuze;
(g) high rate of fire.

The system has been upgraded to the Mk 10 version.

Operational status
No longer in production. First entered service early 1960s. Fitted in three Royal Norwegian Navy frigates of the Oslo class.

Specifications (Rockets)
Length: 1.97 m
Diameter: 20 cm
Weight: 120 kg
Warhead: 70 kg TNT equivalent
Fuze: proximity, time and impact
Range: 400-5,000 m (Mk 10 version)

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

VERIFIED

Romania

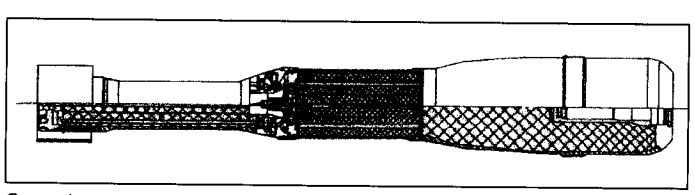
ASW Rocket

Type
Anti-submarine rocket.

Description
The rocket is designed to destroy or seriously damage submarines at depths between 10 and 350 m. It can also be used as an anti-torpedo defence system or for clearing a path through a minefield by causing sympathetic detonation of mines.

The rocket is automatically launched from the RBU-6000 using the Buria fire-control system.

Operational status
In production and service.



General arrangement of anti-submarine rocket (Romtehnica) 0110107

Specifications
Length: 1,825 mm
Calibre: 212 mm
Weight: 120 kg
Charge: TGAG-5 (TGAF-5)
Range: 300-6,000 m
Operational depth: 10-350 m

Contractor
Romtehnica, Bucharest

VERIFIED

GIS-1

Type
Anti-frogman grenade.

Description
The GIS-1 anti-frogman grenade is designed to protect ships and harbour installations against attack from special forces divers. The grenade is equipped with three depth settings, one of which is selected before launching. The system is fitted with all the safety devices necessary for handling and transportation. The device can be dropped overboard from a ship, or from a jetty or shore feature or from a helicopter.

Operational status
In production and service.

Specifications
Length: 292 mm
Diameter: 62 mm
Weight: 1.1 kg
Charge: 0.250 kg Tetryl
Range: 10 m
Operational depth: 5, 10 or 15 m

Contractor
Romtehnica, Bucharest.

VERIFIED

Russian Federation

ASW rocket launchers

There is a wide variety of short-range anti-submarine rocket launchers in the units of the RFAS fleet, although all appear to operate on much the same principle of firing charges in a pattern ahead of an attacking ship from a mounting which can be trained and elevated under remote control. Two different calibres of 250 mm and 300 mm exist and the weight of the bombs in the 250 mm versions has been estimated at 180 to 200 kg. The RBU associated number is understood to mean the maximum range possible in metres. Some of the systems are also believed to have an anti-torpedo capability. The projectiles are thought to be fitted with impact fuzes.

RBU 2500: a 16-barrelled 250 mm calibre system introduced in 1957 and fitted with two horizontal rows each of eight launching tubes about 1.6 m long. The trainable launchers can elevate up to about 85°. Depth bombs are loaded by hand. The system is operational aboard 'Petya' class frigates of the Indian, Russian, Syrian and Vietnamese navies, the Sukanya class OPVs of the Indian and Sri Lankan navies, the Russian Smolny class training ship and also Romanian 'Tetal' class frigates. No longer in production.

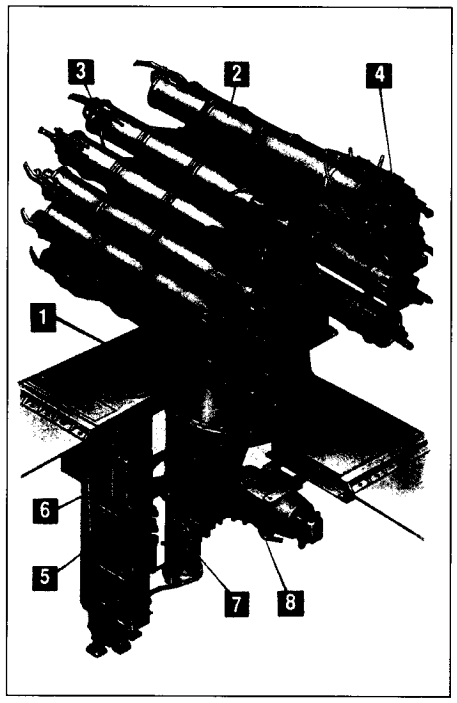
RBU 6000: probably of 300 mm calibre and fitted very widely, this system entered service around 1967. Twelve launch tubes are arranged in a circular fashion and it is believed that they are reloaded automatically by bringing them to the vertical and indexing one by one while depth bombs are loaded from below. Range is 3.25 n miles and the launch barrel length has been extended to about 1.8 m and can be elevated to about 50°. The system remains in production. Salvos are rifle fired sequentially in pairs. The system is widely fitted to cruisers, destroyers and frigates.

RBU 1200: a five-barrelled system reportedly introduced in 1957 and which was fitted normally to the quarters of larger ships such as the *Kara* and *Kresta*. Almost certainly it has a range of no more than 1.5 n miles covering an area 70 × 150 m. The system, because of its size and mounting, almost certainly employs automatic reloading. It is probably intended to deal with torpedoes, if they can be detected in the closing stages of an attacking run. The tubes are on a fixed mounting and can elevate up to about 65°. Production continues, but possibly only for export. It is manufactured in China probably without a licence. Chinese built versions have been used by the Bangladesh Navy.

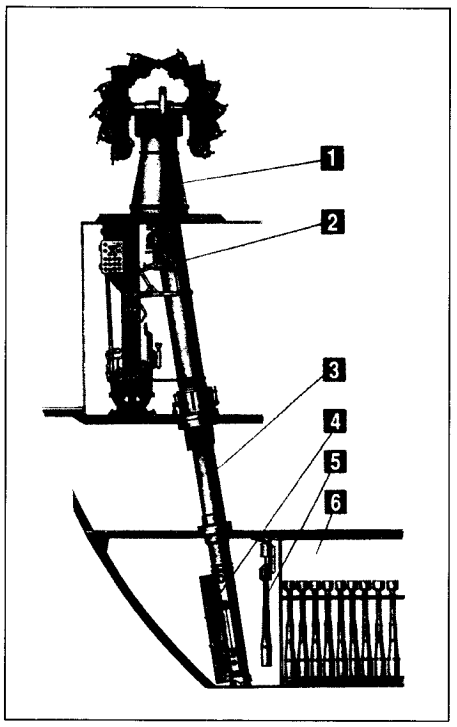
Specifications: ASW rocket launchers

	RBU 1200	RBU 2500	RBU 6000	RBU 12000
Length	1,228 mm	1,340 mm	1,830 mm	n/k
Range	0.8 n miles	1.5 n miles	3.25 n miles	6.5 n miles
Warhead	34 kg	21 kg	31 kg	80 kg
Diameter	252 mm	312 mm	212 mm	n/k
Weight	70 kg	84 kg	100 kg	232.5 kg*
Elevation	65°	85°	50°	n/k
Operating depths	10-330 m	10-320 m	10-500 m	n/k

Note: * ASW rocket; the decoy round weighs 201 kg. Dimensions and warhead refer to the rocket.



RBU 6000 anti-submarine rocket launcher:
(1) *launcher pedestal;*
(2) *tube;*
(3) *front clip;*
(4) *rear clip;*
(5) *rocket hoist;*
(6) *control panel;*
(7), *training wheel*
(8) *traversing and elevating handwheels*
0007238



RBU 6000 anti-submarine rocket launcher with rocket hoist and elevator:
(1) *rocket launcher;*
(2) *rocket hoist;*
(3) *elevator;*
(4) *elevator feeder;*
(5) *anti-submarine rocket RGB-60;*
(6) *rocket magazine*
0007239

RBU 12000: A 10-tube system deploying a much heavier rocket than other variants. The system equips the latest carriers of the Russian Navy. Like the other ASW rocket launchers, the RBU 12000 is designed to form part of a layered defence. It is able to deploy two types of munition: a decoy round and an ASW rocket round. In Russian service the system is referred to as UDAV-IM. The system equips the carrier *Kuznetsov*, the 'Neustrashimy' class frigates and 'Kirov' class cruisers.

The system is thought to remain in production.

VERIFIED

S-3V

Type
Air-launched depth charge.

Description
This weapon first seen in 1994 is designed to attack all types of submarine down to depths of 600 m. The torpedo-shaped depth charge features a cylindrical body with a flattened rounded nose to ensure correct aerodynamic and hydrodynamic trajectories. The bolt-on tail unit with integral retarding stabilising parachute is fitted with eight long, narrow-span, rectangular fins with a swept leading edge and flat ring assembly. On entering the water the parachute and a protective nose fairing are discarded.

The shaped charge warhead is reported to be fitted with an active sonar guidance system. The precise type of fuze is unknown, but is conjectured to include both contact and proximity.

Helicopters equipped with dipping sonar deploy the depth charge. After the parachute and nose fairing have been discarded on entering the water, the sonar is activated and the depth charge descends towards the target. Once the active sonar detects the target it steers the weapon on to the target. The maximum angle of descent is 60° and the underwater speed 16 m/s. The maximum trajectory correction pattern is ±60°.

Operational status
In service aboard Russian helicopters since the late 1980s and offered for export since 1996.

Specifications
Length: 130 cm
Diameter: 0.211 cm
Weight: 94 kg (in air)
Charge: 19 kg shaped charge
Operational depth: 600 m

Contractor
State Scientific and Production Enterprise 'Region' (FSUE Region), Moscow.

UPDATED

Sweden

ALECTO

Type
ASW multimission warfare system.

Description
The Alecto system, although similar to the ASW 601 is a new-generation weapon based on the KAS 2000 terminally guided 127 mm rocket launched ammunition. It is primarily designed for rapid engagement of submarines sailing near to or resting on the seabed at depths between a few hundred metres and 6,000 m. The multimission system can also be used in an ECM or torpedo countermeasures role. There is a requirement for rapid change from the ASW role to torpedo countermeasures and for this the two sets of launchers, each of six barrels mounted on a stabilised trainable mounting sited below deck, can carry a mixed payload for ASW, ECM or torpedo countermeasures. The torpedo countermeasures could comprise either an acoustic jammer or a bubble decoy. Alecto is required to counter at least two torpedoes with conventional propulsion system on two bearings simultaneously.

In the Visby class the launchers are mounted to port and starboard below sliding deck hatches in front of the 57 mm gun mount from which position they are trained and elevated. Loading is carried out automatically with a manual loading capability if required. Using target designation data from sonars, the system calculates the predicted point of impact and trains the gyrostabilised launcher. The system then locks on and tracks the target until firing. Target data is fed into the ammunition immediately before launching. After firing, the ammunition achieves a maximum speed of 120 m/s and follows a ballistic path to the target area. Descent is stabilised and slowed to 80 m/s by a parachute assembly, which ensures the correct angle of entry into the water. On entering the water the parachute is jettisoned and the active acoustic homing system commences seeking the target

using a medium sized number of preformed beams. On impact, a specially shaped charge detonates to punch a hole in the submarine's hull. Firing can be generated from a general purpose console or from a separate dedicated operator console. Range is between 150 and 1,200 m.

The system can be used in a multipurpose role, deploying active and passive ECM decoys both above and below the surface, as well as the ASW ammunition.

Operational status
The system is being installed on the new Visby YS 2000 class corvettes now under construction.

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED

ASW-601

Type
Lightweight multibarrel ASW system.

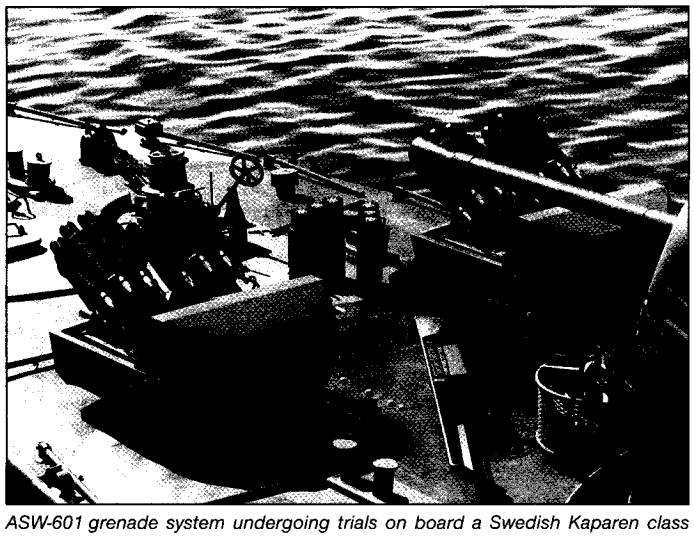
Development
The system was developed to meet the threat of small- and medium-sized submarines operating in coastal waters in the Baltic.

Description
The ASW-601 consists of two trainable platforms each fitted with four launchers carrying nine barrels. The launchers are trainable over an arc of 110°. The ASW-601 is specially designed for operation in shallow waters. Using data from sonar or other target designators the system calculates an impact point and trains the platform to the predicted angles. These are then continuously updated to track the target until the decision is made to fire. The computer in the fire-control unit calculates and recommends the best firing instant, salvo size and number of grenades. A carpet of up to 36 grenades can be laid in a selectable pattern optimised to achieve the highest hit probability. Salvos are alternated between launchers. The non-firing launchers aim continuously at the target area guided by the fire-control units, thus optimising the grenade pattern. The ASW-601 can cover an area out to a range of 150 to 450 m. The ammunition used is the M-90E grenade fitted with a shaped charge specially designed for underwater penetration. For the ASW-601 system there is also chaff and IR ECM ammunition. The ASW 601 system replaces ASW-600 systems, which are in service in the Swedish Navy (for details of ASW-600 see previous editions).

The ASW-604 is designed to fit almost any type of helicopter. Part of the concept involves integrating the grenade launcher with the Hawkeye and using a simple sighting system. The grenades are then fired from two multibarrel launchers mounted on either side of the helicopter, each containing 20 grenades. Grenades are either launched in batches of two to four or all together with a short timed delay between each grenade launching.

Operational status
More than 40 systems of the ASW-600 have been delivered and are operational on all corvettes, FACs and MCMVs of the Swedish Navy. These are being replaced by the ASW-601 system. The system is also operational on board Finnish patrol boats. The system will also be fitted on the new Meko A 100 corvettes currently under construction for Poland.

Specifications
System
Number of grenades: max 36 per salvo
Range: 150-450 m (approx)
Dispersal: adjustable



ASW-601 grenade system undergoing trials on board a Swedish Kaparen class FAC

Grenade
Calibre: 100 mm
Length: 478 mm
Weight: 5.7 kg

Equipment weights and dimensions
Launcher: 820 kg, 1,600 × 1,200 × 1,100 mm
Relay unit: 7 kg, 330 × 230 × 110 mm
Firing unit: 6 kg, 330 × 230 × 148 mm

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED

BDC 103

Type
Underwater signal/anti-frogman charge.

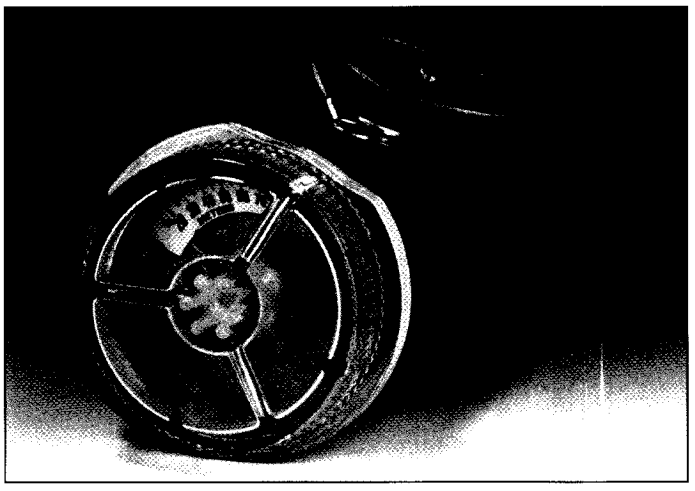
Description
The hand-launched BDC 103 is designed to fire a 55 or 500 g explosive charge when it has sunk to a preset detonation depth. It incorporates a hydrostatic safety device and can be stored and transported ready for use.

Normally used in peacetime as a user-safe signalling device during underwater exercises, for instance to simulate a depth charge attack, the BDC 103 is equally useful as a frogman deterrent in a threat scenario. A complementary 500 g charge can be screwed onto the standard 55 g charge for enhanced impact.

Operational status
The BDC 103 is in service with the Swedish Navy.

Contractor
Saab Bofors Dynamics AB Karlskoga.

VERIFIED



The BDC 103 anti-frogman charge (Saab Bofors Underwater Systems) 0038679

Type 375

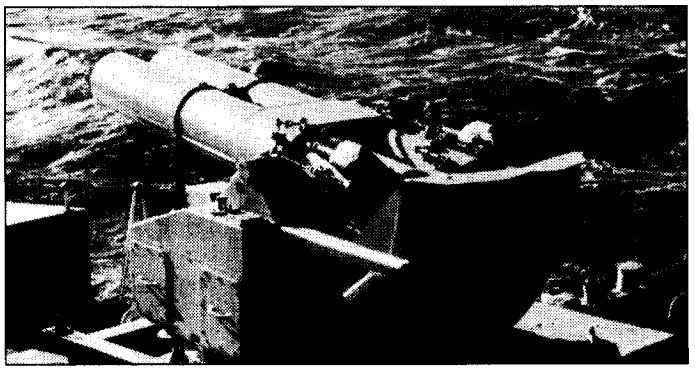
Type
Shipborne surface-to-surface short- and medium-range ASW rocket system (two-, four- and six-tube arrangements).

Description
The ship's sonar provides submarine position for prediction of Type 375 launcher elevation and bearing data. The launcher has either two or four tubes and can fire single- or multiple-shot salvos. A special design ensures a predictable and accurate underwater trajectory. The launcher is reloaded by automatic means from the magazine, which is disposed directly below the launcher. The twin launcher has an integral motor-driven twin hoist, for loading both tubes at once, and a rotating loading table. The laying mechanism is electrohydraulic with a choice of local or remote operation. Fuze setting is with the rocket in the tube. The rocket table holds four rounds and the total number of rockets in the operating room is 24. The shortest time between successive firings is 1 second. The time to fire six ready rockets (four on the table and two in the tubes) is 1 minute, and the firing rate for continuous fire is two rockets every 45 seconds. The manning complement during continuous firing is three men.

Rockets have two types of motor giving differing range brackets. The rocket trajectory is flat, thus giving a short time of flight to minimise target evasive action. Fuzes are fitted with proximity, time, and DA devices.

Specifications: Type 375

	Weight		Length		Charge	Max velocity		Final sinking	Range to
375 mm ASW	**with fuze**	**w/out fuze**	**time fuze**	**proximity fuze**		**1 motor**	**2 motor**	**speed**	**30 m depth**
Erika	250 kg	236 kg	2,000 mm	2,050 mm	107 kg hexotonal	100 m/s	130 m/s	10.7 m/s	655-1,635 m
Nelli	230 kg	216 kg	2,000 mm	2,050 mm	80 kg hexotonal	165 m/s	205 m/s	9.2 m/s	1,580-3,625 m
Practice									
Type H	100 kg	86.5 kg	-	-	-	135 m/s	-	-	980-1,570 m
80 mm MI	-	-	1,120 mm	-	-	130 m/s	-	-	980-1,600 m
15.5									



Bofors twin-tube ASW rocket launcher

The 80 mm MI type is launched from a special holder that is handled as a live rocket in the operating room, hoist and launcher.

Operational status

The system is no longer in production.The twin-tube launcher and anti-submarine rockets are in service with a number of navies including: the Mk 9 corvettes of the Nigerian Navy (2 ships); Nilgiri class (two Leander type) frigates of the Indian Navy; the Descubierta class frigates of the Egyptian (2 ships), Spanish (6 ships) and Moroccan (1 ship) navies; the Niteroi class of the Brazilian Navy (6 ships); the Fatahillah class frigates of the Indonesian Navy (3 ships), 'Yamagumo' class destroyers of the Japanese MSDF (3 ships 4-barrel version); and the Kasturi class frigates of the Malaysian Navy (2 ships).

Specifications (twin-tube launcher)

Weight, excluding rockets but including flame guard and deck plate: 3.8 t
Traversing speed: 30°/s
Elevating speed: 27°/s
Traverse limits: unlimited
Elevation limits: 0 to +90° (mechanical); 0 to +60° (for firing)
Power supplies: 440 V, 60 Hz, 3-phase
Power consumption: tracking 6 kW (mean)

Contractor

Saab Bofors Dynamics AB, Karlskoga.

VERIFIED

United Kingdom

Limbo AS Mk 10

Type

Surface-launched anti-submarine mortar.

Description

This is a shipborne surface-to-subsurface medium-range anti-submarine mortar system. Mortars are stabilised in pitch and roll by a metadyne system referenced to the ship's stable platform. Training of the mortar is carried out automatically from the combat information centre using data from the ship's sonar system, which provides target position data to a predictor to compute mortar elevation and lateral tilt. The triple barrelled mortar fires a pattern of three projectiles that are programmed to give a 3-D explosive pattern ahead of the firing ship. They can be set to explode at variable depths down to 375 m using hydrostatic or direct impact fuzes. The fuzes are set by remote control through relays and uniselectors. The projectiles are loaded automatically from magazines alongside the mounting, the mortar tubes being laid horizontally with a pneumatic system moving rounds down the barrel. The magazine has a capacity of 51 rounds.

The range of the rocket is varied by adjusting gas vents in the tail of the weapon.

Two launchers (each launcher comprises three barrels) are used together with firing being spaced between barrels by a short time delay. This produces a triangular pattern of detonations above and below the target's estimated position.

Operational status

Only a few systems remain in service: on three 'Nilgiri' ('Leander' type) class frigates of the Indian Navy; three Alvand class frigates of the Iranian Navy; the frigate *Hang Tuah* of the Malaysian Navy; and the frigate *Makut Rajakumarn* of the Thai Navy.

Specifications

Weight of system: 35 t
Weight of bomb: 177 kg
Warhead: 92 kg Minol
Range: 1,000 m

Contractor

Manufactured to MoD (Navy) designs by several contractors.

VERIFIED

Mk 11

Type

Air-launched depth charge.

Description

The Mk 11 depth charge quick-reaction air-launched ASW weapon was designed for shallow water operations against submarines on the surface or at periscope depths. It is fully compatible for carriage and release from a wide range of ASW helicopters and fixed-wing maritime patrol aircraft.

The Mk 11 depth charge tolerates the harsh vibration levels associated with helicopter operations. The Mod 3 version incorporates a 4 mm mild steel outer case and nose section which is designed to withstand entry into the water at high velocities without distortion. The charge is fitted with a modern fuze system that is inserted at the rear of the body cylinder. It comprises a pistol unit, detonator and primer assembly, which can withstand severe vibration and shock to ensure accurate detonation at the set depth. On impact with the sea the hydropneumatic arming system is activated and the tail assembly is detached.

The Mk 11 is currently supplied with a Torpex filling. However, an insensitive Polymer Bonded Explosive (PBX) filling was developed as an alternative in the early 1990s. The PBX uses long-chain molecules to bind the energetic materials together forming a relatively insensitive explosive matrix, which substantially reduces the risk of accidental explosion due to mishandling.

Operational status

No longer operational with the Royal Navy, although a number of weapons may be held in store. The Mk 11 has been supplied to many overseas navies and remains operational with the navies of France, India and Pakistan.

Specifications

Length: 139 cm
Diameter: 27.9 cm
Weight: 145 kg
Warhead: 80 kg HE

Contractor

BAE Systems Underwater Systems, Bristol, Avon.

NEW ENTRY

MINE WARFARE VESSELS

Mine warfare forces

Mine warfare vessel designs

MINE WARFARE FORCES

Albania

Two former Soviet vessels are obsolete.

UPDATED

Algeria

Plans exist to acquire two new mine warfare vessels and tenders are expected to be invited sometime in the future.

UPDATED

Argentina

Two former UK Ton type purchased in 1967 have been removed from service. Options for their replacement are now under consideration but it is doubtful if the current economic situation and military budget will permit replacement.

UPDATED

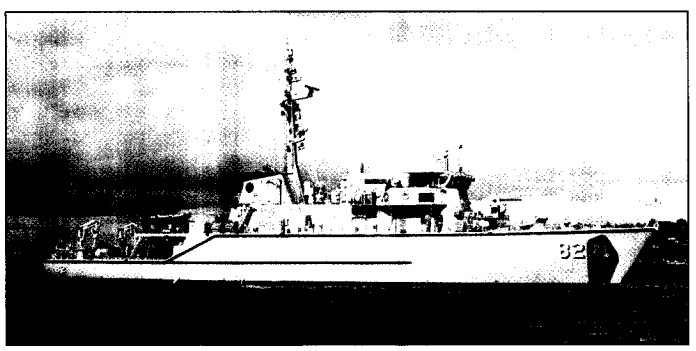
Australia

7 November 2003 – Defence Capability Review notes that two Huon class MCMVs will be mothballed to offset costs in other projects.
1994 – Consortium of Australian Defence Industries and Intermarine of Italy awarded contract for construction of six Huon class MCMVs.
June 1991 – Review and subsequent Minehunter Coastal Project projects a force of six vessels.
May 1991 – Force Structure Review recommends urgent acquisition of proven design of coastal minehunter.

The RAN is currently evaluating a series of minor equipment modifications for the Huon class. These include the incorporation of a Towed Acoustic Generator (TAG) into the AMASS Dyad system which has not yet been specified as standard equipment for the class. Also under consideration is the development of an engineering prototype of an Acoustic Mine Imaging System by Thomson Marconi Sonar Pty Ltd to be incorporated into Double Eagle Mk II. This is required to overcome problems of using the LLTV camera for detection in turbid waters with low visibility conditions.

Trials were due to be undertaken in 2001/02 with installation due in 2003/04. A further class of six minesweepers is planned which will use an indigenous sweep system possibly based on the AMASS Dyad system.

UPDATED



Lead ship of the Huon class HMAS Huon (H & L van Ginderen) 0099760

Azerbaijan

Two Sonya and two Yevgenya class MCMVs were transferred by Russia in 1992.

UPDATED

Bangladesh

In 1994, four former Royal Navy River class minesweepers were acquired. Plans exist to fit the vessels with influence sweeps to handle acoustic and magnetic mines. The navy has also acquired a new T 43 minesweeper ordered from China. A C-Tech CMAS-36/39 sonar was fitted in 1998. A further three units may be acquired.

UPDATED

Belgium

Six of the seven Flower class minehunters (Tripartite design) are due to undergo a Capability Upkeep Programme (CUP) which will enable the vessels to remain effective until around 2015-2020. Under the CUP the command, navigation and ship positioning systems will be integrated with the ship's sonar and mine-neutralising system being improved. The navy is also studying the possibility of equipping the vessels with a minesweeping capability, following the cancellation of the KMV project. The first vessel was due to undergo the CUP between 2000/1, with all seven vessels due to have undergone the CUP by 2004. Under the CUP the DUBM-21 hull-mounted sonar will be upgraded, while the EVEC tactical system will be replaced. Other improvements will be made to the mine identification and neutralisation system by replacing the PAP 104 ROV. In addition, a drifting mine detection system will be installed while system integration will allow a reduction in crew numbers. An upgrading of the propulsion system was completed in 1999.

An international project to build a new class of GRP-hulled minesweepers collapsed, but Belgium decided to continue with the project on her own and authorisation for the acquisition of four units was given in July 1994. A contract for the lead ship was placed in 1999 but the project was cancelled on 12 May 2000.

UPDATED

Brazil

Class of six minesweepers acquired in the 1970s are in urgent need of major modernisation, and this may be undertaken early this decade, but funds are limited. In view of coastal littoral a larger type of vessel is needed. Numbers are also inadequate in view of size of the navy, number of bases and so on. When SSNs are eventually acquired, an effective MCM capability including modern minehunters, will be essential. Plans exist for a new class of six minesweepers, but no funding has been allocated.

UPDATED

Bulgaria

A number of former Soviet minesweepers, all of which are obsolete and need replacing, remain in service. The most recent units to enter service are six Olya class built in Bulgaria between 1988 and 1996.

UPDATED

Canada

Twelve MCDVs are now operational. The units have a dual role of MCM and general patrol, operating with one of three modular payloads; enabling them to adapt quickly to different tasks. It is planned that the vessels will deploy a remote minehunting system based on the Dolphin vehicle.

UPDATED

China

Although there is an MCM force of considerable size, this does not appear to be very effective. Plans for a new class of minehunter are thought to have been drawn up. A force of up to 38 Italian Lerici type minehunters may possibly be planned.

UPDATED

Croatia

Two inshore minehunters are on order. Work on the first unit has stopped due to lack of funds.

UPDATED

Cuba

A few former Soviet units exist, some of which are non-operational.

UPDATED

Denmark

Modern MCM capability is being developed based on the Stanflex 300 Flyvefisken multirole design. Units use 'plug in' systems so force can be rapidly expanded or reconfigured for other roles. Six MCM modules are available. Six SAV drones are operational and four other units to a modified larger design to enable them to operate more effectively in a more open ocean environment have been delivered. Six more of these craft may be acquired.

UPDATED

Egypt

A limited MCM capability has been developed with three MHC ordered from Swiftships in America in 1991, the first unit was delivered in June 1994. Apart from this, the navy operates a mixed force of 10 former Soviet units which are now obsolescent. Swiftships has also delivered two route survey vessels and it is planned to acquire two more.

UPDATED



Egyptian T 43 type minesweeper Sinai (H & L van Ginderen)

Estonia

2 September 2000 - second Lindau (Type 331) class minehunter commissioned.
January 2000 - Lindau (Type 331) class minehunter transferred with PAP 104 ROVs
1997 - two ex-German Type 394 Frauenlob class vessels transferred. May be upgraded with new ROVs.

UPDATED

Finland

A small MCM force of 13 inshore minesweepers exists and plans exist for the construction of a new class of minehunters. Four of the Kuha class have been refitted and modernised with an additional 6 m long section added to afford greater versatility in MCM. The vessels recommissioned in the Autumn of 1998.

A procurement programme exists for the acquisition of Finnish manufactured influence mines.

UPDATED

France

February 2003 - First of upgraded Eridan class *Andromede* delivered

The bulk of the MCM force, 13 Eridan class Tripartite type, is stationed at Brest to protect the SSN and SSBN force, but overall MCM forces are insufficient to provide effective cover for all bases and shipping routes. The Eridan class is to have its minehunting capability upgraded with the TSM 2061 combat data system and the PVDS (TSM 2022 Mk 3) selected as the offboard platform. There are no plans for a replacement design for the Eridan class.

UPDATED

Georgia

Four former Soviet Yevgenya class inshore minesweepers were transferred in 1998.

UPDATED

Germany

A powerful, modern MCM capability is retained. A major programme of new construction to replace units built in the 1950s and 60s is complete. The Type 343 minesweepers are being modernised and five will be upgraded to include a minehunting capability, while five will be converted to include a drone control capability. Work on the conversion began in April 2000.

UPDATED

Greece

Early 2001 - 2nd Hunt class *Berkeley* handed over.
31 July 2000 - First of two ex-UK Hunt class acquired. *Bicester* renamed *Europe*.
1995 - two Adjutant class acquired from Italy.
Early 1990s - eight former US MSC 294 class completed major upgrade. May be given new sonar in the near future.

The MCM force is obsolescent and desperately in need of replacement. Acquisition of modern units and equipment is now an urgent priority.

UPDATED

Hungary

Hungarian forces have an important role in patrolling the river Danube. Six Nestin class river minesweepers are in service together with a number of small road-transportable craft.

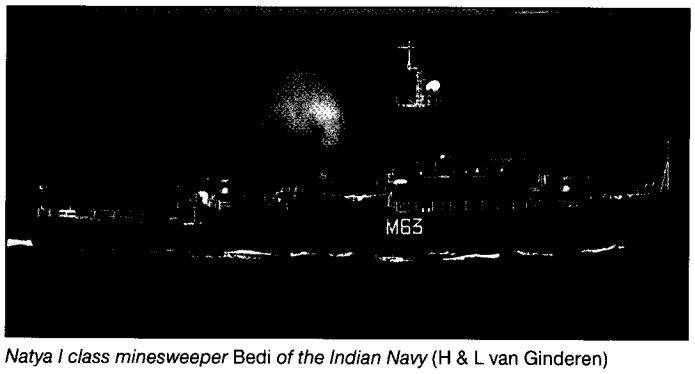
UPDATED

India

With an extensive coastline and many major ports and naval bases, not to mention a large merchant fleet, the current MCM capability is inadequate for the task. The force needs to be expanded and existing units either need urgently replacing or modernising with new systems. The need for at least 10 minehunters has been recognised, and construction of six units at the Goa shipyard is projected, but no decision has yet been made concerning this programme.

Following trials carried out in 2002, the Indian Navy is to introduce a force of dolphins to deposit limpet mines on hostile ships.

UPDATED



Natya I class minesweeper Bedi *of the Indian Navy* (H & L van Ginderen)

Indonesia

A modest programme of two Tripartite minehunters was completed, but more ambitious plans to build up to 12 units have been shelved due to budget restrictions. The MCM force urgently needs building up, and the acquisition of nine former East German patrol vessels partly meets this need, although their priority task is Economic Exclusion Zone (EEZ) patrol.

UPDATED

Iran

A small force of two minesweepers exists but may be non-operational. No effective minehunting force exists.

UPDATED

Israel

With three just completed highly capable submarines and powerful surface units there is an urgent need for a small MCMV force.

UPDATED

Italy

A major programme of modernisation is now complete with the construction of 12 Lerici and Gaeta class minehunters. An upgraded Gaeta design to encompass a multirole configuration is under consideration and a class of three/four vessels may be ordered around 2008. The MCMVs will have improved mine neutralisation capability with the acquisition of the Pluto ROV.

UPDATED

Japan

The mine threat has been clearly recognised and a major programme of modernisation has been completed. Three new ocean-going MCMVs have been built, together with 23 coastal MCMVs. Four units of a new class of coastal minehunter (Sugashima class) have been built and three more units have been authorised. A total of 12 units is planned. Six Swedish SAM drones have been acquired and two Hatsushima class units have been converted into drone control units.

UPDATED

Korea, North

A modern force of coastal minesweepers has been built.

UPDATED

Korea, South

A major mine threat exists and a new MCM programme is under way, with six GRP-hulled minehunters of the Kang Keong class completed. A new 750 tonne combined minehunter/sweeper design has been developed and the lead ship entered service in December 1999. Four more units are planned.

UPDATED

Latvia

Two former East German Kondor class vessels were transferred in 1993 and a Lindau (Type 331) class minehunter from Germany in June 1999.

UPDATED

Libya

Eight former Soviet Natya units delivered in the early to mid-1980s remain operational.

UPDATED

Lithuania

An ex-German Lindau (Type 331) class minehunter was transferred in June 1999 and a second in November 2000.

UPDATED

Malaysia

A major programme of construction of four minehunters has been completed. The tactical data system is to be upgraded.

UPDATED

Myanmar

It is anticipated that two new-build Chinese Type T 43 minesweepers may be acquired in due course.

UPDATED

Netherlands

The current force comprises 12 Tripartite minehunters. Modernisation of this class commenced in 1996, and as part of the programme, units are to be converted to the drone control role each controlling four drones. The upgrade will include a new hull sonar, new PVDS, new command system and a new mine disposal system. Under the Defence White Paper 2000, three minehunters have been removed from operational service and the remaining 12 will be modernised by 2009.

The project definition study for a new drone concluded in 2000, and a prototype was due to be built in 2002/03.

UPDATED

Nigeria

Two Italian Lerici units exist.

UPDATED

Norway

Construction of nine units under a major programme to replace the obsolete former US minesweepers has been completed. The minesweeper *Orkla* was destroyed in a fire on 19 November 2002.

UPDATED

Pakistan

Three French Tripartite MCMVs have been acquired to replace obsolete units. The first of these was a unit transferred directly from the French Navy. The second unit has been built in France and outfitted in Pakistan and commissioned in 1996, while the third unit was assembled and fitted out in Pakistan under a technology transfer agreement and has now commissioned.

UPDATED

Philippines

Acquisition of three MCMVs was projected for 2002 but is likely to be delayed due to financial problems and a generally unstable situation which demands other military priorities.

UPDATED

Poland

A mixed fleet of MCMVs exists, with 13 Polish-built Notek class completed between 1981-91, and three older Krogulec class. Four coastal minehunters based on the Notec design entered service in 1992-94 but plans to build more of this class appear to have been abandoned. The Krogulec class have been modernised with new minehunting equipment. This includes Polish-manufactured hull-mounted and towed sidescan HF sonars and the indigenous Ukwial ROV. The older Notek class minesweepers are to be upgraded to the same standard as the four minehunters.

Under the Programme for Restructuring and Technical Modernisation of the Armed Forces 2001-2006, it is intended to build two Kormoran class minesweepers (Project 257) which will be introduced by 2006. The first was due to be laid down in January 2003.

UPDATED

Portugal

Currently, no MCM force exists and plans to acquire four new coastal minesweepers in conjunction with Belgium have been dropped although a requirement for four MCMVs still exists. Development of an MCM force is now an urgent requirement.

UPDATED

Romania

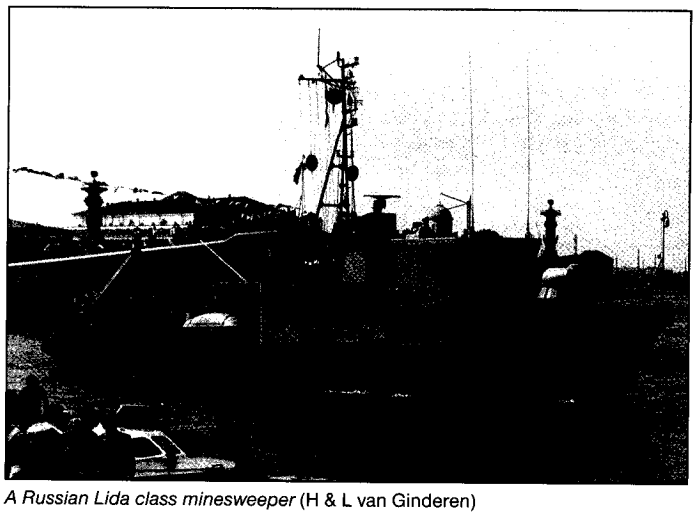
The MCM force was modernised in 1986-89 with four locally built Musca class.

UPDATED

Russian Federation

Russia currently operates the largest MCM force in the world, but much of it is obsolete. A number of new designs has been tried in recent years, but not proved successful. The most modern units are the 12 vessels of the Natya class, but early boats are now paying off. An uprated minehunting version of this class is expected to complete sometime in the future, but progress is very slow. Glass Reinforced Plastic (GRP) construction has not proved a success and the main material used is still wood, sometimes sheathed in GRP.

UPDATED

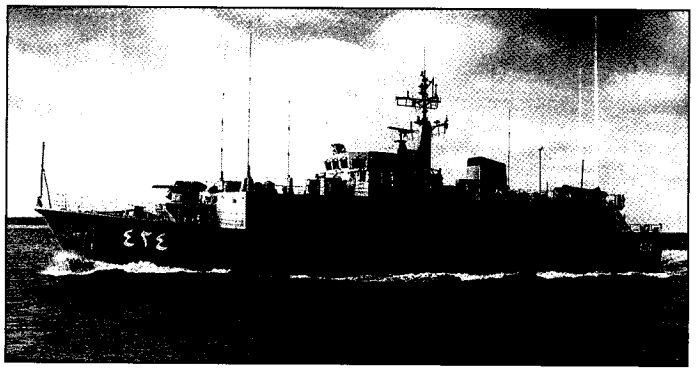


A Russian Lida class minesweeper (H & L van Ginderen)

Saudi Arabia

An effective MCM force has been built up with three Sandown class units now operational.

UPDATED



Al Kharj 0007413

Singapore

Four Swedish Landsort type MCMVs have been acquired to establish an MCM capability.

UPDATED

South Africa

Four coastal minehunters of the River class have been built to a design based on the German Schutze class. These have been upgraded with a domestically developed tactical data system. A new MCMV is projected for acquisition in about 2015 to replace the River class. Six Type 351 Troika class control ships were purchased from Germany in late 2000 and left for South Africa on 15 January 2001. The sale did not include Troika drone craft, and there is no mine disposal equipment on the vessels. Two are operational, two are in reserve and two will be used to provide spares. Future requirements also envisage the procurement of UUVs.

UPDATED

Spain

Plans have been drawn up to acquire eight minehunters to be built by Bazán based on GRP technology. The first unit commissioned in July 1998 and the last was launched in November 1999. It was anticipated that a follow-on order for four more units would be placed and two were ordered in 2000. They will be configured for minesweeping.

UPDATED

Sweden

A modern MCM force exists based on the seven Landsort class, and a new class of four inshore minesweepers the Styrso is now operational. A new class of drone for remote control by the Styrso class is under consideration.

UPDATED

Syria

Four MCMVs remain on the fleet list but are all obsolete.

UPDATED

Taiwan

Existing forces are obsolete and ineffective and the force is being modernised. Four MWV 50 offshore oil support vessels were built by Abeking & Rasmussen in Germany in 1990-91 for the Chinese Petroleum Corporation (CPC), and on arrival in Taiwan were converted to coastal minehunters. A new class is planned, and tenders are expected to be issued when funds are made available.

UPDATED

Thailand

Two M 48 MCMVs have been built in Germany, no more units of this type will be acquired. An order for two new coastal minehunters was placed with Intermarine of Italy on 17 September 1996. Both units are now operational. Six more units may be acquired, inshore minehunters may also be acquired.

UPDATED

Turkey

2003 - First of Aydin scheduled enters service.
30 July 1999 - Contract signed with Lürssen and Abeking & Rasmussen for acquisition of six Aydin'class minehunters based on the German Type 332 design. The first boat will be built in Germany by Abeking & Rasmussen, with the remaining vessels to be built in Turkey. They will be equipped with the Nautis 3 combat system.
Mid-1999 - Turkey purchases five ex-French Circe class. Ships refitted with new Mintac tactical system developed by DCN and upgraded DUBM-21D minehunting sonar, two PAP-plus ROVs and a new navigation system.

UPDATED

Ukraine

Two Natya and two Sonya class vessels were transferred from Russia in 1996 together with a Yevgenya class unit.

UPDATED

United Arab Emirates

In December 1997, an ITT for three MHCs was issued. This now forms the main priority of the UAE.

UPDATED

United Kingdom

A cut back mid-life update for the 11 Hunt class was scheduled to commence in 2003. Under this modernisation the minehunters will have their CAAIS combat system replaced by the Nautis 3M system and Type 2193 sonar installed in place of the Type 193M. Two of the Hunt class have been transferred to Greece and one of the Sandown class *(Cromer)* is to be laid up.

A Replacement Influence Minesweeping System (RIMS) is to be acquired to replace the CIS system on the Hunt class. The new system will be a remote controlled minesweeping drone and an ITT was issued early in 2001 for an in-service date scheduled as October 2007.

The Successor Identification Friend or Foe (SIFF) system has been fitted to a number of MCMVs of the Hunt and Sandown classes. SIFF is designed to provide a sophisticated and robust system to discriminate between friendly and hostile forces. The system is designed to a common NATO standard and will enable ships to interoperate with armies and air forces of other NATO states equipped with SIFF.

UPDATED

United States

A major programme has been defined to replace obsolete units and build up a modern MCM force. A programme of 14 Avenger class and 12 Osprey class MCMVs is now complete. In addition, the use of MCACs for use in littoral mine countermeasures is being evaluated. Various programmes are underway to provide major fleet units with a remote minehunting capability.

UPDATED

Uruguay

Four former East German Kondor class minesweepers have been acquired.

UPDATED

Table XVII

MCMV building programme 1994-2004

Name (Pt N)	Type	Builder	Date	Stage
Australia				
Huon class				
Huon (M 82)	MH	ADI	15 May 1999	Cd
Hawkesbury (M 83)	MH	ADI	12 Feb 2000	Cd
Norman (M 84)	MH	ADI	26 July 2000	Cd
Gascoyne (M 85)	MH	ADI	Feb 2001	Cd
Diamantina (M 86)	MH	ADI	30 Jan 2002	Cd
Yarra (M 87)	MH	ADI	Sep 2002	Cd
Bangladesh				
Sagar (M 91)	MS	Guangzhou	27 Apr 1995	Cd
Canada				
Kingston class				
Kingston (700)	MS	Halifax	21 Sep 1996	Cd
Glace Bay (701)	MS	Halifax	26 Oct 1996	Cd
Nanaimo (702)	MS	Halifax	10 May 1997	Cd
Edmonton (703)	MS	Halifax	21 June 1997	Cd
Shawinigan (704)	MS	Halifax	14 June 1997	Cd
Whitehorse (705)	MS	Halifax	17 Apr 1998	Cd
Yellowknife (706)	MS	Halifax	18 Apr 1998	Cd
Goose Bay (707)	MS	Halifax	26 July 1998	Cd
Moncton (708)	MS	Halifax	26 July 1998	Cd
Saskatoon (709)	MS	Halifax	21 Nov 1998	Cd
Brandon (710)	MS	Halifax	5 Jan 1999	Cd
Summerside (711)	MS	Halifax	18 July 1999	Cd
Croatia				
Unnamed	MSI	Greben	1998	LD
Denmark				
Flyvefisken class				
Skaden (P 561)	MRB	Danyard	10 Apr 1995	Cd
Viben (P 562)	MRB	Danyard	15 Jan 1996	Cd
Soloven (P 563)	MRB	Danyard	28 May 1996	Cd
Slave minesearchers				
Four unnamed (MRD 3/6)	Slave MS	Danyard	1996	Cd
Four unnamed (MRD 7-10)	Slave MS	Danyard	1998-99	Cd
Egypt				
Yard No 0423	MH	Swiftships	13 July 1997	Cd
Yard No 0424	MH	Swiftships	13 July 1997	Cd
Yard No 0425	MH	Swiftships	13 July 1997	Cd
France				
Eridan class				
Sagittaire (M 650)	MH	Lorient DY	2 Apr 1996	Cd
Altair class				
Aldebaran (M 772)	M-S	Socarenam	10 Mar 1995	Cd
Germany				
Frankenthal class				
Dillingen (M 1065)	MH	Abeking & Rasmussen	25 Apr 1995	Cd
Homburg (M 1069)	MH	Kroger	26 Sep 1995	Cd
Sulzbach-Rozenburg (M 1062)	MH	Lürssen	23 Jan 1996	Cd
Fulda (M 1058)	MH	Abeking & Rasmussen	28 May 1998	Cd
Weilheim (M 1059)	MH	Lürssen	3 Dec 1998	Cd
India				
Ten unnamed (M 89/M 98)	MH	Goa Shipyard	1993	P
Italy				
Chioggia (M 5560)	MH	Intermarine	19 May 1996	Cd
Rimini (M 5561)	MH	Intermarine	26 Nov 1996	Cd
Japan				
Uwajima class				
Tobishima (678)	MH	NKK	10 Mar 1995	Cd
Yugeshima (679)	MH	Hitachi	11 Dec 1996	Cd
Nagashima (680)	MH	NKK	25 Dec 1996	Cd
Sugashima class				
Sugashima (681)	MH	NKK	16 Mar 1999	Cd
Notojima (682)	MH	Hitachi	16 Mar 1999	Cd
Tsunoshima (683)	MH	Hitachi	13 Mar 2000	Cd
Naoshima (684)	MH	NKK	16 Mar 2001	Cd
Toyoshima (685)	MH	Hitachi	4 Mar 2002	Cd
Ukushima (686)	MH	Universal	18 Mar 2003	Cd
Izushima (687)	MH	Universal	18 Mar 2003	Cd
Aishima (688)	MH	Universal	10 Oct 2003	

Name (Pt N)	Type	Builder	Date	Stage
Korea, South				
Yang Yang class				
Yang Yang	MH	Kangnam Corp	Dec 1999	Cd
Two unnamed	MH	Kangnam Corp	2001	O
Norway				
Oksøy class				
Måløy (M 342)	MH	Kvaerner-Mandal	24 Mar 1995	Cd
Hinnøy (M 343)	MH	Kvaerner-Mandal	8 Sep 1995	Cd
Alta class				
Alta (M 350)	MS	Kvaerner-Mandal	12 Jan 1996	Cd
Otra (M 351)	MS	Kvaerner-Mandal	8 Nov 1996	Cd
Rauma (M 352)	MS	Kvaerner-Mandal	2 Dec 1996	Cd
Orkla (M 353)	MS	Kvaerner-Mandal	4 Apr 1997	Cd
Glomma (M 354)	MS	Kvaerner-Mandal	1 July 1997	Cd
Pakistan				
Tripartite type				
Muhafiz (163)	MH	Lorient Dockyard	15 May 1996	Cd
Mujahid (164)	MH	Karachi Shipyard	9 July 1998	Cd
Philippines				
Three unnamed	MH		2002	P
Poland				
Kormoran class				
No 1	MCMV		January 2003	L/D
Saudi Arabia				
Sandown class				
Al Kharj (424)	MH	Vosper Thornycroft	7 Aug 1997	Cd
Singapore				
Landsort class				
Bedok (M 105)	MCMV	Karlskronavarvet	7 Oct 1995	Cd
Kallang (M 106)	MCMV	Singapore SB	7 Oct 1995	Cd
Katong (M 017)	MCMV	Singapore SB	7 Oct 1995	Cd
Punggol (M 108)	MCMV	Singapore SB	7 Oct 1995	Cd
Spain				
CME Type				
Segura (M 51)	MH	Bazan	27 Apr 1999	Cd
Sella (M 52)	MH	Bazan	28 May 1999	Cd
Tambre (M 53)	MH	Bazan	18 Feb 2000	Cd
Turia (M 54)	MH	Bazan	Sep 2000	Cd
Sweden				
YSB Type				
Styrsö (M 11)	MCMV	Karlskronavarvet	20 Sep 1996	Cd
Spårö (M 12)	MCMV	Karlskronavarvet	21 Feb 1997	Cd
Skaftö (M 13)	MCMV	Karlskronavarvet	13 June 1997	Cd
Sturkö (M 14)	MCMV	Karlskronavarvet	19 Dec 1997	Cd
Taiwan				
Eight unnamed	MCMVs		1993	P
Thailand				
Gaeta type				
Lat Ya (633)	MH	Intermarine	18 June 1999	Cd
Tha Din Daeng (634)	MH	Intermarine	18 Dec 1999	Cd
Turkey				
Aydin class				
Alanya	MCMV	Abeking & Rasmussen	6 Nov 2000	L/D
Amasra	MCMV	Pendik Naval Shipyard, Istanbul	25 July 2002	L/D
Unnamed	MCMV	Pendik Naval Shipyard, Istanbul	25 Jul 2002	L/D
Three unnamed	MCMVs			O
United Arab Emirates				
Three unnamed	MHC		10 Dec 1997	OTT
UK				
Sandown class				
Penzance (M 106)	MH	Vosper Thornycroft	14 May 1998	Cd
Pembroke (M 107)	MH	Vosper Thornycroft	6 July 2000	Cd
Grimsby (M 108)	MH	Vosper Thornycroft	25 Sep 1999	Cd
Bangor (M 109)	MH	Vosper Thornycroft	26 July 2000	Cd
Ramsey (M 110)	MH	Vosper Thornycroft	22 June 2001	Cd
Blyth (M 111)	MH	Vosper Thornycroft	20 July 2001	Cd
Shoreham (M 112)	MH	Vosper Thornycroft	July 2002	Cd

Name (Pt N)	Type	Builder	Date	Stage
USA				
Osprey class				
Oriole (MHC 55)	MH	Intermarine, Savannah	16 Sep 1995	Cd
Pelican (MHC 53)	MH	Avondale	18 Nov 1995	Cd
Kingfisher (MHC 56)	MH	Avondale	26 Oct 1996	Cd
Black Hawk (MHC 58)	MH	Intermarine, Savannah	27 Apr 1996	Cd
Falcon (MHC 59)	MH	Intermarine, Savannah	8 Feb 1996	Cd
Cormorant (MHC 57)	MH	Avondale	12 Apr 1997	Cd
Raven (MHC 61)	MH	Intermarine, Savannah	5 Sep 1998	Cd
Shrike (MHC 62)	MH	Intermarine, Savannah	31 May 1999	Cd
Robin (MHC 54)	MH	Avondale	11 May 1996	Cd
Cardinal (MHC 60)	MH	Intermarine, Savannah	18 Oct 1997	Cd

Type: AMS — Auxiliary minesweeper, MCMV — Mine countermeasures vessel, MH — Minehunter, MRB — Multirole boat (can be equipped as a minelayer/minehunter/minesweeper as required), MS — Minesweeper, M-S — Minesearcher
Stage: A — Authorised, B — Building, C — Completed, Cd — Commissioned, L — Launched, LD — Laid down, O — Ordered, OTT— Out-to-tender, P — Planned/projected, RO — Rolled out, HO — Handed over

UPDATED

Table XVIII

MCMV age 1970-2004

Country	1996-2000	1991-95	1986-90	1981-85	1976-80	Pre-1976	TOTAL
	0-5 years	6-10 years	11-15 years	16-20 years	21-25 years	over 25 years	
Albania						4	**4**
Argentina						2	**2**
Australia	4		2				**6**
Bangladesh		1 + 4[2]					**5**
Belgium		1	5	1		1	**8**
Brazil						6	**6**
Bulgaria	1	2	3	6[2]	4[2]	4[2]	**20**
Canada	12						**12**
China	2	4	2<		27	>	**35**
Cuba				6[2]			**6**
Egypt	3					10[2]	**13**
Estonia	4[2]						**4**
Finland				7		6	**13**
France	1		8	4			**13**
Germany	3	11	8			3	**25**
Greece	2[2]					3 + 8[2]	**13**
Hungary					6	45	**51**
India			6	5	6		**17**
Indonesia		9[2]	2			1[2]	**12**
Iran						3[2]	**3**
Italy	2	6		4			**12**
Japan	6	8	10	3			**27**
North Korea		<	24	>			**24**
South Korea	1	5	1			8[2]	**15**
Latvia	1[2]	2[2]					**3**
Libya			1[2]	4			**5[2]**
Lithuania	2						**2**
Malaysia				4			**4**
Netherlands			7	5			**12**
Nigeria			2				**2**
Norway	5	4					**9**
Pakistan	2		1				**3**
Poland		5	9	5		3	**22**
Romania			4	14	11	7	**36**
RFAS		<		56		>	**56**
Saudi Arabia	1	2			4		**7**
Singapore		4					**4**
South Africa	4[2]			4			**8**
Spain	4		4			5	**13**
Sweden	4	1	4	2		6	**17**
Syria			3[2]	2[2]			**5**
Taiwan		4 + 4[2]				4[2]	**12**
Thailand	2		2			2	**6**
Turkey	5[2]					19[2]	**24**
Ukraine	5[2]						**5**
UK	7	4	3	8	1		**23**
Uruguay		3[2]					**3**
USA	8	12	6				**26**
Vietnam			6[2]		2[2]		**8**
Yemen		1[2]	4[2]	1[2]			**6**
Yugoslavia	1				5	5	**11**
TOTAL	**71 + 21[2]**	**74 + 23[2]**	**113 + 14[2]**	**122 + 19[2]**	**60 + 6[2]**	**98 + 57[2]**	**678**

[1] Figures do not cover drones or miscellaneous craft such as small minesweeper auxiliaries or container modules (for example for Denmark).
[2] Transferred – hulls may be considerably older.
[3] Many of these were built over a large number of years and actual dates are not readily available. The majority however, are in need of replacement.

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MINE WARFARE VESSEL DESIGNS

Table XIX

Mine warfare vessel designs – specifications and electronics

Class	Navy	Displacement[1]	Dimensions[2]	Command	Sonars	Radar	EW	Hull
MINESWEEPERS								
K 8 (M/S boat)	Vietnam	n/k/26	16.9 × 3.2 × 0.8	None	None	None	None	
MSB (M/S boat)	Thailand	21/25	15.3 × 4 × 0.9	None	None	None	None	Wood
MSB 07 (M/S boat)	Japan	50/n/k	22.5 × 5.4 × 1	None	None	OPS-29D	None	Wood
KMV (new minesweepers)	Belgium	n/k/644	52.4 × 10.4 × 3.1		Mine avoidance	ARPA	ESM	GRP
MSC (river minesweepers)	Romania	n/k/97	33.3 × 4.8 × 0.9		None	Nayada		
MSC 268	South Korea	320/370	43 × 8 × 2.6	None	UQS-1 or TSM 2022	Decca 45	None	Wood
MSC 268 & 292	Iran	320/384	44.5 × 8.5 × 2.5	None	UQS-1D	Decca 707	None	Wood
MSC 289	South Korea	315/380	44.3 × 8.3 × 2.7	None	UQS-1 or TSM 2022	Decca 45	None	Wood
MSC 294	Greece	320/370	43.3 × 8.5 × 2.5		UQS-1D	Decca		Wood
M 15	Sweden	70/n/k	27.7 × 5 × 2	None	None	Terma	None	
M 301	Yugoslavia	n/k/38				Racal Decca		
PO 2 Type 501	Bulgaria	n/k/56	21.5 × 3.5 × 1					
T 43	Albania	500/580	58 × 8.4 × 2.1	None	Stag Ear	Ball End, Neptun	None	Steel
T 43 (China built)	Bangladesh	520/590	60 × 8.8 × 2.3	None	Tamir II	Fin Curve	None	Steel
T 43 Type 010	China	520/590	60 × 8.8 × 2.3	None	Tamir II	Fin Curve/Type 756	None	Steel
T 43	Egypt	500/580	58 × 8.4 × 2.1	None	Stag Ear	Don 2	None	Steel
T 43	Indonesia	500/580	58 × 8.4 × 2.1	None	Stag Ear	Decca 110	None	Steel
T 43	Syria	500/580	60 × 8.4 × 2.1	None	Stag Ear (MG 11)	Ball End, Don 2	None	Steel
T 301	Albania	146/170	38 × 5.7 × 1.6	None	None	None	None	Wood
T 301	Romania	145/170	38 × 5.7 × 1.6	None	None	None	None	Wood
Adjutant & MSC 268	Spain	355/384	43.9 × 8.5 × 2.5	None	UQS-1D	TM 626 or RM 914	None	Wood
Adjutant & MSC 268	Taiwan	320/375	43.9 × 8.5 × 2.4		UQS 1D	Decca 707		Wood
Adjutant, MSC 268 & MSC 294	Turkey	320/370	43 × 8 × 2.6	None	UQS-1D	TM 1226	None	Wood
Aggressive	Spain	720/817-853	52.6 × 10.7 × 4.3	None	SQQ-14	TM 1226 & Decca 626	None	Wood
Aggressive	Taiwan	720/780	52.6 × 10.7 × 4.3		SQQ-14	SPS-53L		Wood
Alta	Norway	n/k/375	55.2 × 13.6 × 2.5	Micos	SA 950	Racal Decca	None	FRP
Arko	Sweden	285/300	44.4 × 7.5 × 3	None	None	Skanter 009	None	Wood
Baltika Type 1380	RFAS	210/235	25.4 × 6.8 × 3.3	None	None	Spin Trough	None	Wood
Bluebird	Denmark	350/376	45 × 8.5 × 2.6	None	UQS-1D	NWS 3	None	Wood
Bluebird	Thailand	317/384	44.3 × 8.2 × 2.6	None	UQS-1D	Decca TM 707	None	Wood
Cape	Iran	200/239	33.9 × 7 × 2.4	None	None	Decca 303N	None	
Cove	Turkey	180/235	34 × 7.1 × 2.4	None	None		None	
Frauenlob Type 394	Germany	n/k/246	38 × 8.2 × 2	None	None	Kelvin Hughes 14/9	None	
Gassten	Sweden	120/135	24 × 6.5 × 3.5	None	None	Skanter 009	None	GRP
Ham	Yugoslavia	120/159	32.5 × 6.5 × 1.7	None	None	Decca 45	None	Wood
Hameln	Germany	590/635	54.4 × 9.2 × 2.5	MWS-80	DSQS-11M	WM20/2, SPS-64	DR 2000	Steel
Hisingen	Sweden	130/150	24 × 6.5 × 3.5	None	None	Skanter 009	None	Wood
Kiiski	Finland	18/20	15.2 × 4.1 × 1.2	None	None	Type 1229	None	GRP
Kondor II Type 89	Indonesia	n/k/310	56.7 × 7.5 × 2.4	None	AQS 17	TSR 333	None	
Kondor II Type 89.2	Latvia	n/k/310	56.7 × 7.5 × 2.4	None	None	I-band	None	
Kondor II	Uruguay	n/k/310	56.7 × 7.5 × 2.4	None	None	TSR 333 or Raytheon 1900	None	
Kuha	Finland	n/k/90	26.6 × 6.9 × 2	None	None	Type 1229	None	GRP
Leniwka Type 410S	Poland	195/269	25.8 × 7.2 × 2.7	None	None	SRN 311	None	
Lienyun	Vietnam	n/k/400	40 × 8 × 3.5					
Musca	Romania	660/790	60.8 × 9.5 × 2.8		Hull	Krivach, Drum Tilt		
Natya I Type 266M	India	650/804	61 × 10.2 × 3	None	MG 69/79	Don 2, Drum Tilt	None	Aluminium/ steel
Natya I Type 266ME	Libya	650/804	61 × 10.2 × 3	None	Hull-mounted	Don 2. Drum Tilt	None	Aluminium/ steel
Natya I Type 266M	RFAS	650/804	61 × 10.2 × 3	None	MG 79/89 or Tamir	Drum Tilt & Don 2 or Low Trough	None	Aluminium/ steel
Natya I Type 266M	Syria	650/804	61 × 10.2 × 3	None	MG 79/89	Don 2, Drum Tilt	None	Aluminium/ steel
Natya I Type 266ME	Yemen	650/804	61 × 10.2 × 3	None	MG 69/79	Don 2	None	Aluminium/ steel
Nestin (river)	Hungary	66/72.3	27 × 6.5 × 1.2	None	None	Decca Type 101	None	
Nestin (river)	Iraq	65/72	27 × 6.5 × 1.2	None	None	Decca Type 101	None	
Nestin (river)	Yugoslavia	65/72	27 × 6.3 × 1.6	None	None	TM 1226		
Notec Type 207P	Poland	208/225	38.3 × 7.2 × 1.8	None	MG 79/89	SRN 302	None	GRP
Olya Type 1259	Bulgaria	44/64	25.8 × 4.5 × 1	None	None	Pechora	None	Wood
Olya Type 1259	RFAS	44/64	25.8 × 4.5 × 1	None	None	Don 2	None	Wood
River	Bangladesh	n/k/890	47.5 × 10.5 × 2.9	None	System 880	TM 1226C	None	Steel
River	UK	n/k/770	47.5 × 10.5 × 2.9	None	System 880	TM 1226C	None	Steel
Schutze	Brazil	230/280	47.2 × 7.2 × 2.1	None	None	ZW06		Wood
Sonya Type 1265	Bulgaria	350/450	48 × 8.8 × 2	None	MG 69/79	Kivach	None	Wood & GRP
Sonya Type 1265	Cuba	350/450	48 × 8.8 × 2	None	MG 69/79	Don 2	None	Wood & GRP
Sonya Type 1265	Syria	350/450	48 × 8.8 × 2	None	MG 69/79	Don 2	None	Wood & GRP

Class	Navy	Displacement[1]	Dimensions[2]	Command	Sonars	Radar	EW	Hull
Sonya Type 1265	Vietnam	350/400	48 × 8.8 × 2	None	MG 69/79	Nayada	None	Wood & GRP
Styrsö	Sweden	n/k/175	36 × 7.9 × 2.2	Ericsson	RESON & EdgeTech	Bridgemaster		GRP sandwich
Vanya Type 257D	Bulgaria	220/245	40 × 7.3 × 1.8	None	MG 69/79	Don 2	None	Wood & GRP
Vanya	Syria	220/245	40 × 7.3 × 1.8	None	MG 69/79	Don 2	None	Wood & GRP
Vegesack	Turkey	362/378	47.3 × 8.6 × 2.9	None	Simrad	Decca 707	None	
Wosao	China	320/n/k	44.8 × 6.8 × 2.3		Hull-mounted	China Type 753		Steel
Yang Yang	South Korea	880/n/k	59.4 × 10.5 × 3	TSM 2061	Type 2093	I-band	None	GRP
Yevgenya Type 1258	Bulgaria	77/90	24.5 × 5.5 × 1.4	None	MG 7	Spin Trough	None	GRP
Yevgenya	India	77/90	24.6 × 5.5 × 1.5	None	MG 7	Spin Trough	None	GRP
Yevgenya	Syria	77/90	24.6 × 5.5 × 1.5	None	MG 7	Spin Trough	None	GRP
Yukto I	North Korea	n/k/60	24 × 4 × 1.7	None	None	Skin Head	None	Wood
Yukto II	North Korea	n/k/52				Skin Head		Wood
Yurka Type 266	Egypt	400/540	52.4 × 9.4 × 2.6	None	Stag Ear	Don 2	None	Aluminium/ steel
Yurka Type 266	RFAS	400/540	52.4 × 9.4 × 2.6	None	Stag Ear	Drum Tilt & Don 2 or Spin Trough	Watch Dog	Aluminium/ steel
Yurka Type 266	Vietnam	400/540	52.4 × 9.4 × 2.6	None	Stag Ear	Don 2 & Drum Tilt	None	Aluminium/ steel
MINEHUNTERS								
MHC (Swiftships type)	Egypt	178/203	33.8 × 8.2 × 2.3	SYQ-12 mod	TSM 2022	Sperry	None	GRP
Bay	Australia	100/178	30.9 × 9 × 2	MWS-80-5	DSQS-11M	Type 1006	None	GRP sandwich
Circe	Turkey	460/510	50.9 × 8.9 × 3.4	None	DUBM 20B	Type 1229	None	Wood
Flyvefisken	Denmark	n/k/450	54 × 9 × 3		Ibis 43			GRP
Frankenthal	Germany	590/650	54.4 × 9.2 × 2.5	MWS-80	DSQS-11M	SPS-64	DR 2000	Steel
Huon (Gaeta)	Australia	n/k/720	52.5 × 9.9 × 3.0	Nautis 2M	Type 2093	Type 1007	Prism	GRP
Lida Type 10750	RFAS	n/k/135	31.5 × 6.5 × 1.6		Karbarga I	Pechora		GRP/ aluminium/ steel
Oksøy	Norway	n/k/375	55.2 × 13.6 × 2.5[3]	Micos	TSM 2023N	Racal Decca	None	FRP
Osprey	USA	750/918	57.3 × 11 × 2.9	SQQ-13 & SYQ-109	SQQ-32	SPS-64(V)9		GRP
Sandown	Saudi Arabia	450/480	52.7 × 10.5 × 2.1	Nautis M	Type 2093	Type 1007	Shiploc	GRP
Sandown	UK	450/484	52.5 × 10.5 × 2.3	Nautis M	Type 2093	Type 1007		GRP
Segura	Spain	n/k/530	54 × 10.7 × 2.2	Nautis	SQQ-32	I-band		GRP
Swallow	South Korea	470/520	50 × 8.3 × 2.6	Mains 500	193M Mod 1 or 3	Raytheon; I-band		GRP
Tripartite	Belgium	562/595	51.5 × 8.9 × 2.5	Evec	DUBM 21B	Type 1229C		GRP
Tripartite	France	562/595	51.5 × 8.9 × 2.5	Evec	DUBM 21B or 21D	Type 1229C	None	GRP
Tripartite	Indonesia	502/568	51.5 × 8.9 × 2.5	Ibis V	TSM 2022	Type 1229C		GRP
Tripartite	Netherlands	562/595	51.5 × 8.9 × 2.6	Sewaco IX	DUBM 21A	Type 1229C		GRP
Tripartite	Pakistan	562/595	51.5 × 8.9 × 2.9	TSM 2061[4]	DUBM 21B or 21D[5]	Type 1229C	None	GRP
Yevgenya Type 1258	Angola	77/90	24.5 × 5.5 × 1.4	None	MG-7	Don 2	None	GRP
Yevgenya Type 1258	Cuba	77/90	24.6 × 5.5 × 1.5	None	MG-7	Don 2	None	GRP
Yevgenya Type 1258	RFAS	77/90	24.6 × 5.5 × 1.5	None	MG-7	Spin Trough or Mius	None	GRP
Yevgenya Type 1258	Vietnam	77/90	24.6 × 5.5 × 1.5	None	MG 7	Spin Trough	None	GRP
Yevgenya Type 1258	Yemen	77/90	24.6 × 5.5 × 1.5	None	MG 7	Spin Trough	None	GRP
MINEHUNTERS/SWEEPERS								
MSC 322	Saudi Arabia	320/407	46.6 × 8.2 × 2.5	None	SQQ-14	SPS-55	None	Wood
MWV 50	Taiwan	n/k/500	49.7 × 8.7 × 3.1	Ibis V	TSM-2022	I-band		
Adjutant	Greece	330/402	44.2 × 8.5 × 2.4	None	SQQ-14 or UQS-1D	Decca or 3RM 20R	None	Wood
Avenger	USA	1,145/1,312	68.3 × 11.9 × 3.5	Nautis M[6]	SQQ-32	SPS-55 & SPS-66(V)9		Wood & GRP
Aydin	Turkey	n/k/715	54.46 × 9.66 × 2.5	Nautis 3M	Type 2093	Type 1007	n/k	Steel
Bang Rachan	Thailand	390/444	48 × 9.3 × 2.7	MWS-80R	DSQS-11H	STN 8600 ARPA		Composite
Gaeta	Italy	592/697	52.45 × 9.9 × 2.9	Mactis	SQQ-14(IT)	SSN-728V(3)	SPN-714V(2)	GRP
Hatsushima	Japan	440/510	55 × 9.4 × 2.4		ZQS 2B	OPS-9		Wood
Hunt	UK	615/750	60 × 10 × 3.4	CAAIS DBA 4	Type 193M Mod 1 Type 2059 & Mil Cross	Type 1006 or 1007	Matilda UAR 1 Mentor A (in some)	GRP
Kingston	Canada	713/962	55.3 × 11.3 × 3.05		Towed side-scan	Type 6000		Steel
Krogulec Type 206FM	Poland	426/503	60 × 7.7 × 2.1	Pstrokosz	SHL100MA & SHL 200	TRN 823	None	
Landsort	Singapore	270/360	47.5 × 9.6 × 2.3	Ibis V	TSM 2022	Terma	None	GRP
Landsort	Sweden	270/360	47.5 × 9.6 × 2.3	9MJ400 + Mains	TSM-2022	Terma	Matilda	GRP
Lat Ya (Gaeta)	Thailand	650/680	52.45 × 9.9 × 2.9	MWS 80-6	DSQS-11M	9,600 M	n/k	GRP
Lerici	Italy	470/572	50 × 9.9 × 2.6	Mactis	SQQ-14(IT)	SSN-714V(2)	SPN-728V(3)	GRP
Lerici	Malaysia	470/572	51 × 9.9 × 2.8	Ibis V	TSM 2022	Decca Type 1226	None	GRP
Lerici	Nigeria	470/540	51 × 9.9 × 2.8	Ibis V	TSM 2022	Decca Type 1226	None	GRP
Lindau Type 331	Germany	388/463	47.1 × 8.3 × 3	None	DSQS-11 or 193M	14/9 or TRS N	None	Wood
Lindau Type 351	Germany	390/465	47.1 × 8.3 × 2.8	None	DSQS-11	TRS N	ESM	Wood
Notec II Type 207M	Poland	208/225	38.3 × 7.2 × 1.6	None	SHL 100/200	SRN 401XTA or RN 231	None	GRP
River	South Africa	n/k/380	48 × 8.5 × 2.5	None	Simrad, Klein	Racal Decca		Wood
Sonya Type 1265/1265M	RFAS	350/450	48 × 8.8 × 2	None	MG 69/79	Don 2 or Krivach or Nayada	None	Wood & GRP
Sugashima	Japan	n/k/510	57.7 × 9.4 × 4.2	Nautis-M	Type 2093	OPS-39		Wood
Uwajima	Japan	490/586	58 × 9.4 × 2.9		ZQS 3	OPS-39		Wood
Vanya Type 257D/DM/DT	RFAS	200/245	40 × 7.3 × 1.8	None	MG 69/79	Don 2 or Don Kay	None	Wood

Class	Navy	Displacement[1]	Dimensions[2]	Command	Sonars	Radar	EW	Hull
Vukov Klanac (Ton)	Yugoslavia	365/424	46.4 × 8.6 × 2.5	None	TSM 2022	DRBN 30		Wood
Yaeyama	Japan	1,000/1,275	67 × 11.8 × 3.1		SQQ-32	OPS-39		Wood
DRONES								
MSD	Australia		7.3 × 2.8 × 0.6	None	None	None	None	GRP
MSF	Denmark	n/k/125	26.5 × 7 × 2.1	None	TSM 2054	n/k	None	GRP
SAM	Sweden	n/k/20	18 × 6.1 × 1.6	None	None	None	None	GRP
SAM II	Sweden	n/k/56	22.5 × 11.7	None				
SAV	Denmark	32/38	18.2 × 4.75 × 1.2	None	TSM 2054	Furuno	None	GRP
Futi Type 312	China	47/n/k	20.9 × 3.9 × 2.1	None	None	None	None	
Futi Type 312	Pakistan	47/n/k	20.9 × 3.9 × 2.1	None	None	None	None	
Ilyusha Type 1253	RFAS	n/k/85	26.4 × 5.9 × 1.4	None	None	Spin Trough		
Tanya Type 1300	RFAS	n/k/73	26.5 × 4 × 1.5	None	None	Spin Trough		
Troika	Germany	99	26.9 × 4.6 × 1.4	None	None	None	None	Wood

[1] Standard/Full Load tonnes.
[2] Length (overall) × beam × draught in metres.
[3] 0.9 m on cushion.
[4] In last pair
[5] TSM 2054 in last pair.
[6] In last two ships and to be retrofitted to rest of class.
n/k not known

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Table XX

Mine countermeasure vessel designs – mine warfare systems

Class	Navy	ROVs	Sweep gear	Guns[1]	Missiles	Mines[2]
MINESWEEPERS						
K8 (M/S boat)	Vietnam					
MSB (M/S boat)	Thailand					
MSB 07 (M/S boat)	Japan					
KMV (new minesweepers)	Belgium	2 ROVs	Sterne & Mk 9 wire	1-25		
MSC (river minesweepers)	Romania					6
MSC 268	South Korea			1 × 2-20 or 2 × 1-20		
MSC 268 & 292	Iran		Wire + M, A	1 × 2-20		
MSC 289	South Korea			1 × 2-20 or 2 × 1-20		
MSC 294	Greece			1 × 2-20		
M 15	Sweden					
M 301	Yugoslavia			2-20		
PO 2 Type 501	Bulgaria					
T 43	Albania			2 × 2-37		16
T 43 (China built)	Bangladesh		MPT-3 wire	2 × 2-37		12-16
			M, A	& 2 × 2-25		
T 43 Type 010	China		MPT-3 wire	1 or 2 × 2-37		12-16
			M, A	1-85 in some		
T 43	Egypt			2 × 2-37		20
T 43	Indonesia			2 × 2-37		
T 43	Syria			1 × 2-37		16
T 301	Albania			2-37		18
T 301	Romania			2 × 1-37		18
Adjutant & MSC 268	Spain			1 × 2-20		
Adjutant & MSC 268	Taiwan			1 × 2-20		
Adjutant, MSC 268 & MSC 294	Turkey			1 × 2-20		
Aggressive	Spain	Pluto[3]		1 × 2-20		
Aggressive	Taiwan		SLQ-37 wire, M & A			
Alta	Norway	None	Oropesa, Agat, Elma	1 or 2-20	1 × 2 Sadral	
Arko	Sweden			1-40		
Baltika Type 1380	Russian Federation					
Bluebird	Denmark			1 Bofors 40		
Bluebird	Thailand		Mk 4 & Mk 6 Type Q2 M	1 × 2-20		
Cape	Iran		Wire, M, A			
Cove	Turkey					
Frauenlob Type 394	Germany			1-40		n/k
Gassten	Sweden			1-20		
Ham	Yugoslavia			1 × 2-20		
Hameln	Germany		SDG-31 wire	2 × 1-40	2 × 4 Stinger	60
Hisingen	Sweden			1-20		
Kiiski	Finland					
Kondor II Type 89	Indonesia		Dyad influence	3 × 2-25		2 rails
Kondor II Type 89.2	Latvia	None	Temp. removed	3 × 2-23		
Kondor II	Uruguay		MSG-3 variable depth	1-40		2 rails
Kuha	Finland	1 × Pluto	M, A, P	1 × 2-23		
Leniwka Type 410S	Poland		Wire + M, A			
Lienyun	Vietnam					
Musca	Romania			2 × 2-30		
Natya I Type 266M	India		GKT-2 wire	2 × 2-30 & 2 × 2-25	2 × 4 SA-N-5[3]	10
			AT-2 A			
			TEM-3 M			
Natya I Type 266ME	Libya		GKT-2 wire	2 × 2-30 & 2 × 2-25		10
			AT-2 A			
			TEM-3 M			
Natya I Type 266M	Russian Federation		1 or 2 GKT-2 wire	2 × 2-30 or 2 × 6-30	2 × 4 SA-N-5/8 & 2 × 2-25	10
			1 AT-2 A			
			1 TEM-3 M			
Natya I Type 266M	Syria			2 × 2-30 & 2 × 2-25	2 × 4 SA-N-5	
Natya I Type 266ME	Yemen		Wire, M, A	2 × 2-30 & 2 × 2-25		10
Nestin (river)	Hungary	None	M, A Kram wire	1 × 4-20, 2 × 1-20	24	
Nestin (river)	Iraq		Wire + M, A	1 × 3-20 & 2 × 1-20		24
Nestin (river)	Yugoslavia		Wire + M, A	1 × 3-20 & 2 × 1-20		24
Notec Type 207P	Poland		Wire + M, A	1 × 2-23		24
Olya Type 1259	Bulgaria		AT-6, SZMT-1			
			3 PKT-2			
Olya Type 1259	Russian Federation			1 × 2-25		
River	Bangladesh		Wire	1-40		
River	UK		Wire	1-40		
Schutze	Brazil		Wire + M, A	1-40		
Sonya Type 1265	Bulgaria			1 × 2-30, 1 × 2-25		5
Sonya Type 1265	Cuba			1 × 2-30		8
				1 × 2-25		
Sonya Type 1265	Syria			1 × 2-30 or 2 × 1-30 & 1 × 2-25		8
Sonya Type 1265	Vietnam			2-30 & 1 × 2-25		8
Styrsö	Sweden	2 × DE	AK-90 A			
			EL-90 M & wire			

Class	Navy	ROVs	Sweep gear	Guns[1]	Missiles	Mines[2]
Vanya Type 257D	Bulgaria			1 × 2-30		8
Vanya	Syria			1 × 2-30		8
Vegesack	Turkey			1 × 2-20		
Wosao	China		Wire, M, A	2 × 2-25		6
Yevgenya Type 1258	Bulgaria			1 × 2-25		
Yevgenya	India			1 × 2-25		
Yevgenya	Syria			1 × 2-25		
Yukto I & II	North Korea			1-37 or 1 × 2-25		8
Yurka Type 266	Russian Federation		Wire + M, A	2 × 2-30	2 × 4 SA-N-5/8	10
Yurka Type 266	Egypt	? ROV		2 × 2-30		10
Yurka Type 266	Vietnam			2 × 2-30		10
MINEHUNTERS						
Segura	Spain	2 Pluto Plus		1-20		
MHC (Swiftships type)	Egypt	Pluto				
Bay	Australia	2 PAP 104				
Circe	Turkey	PAP	None	1-20		
Flyvefisken	Denmark	DE	None	1 × 76		n/k
Frankenthal	Germany	2 × Pinguin		1-40	2 × 4 Stinger	
Huon (Gaeta)	Australia	2 × DE	Double Oropesa wire Mini-Dyad influence	1-30 mm, 2 × 2-20 mm		
Lida Type 10750E	Russian Federation		1 wire + M, A	1 × 6-30		
Oksøy	Norway	2 Pluto	None	1 or 2-20	1 × 2 Sadral	
Osprey	USA	SLQ-48	SLQ-53			
Sandown	UK	2 PAP 104		1-30		
Sandown	Saudi Arabia	2 PAP 104		1 × 2-30		
Swallow	South Korea	2 Pluto	Wire	1-20		
Tripartite	Belgium	2 PAP 104	Mechanical	1-20		
Tripartite	France	2 PAP 104	AP-4 + wire	1-20		
Tripartite	Indonesia	2 PAP 104	OD3 oropesa wire F-82 M & AS 203 A	2 × 1-20		
Tripartite	Netherlands	2 PAP 104	OD 3 wire	1-20		
Tripartite	Pakistan	2 PAP 104	Wire + MKR 400 A & MRK 960 M	1-20		
Yang Yang	South Korea	2 × Pluto Gigas	CIS, Mk 9	1 × 20 Sea Vulcan		
Yevgenya Type 1258	Angola		M	1 × 2-25		
Yevgenya Type 1258	Cuba					
Yevgenya Type 1258	Russian Federation			1 × 2-25		8 racks
Yevgenya Type 1258	Vietnam			1 × 2-25		
Yevgenya Type 1258	Yemen			1 × 2-25		
MINEHUNTERS/SWEEPERS						
MSC 322	Saudi Arabia		Wire + M	1-20		
MWV 50	Taiwan	2 Pinguin		1-40		
Adjutant	Greece			1-20		
Avenger	USA	2 SLQ-48	SLQ-37M/A SLQ-38 Oropesa wire ALQ 166 M, M/S vehicle			
Aydin	Turkey	2 × PAP 104 Mk 5	SLQ-38 Oropesa	1 × 30		
Bang Rachan	Thailand	2 Pluto	Wire + M, A	3-20		
Gaeta	Italy	1 MIN Mk 2 1 Pluto	Oropesa wire	1 × 2-20		
Hatsushima	Japan		S4	1 × 3-20		
Hunt	UK	2 PAP 104	MS 14 M MSSA Mk 1 A Mk 8 oropesa wire	1-30 2-20		
Krogulec Type 206F/M	Poland	1 × Ukwial	MT-2, M, A	1 × 2-23	2 × 4 SA-N-5	8 or 16
Kingston	Canada	ROV module	M/S module	1-40		
Landsort	Singapore	2 PAP 104	SAM wire	1-40		2 rails
Landsort	Sweden	2 × DE	Wire + M, A	1-40		
Lat Ya (Gaeta)	Thailand	2 Pluto Plus	Wire + MS 106, Mini Dyad	1 × 30		
Lerici	Italy	1 MIN 77 1 Pluto	Oropesa wire	1-20		
Lerici	Malaysia	2 PAP 104	'O' Mis-4 wire	1-40		
Lerici	Nigeria	2 Pluto	'O' Mis-4 wire	1 × 2-30 & 2 × 1-20		
Lindau Type 331	Germany	2 × PAP 104		1-40		
Lindau Type 331	Germany	None	Wire	1-40		
Notec II Type 207M	Poland		Wire, + M, A	1 × 2-23	2 SA-N-5	6-24
River	South Africa	2 PAP 104		1-20		
Sonya Type 1265/1265M	Russian Federation			2 × 6-30 or 1 × 2-30 & 1 × 2-25	2 × 4 SA-N-5	8
Sugashima	Japan	PAP 104	Dyad influence	1 × 3-20		
Uwajima	Japan		S7	1 × 3-20		
Vanya Type 257D/DM/DT	Russian Federation			1 × 2-30 & 1 × 2-25		8-12
Vukov Klanac (Ton)	Yugoslavia	PAP 104[4]		2-20		
Yaeyama	Japan	S7	S8 (SLQ-48)	1 × 3-20		

Class	Navy	ROVs	Sweep gear	Guns[1]	Missiles	Mines[2]
DRONES						
MSD	Australia					
MSF	Denmark					
SAM	Sweden		M, A			
SAM II	Sweden		A, M +?E			
SAV	Denmark					
Futi Type 312	China		M, A			
Futi Type 312	Pakistan		M, A			
Ilyusha Type 1253	Russian Federation					
Tanya Type 1300	Russian Federation					
Troika	Germany		M, A			

[1] Machine guns not listed
[2] Depth charges are not listed
[3] In some
[4] In minehunters

DE Double Eagle
M Magnetic sweep
A Acoustic sweep
P Pressure sweep

E Electric influence
n/k not known

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Table XXI

Mine warfare vessel designs – machinery

Class	Navy	Engines[A]	Shafts	Thrusters	Auxiliary	Propellers	Speed	Range	Crew
MINESWEEPERS									
K 8 (M/S boat)	Vietnam	2/300	2				18		6
MSB (M/S boat)	Thailand	1/165	1				8		10
MSB 07 (M/S boat)	Japan	2/480	2				11		10
KMV (new minesweepers)	Belgium	2/2,176	2	n/k	None	cp	16	3,000/12	26
MSC (river minesweepers)	Romania	2/870	2				13		
MSC 268	South Korea	2/880	2				14	2,500/14	40
MSC 268 & 292	Iran	4/696[3]	2				13	2,400/10	40
MSC 289	South Korea	4/696	2				14	2,500/14	40
MSC 294	Greece	2/1,760	2				13	2,500/10	39
M 15	Sweden	2/320	2				12		10
M 301	Yugoslavia	2/n/k	2				12		
PO 2 Type 501	Bulgaria	1/300	2				12		8
T 43	Albania	2/2,000	2	None			15	3,000/10	65
T 43 (China built)	Bangladesh	2/2,000	2				14	3,000/10	70
T 43 Type 010	China	2/2,000	2				14	3,000/10	70
T 43	Egypt	2/2,000	2				15	3,000/10	65
T 43	Indonesia	2/2,000	2				15	3,000/10	77
T 43	Syria	2/2,000	2				15	3,000/10	65
T 301	Albania	3/900	3	None			14	2,200/9	25
T 301	Romania	3/900	3	None			14.5	2,200/9	25
Adjutant & MSC 268	Spain	2/880	2				14	2,700/10	39
Adjutant & MSC 268	Taiwan	2/880	2				13	2,500/12	35
Adjutant & MSC 268 & MSC 294	Turkey	4/696	2				14	2,500/10	35
Aggressive	Spain	4/2,280	2			cp	14	3,000/10	74
Aggressive	Taiwan	4/2,280	2			cp	14	3,000/10	86
Alta	Norway	2/3,700		2[2]	2/1,740		20.5	1,500/20	32
Arko	Sweden	2/1,360	2				14		25
Baltika Type 1380	RFAS	1/300	1			cp	9	1,400/9	10
Bluebird	Denmark	2/880	2				13	3,000/10	31
Bluebird	Thailand	2/880	2				13	2,750/12	43
Cape	Iran	4/1,300	2				13	1,200/12	21
Cove	Turkey	4/696	2				13	900/11	25
Frauenlob Type 394	Germany	2/2,200	2				12+	700/14	25
Gassten	Sweden	1/460	1				11		
Ham	Yugoslavia	2/1,100	2				14	2,000/9	22
Hameln	Germany	2/6,140	2		Electric	cp	18		37
Hisingen	Sweden	1/380	1				10		
Kiiski	Finland	2/340				2[2]	11	260/11	4
Kondor II Type 89	Indonesia	2/4,408	2			cp	17	2,000/14	31
Kondor II Type 89.2	Latvia	2/4,408	2			cp	17		31
Kondor II	Uruguay	2/4,408	2			cp	17	2,000/15	31
Kuha	Finland	2/600	1			cp	12		15
Leniwka Type 410S	Poland	1/570	1				11	3,100/8	16
Lienyun	Vietnam	1/400	1					8	
Musca	Romania	2/4,800	2				17		
Natya I Type 266M	India	2/5,000	2			cp	16	3,000/12	82
Natya I Type 266ME	Libya	2/5,000	2			cp	16	3,000/12	67
Natya I Type 266M	RFAS	2/5,000	2			cp	16	3,000/12	67
Natya I Type 266M	Syria	2/5,000	2			cp	16	3,000/12	65
Natya I Type 266ME	Yemen	2/5,000	2			cp	16	3,000/12	67
Nestin (river)	Hungary	2/520	2				15	860/11	17
Nestin (river)	Iraq	2/520	2				12	860/11	17
Nestin (river)	Yugoslavia	2/520	2				15	860/11	17
Notec Type 207P	Poland	2/1,874	2				14	1,100/9	24
Olya Type 1259	RFAS	2/471	2				12	500/10	15
Olya Type 1259	Bulgaria	2/471	2				12	300/10	15
River	Bangladesh	2/3,100	2	None			14	4,500/10	30
River	UK	2/3,100	2	None			14	4,500/10	30
Schutze	Brazil	4/4,500	2			2 × cp	24	710/20	39
Sonya Type 1265	Bulgaria	2/2,000	2				15	1,500/14	43
Sonya Type 1265	Cuba	2/2,000	2				15	3,000/10	43
Sonya Type 1265	Syria	2/2,000	2				15	3,000/10	43
Sonya Type 1265	Vietnam	2/2,000	2				15	3,000/10	43
Styrsö	Sweden	2/1,104	2	1 bow			13		17
Vanya Type 257D	Bulgaria	1/2,502	1				16	2,400/10	36
Vanya	Syria	1/2,500	1				16	1,400/14	36
Vegesack	Turkey	2/1,500	2			cp	15		33
Wosao	China	4/4,400	4				25	500/15	40
Yevgenya Type 1258	Bulgaria	2/600	2				11	300/10	10
Yevgenya	India	2/600	2				11	300/10	10
Yevgenya	Syria	2/600	2				11	300/10	10
Yukto I	North Korea	2/	2				18		22
Yukto II	North Korea	2/	2				18		22
Yurka Type 266	RFAS	2/5,350	2				17	1,500/12	45
Yurka Type 266	Egypt	2/5,350	2				17	1,500/12	45
Yurka Type 266	Vietnam	2/5,350	2				17	1,500/12	45

Class	Navy	Engines[A]	Shafts	Thrusters	Auxiliary	Propellers	Speed	Range	Crew
MINEHUNTERS									
MHC (Swiftships type)	Egypt	2/1,068		1/300		2 × Schottel	12.4	2,000/10	25
Bay	Australia	2/650	2			2 × Schottel	10	1,500/10	14
Circe	Turkey	1/1,800	1				15	3,000/12	48
Flyvefisken	Denmark	1/5450 GT 2/5800	3	1 bow	1/500	cp (outer)	30	2,400/18	19-29
Frankenthal	Germany	2/5,550	2		1	cp	18		37
Huon (Gaeta)	Australia	1/1,460	1	3	3/506	cp	14	1,500/12	36
Lida Type 10750E	RFAS	3/900	3				12	650/10	14
Oksøy	Norway	2/3,700		2[2]	2/1,740		20.5	1,500/20	38
Osprey	USA	2/1,600		1 bow/180	2/360	2 × VS	12	1,500/10	51
Sandown	Saudi Arabia	2/1,500	2	2 bow		2 × VS	13	3,000/12	34
Sandown	UK	2/1,500	2	2 bow		2 × VS	13	3,000/12	34
Segura	Spain	2/1,523		2	2/125	2 × VS	14	2,000/12	40
Swallow	South Korea	2/1,028		1 bow/102		2 × VS	15	2,000/10	44
Tripartite	Belgium	1/1,860	1	2 bow	2/240	2 × cp	15	3,000/12	46
Tripartite	France	1/1,860	1	2 bow	2/240	2 × cp	15	3,000/12	46
Tripartite	Indonesia	2/2,610	2	2 bow/150	2/240	2 × Schottel	15	3,000/12	46
Tripartite	Netherlands	1/1,860	1	2 bow	2/240	2 × cp	15	3,000/12	29-42
Tripartite	Pakistan	1/1,860	1	2 bow	2/240	2 × cp	15	3,000/12	46
Yang Yang	South Korea	2/2,000	2	1 bow/134	n/k	2 × VS	15	3,000/12	48
Yevgenya Type 1258	Angola	2/600	2				11	300/10	10
Yevgenya Type 1258	Cuba	2/600	2				11	300/10	10
Yevgenya Type 1258	RFAS	2/600	2				11	300/10	10
Yevgenya Type 1258	Vietnam	2/600	2				11	300/10	10
Yevgenya Type 1258	Yemen	2/600	2				11	300/10	10
MINEHUNTERS/SWEEPERS									
MSC 322	Saudi Arabia	2/1,200	2				13		39
MWV 50	Taiwan	2/2,180	2				14	3,500/14	45
Adjutant	Greece	2/880	2				14	2,500/10	38
Avenger	USA	4/2,400	2	1/350	2/400	cp	13.5		81
Aydin	Turkish	2/n/k	2	2 bow	n/k	2 × VS	14	n/k	53
Bang Rachan	Thailand	2/3,220	2		1 electric motor	cp	17	3,100/12	33
Gaeta	Italy	1/1,985	1	3 × 506	3/1,481	cp	14	2,000/12	51
Hatsushima	Japan	2/1,440	2				14		45
Hunt	UK	2/1,900	2	1 bow	1/780		15	1,500/12	45
Kingston	Canada	4-2/3,000[4]		2 Z drive		2 fp	15	5,000/8	37
Krogulec Type 206F/M	Poland	2/3,740	2			cp	18	2,000/17	48
Landsort	Singapore	4/1,592				2 × VS	15	2,000/12	38
Landsort	Sweden	4/1,592				2 × VS	15	2,000/12	29
Lat Ya (Gaeta)	Thailand	2/1,600			3/1,481	2 × VS	14	2,000/12	47
Lerici	Italy	1/1,985	1	3 × 506	3/1,481	cp	14	1,500/14	47
Lerici	Malaysia	2/2,605	2		3/1,481	cp	16	2,000/12	42
Lerici	Nigeria	2/3,120				2[2]	15.5	2,500/12	50
Lindau Type 33I	Germany	2/4,000	2			2	16.5	850/16.5	43
Lindau Type 35I	Germany	2/5,000	2			2	16.5	850/16.5	44
Notec II Type 207M	Poland	2/1,874	2		2/816		13	790/14	24
River	South Africa	2/4,515				2 × VS	16	2,000/13	40
Sonya Type 1265/1265M	RFAS	2/2,000	2				15	3,000/10	43
Sugashima	Japan	2/1,800	2				14		40
Uwajima	Japan	2/1,400	2				14		40
Vanya Type 257D/DM/DT	RFAS	1/2,502	1				16	1,400/14	36
Vukov Klanac (Ton)	Yugoslavia	2/1,620	2				15	3,000/10	40
Yaeyama	Japan	2/2,400	2	1 bow/350			14		60
DRONES									
MSD	Australia	2/300					45		
MSF	Denmark	2/500	2	n/k	n/k	pump jet	12	n/k	
SAM	Sweden	1/210				1 × Schottel	8	330/8	
SAV	Denmark	1/350				1[1]	12		4
Futi Type 312	China	1/300				cp	12	144/12	3
Futi Type 312	Pakistan	1/300				cp	12	144/12	3
Ilyusha Type 1253	RFAS	2/500	2				12	300/10	10
Tanya Type 1300	RFAS	1/270	1				10		
Troika	Germany	1/446	1				10	520/9	3

A number/horsepower
[1] Pump jet propulsion
[2] Water-jets
[3] Except MSC 268-2/880
[4] Diesel electric drive, 4 diesels, 2 motors
[5] VS Voith Schneider propellers
n/k not known

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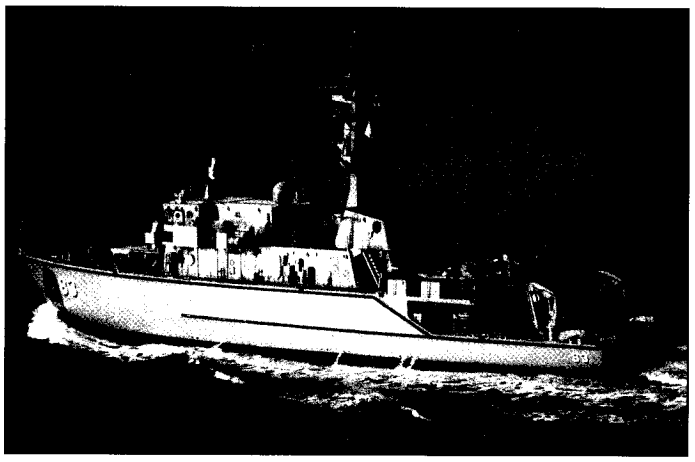
Australia

Huon class

Type
Minehunter.

Description
The GRP Huon class coastal minehunters for the Royal Australian Navy are built to a modified Italian 'Gaeta' design at a purpose-built GRP construction yard in Newcastle, by ADI Limited. The heart of the ships is the AMS Nautis-II M minehunting command and control system. In the Huon class this comprises five multifunction consoles: detection, classification, mine warfare officer and minehunting director consoles in the operations room and the fifth display console on the bridge for the officer of the watch to engage in the tactical decision making process. Data is fed to the Nautis by a comprehensive range of sensors including: a Thales Underwater Systems Type 2093 VDS minehunting sonar; a Kelvin Hughes Type 1007 I-band navigation radar; Link 11 (receive only); and BAE Systems' Prism ESM system with two Wallop Defence Systems SuperBarricade chaff/IR decoy rocket launchers. For mine disposal, the ships carry two Double Eagle Mk II ROVs carrying Danish DAMDIC charges. Precise navigation is provided by a Syledis system. In addition to their primary minehunting role, the ships are fitted with an ADI double Oropesa mechanical sweep and will also be able to deploy the Mini-Dyad influence sweep. Surface surveillance is exercised through a Ultra Information & Power System (formerly Radamec) System 1500 electro-optical tracking and fire-control system.

The communications suite is developed by CEA Technologies, which provides both internal and external communication facilities.



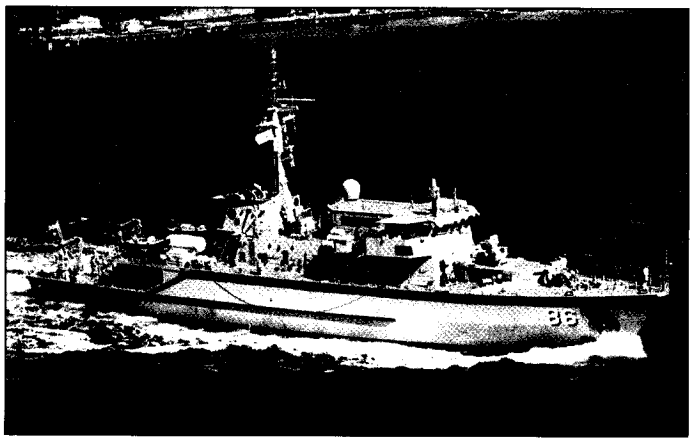
The Australian minehunter Hawkesbury (H & L van Ginderen) 0103422

Propulsion is provided by a Fincantieri GMT BL230.8M 1,460 kW diesel engine driving a LIPS cp propeller through a reduction gearbox for a transit speed of 14 kt. For precise manoeuvring during minehunting, the vessels are fitted with three Calzoni SpA retractable and rotatable 124 kW (each) azimuthal thrusters powered by three electrohydraulic motors driven by three Isotta-Fraschini 1312.TI.ME V-form 350 kW generating sets. Automatic control of the main propulsion system is achieved using the transit autopilot and tactical data system interface.

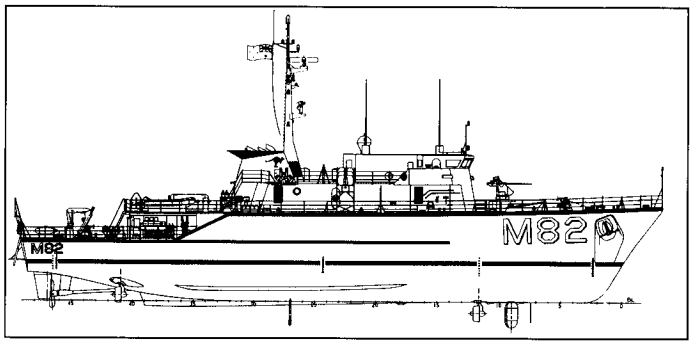
Self-defence is provided by a single MSI Defence Systems DS30B 30 mm gun, two twin 20 mm guns and the SuperBarricade chaff/IR decoy system.

The vessels are also fitted with a Cowan Industries recompression chamber together with a Rigid Inflatable Boat (RIB) and inflatable diving boat to support the six-man diving team.

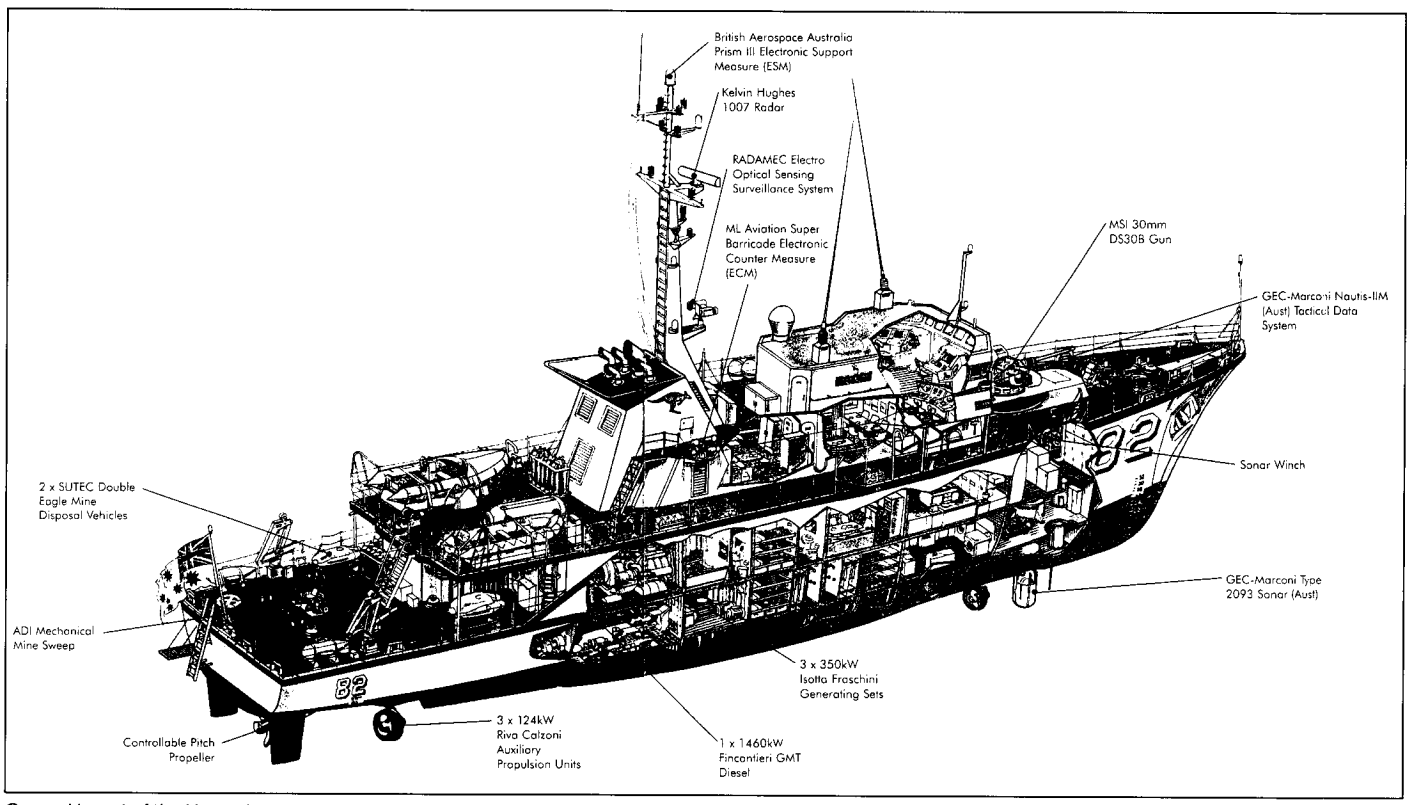
Operational status
Six units in service with the Royal Australian Navy. The lead ship *Huon* was commissioned in May 1999.



Australian minehunter Diamantina (Michael Nitz) 0143745



Outboard profile of the Huon class 0007401

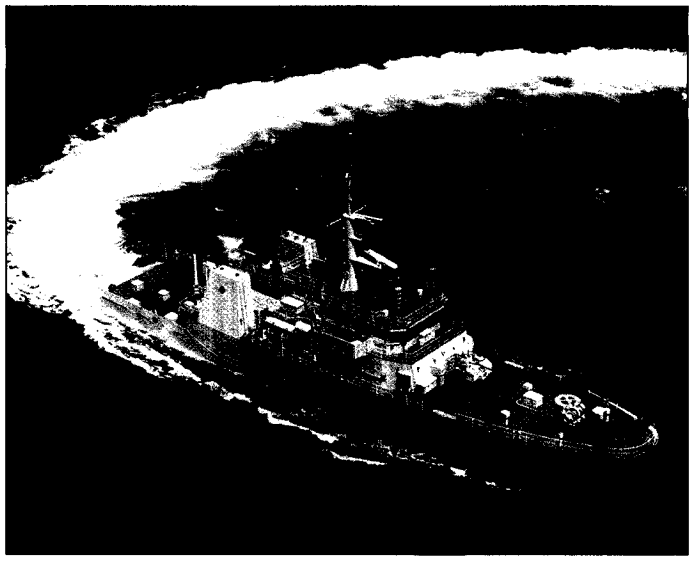


General layout of the Huon class 0007400

Class	**Huon**
Displacement:	
full load:	720 t
Dimensions:	
length:	52.5 m
beam:	9.9 m
draft:	3.0 m
Electronics:	
combat management system:	Nautis 2M
navigation system:	Syledis
sonars:	Type 2093
radar:	Type 1007
electronic warfare:	Type 133 Prism, Super Barricade
weapon control:	System 1500
Weapons:	
wire sweeps:	Double Oropesa
influence sweeps:	Mini Dyad
underwater vehicles:	2 × Double Eagle
guns:	2 × 20 mm
missiles:	none
Machinery:	
diesels:	1 × BL230.8M
power output:	1.46 MW
electric motor:	3 × 1312.TI.ME
power output:	1,058 kW
thrusters:	3 × Calzoni APU
power output:	506 hp
shafts:	1
propeller:	1 × LIPS cp
Speed:	14 kt (6 kt on APU)
Range:	1,600 n miles @ 12 kt
autonomy:	19 days
Personnel:	6 officers, 32 crew

Contractors
ADI Limited, Newcastle, New South Wales.
Intermarine SpA, Sarzana, Italy.

UPDATED



Glace Bay, *the second of the Kingston class* (Canadian Forces) 0105319



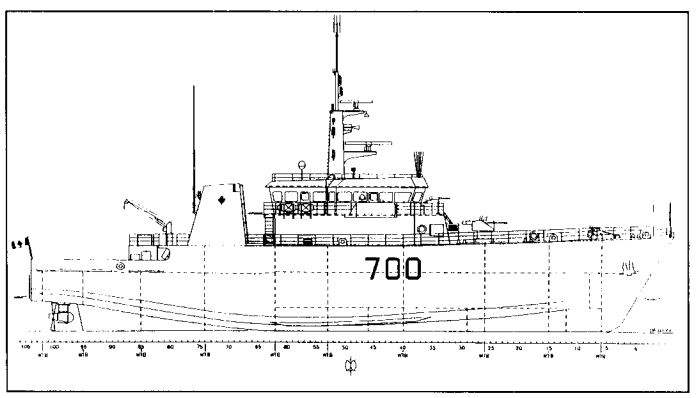
Lead ship Kingston *of the Kingston class* (H L van Ginderen) 0089208

Canada

Kingston class

Type
Multirole mine countermeasures vessel.

Description
The 12 steel-hulled vessels of the multirole MCDV programme have been designed to combine coastal surveillance and general patrol duties with MCM tasks. The ships are being built primarily to commercial standards using COTS equipment wherever practicable, with military standards being applied to stability, flood control zones, doors, turning/stopping distances and ammunition spaces. The design allows the vessels to accommodate various modular MCM payloads for minesweeping and minehunting including: an Indal Technologies SLQ38 Mechanical Minesweeping System (MMS) including single and double oropesa sweeps; AN/SQS-511 route survey system; and mine disposal deploying ROVs. Payloads are contained in standard ISO containers which can be changed over in 12 hours. The heart of the MCM system is the integrated command and control geographic database developed by MacDonald Dettwiler, which incorporates its geocoded sonar imagery system. The primary task is route survey for which four payloads are available (two on each coast) and using the geocoded database, considerable savings in time can be achieved in minehunting tasks, as only new seabed targets need to be examined at any one time. For route survey the vessels deploy a remotely operated survey inspection craft and tow a side scan sonar to maintain the up-to-date database of seabed objects.



Outboard profile of the Kingston class 0007404

The analysed information will be used for route mapping, detection and classification of mine-like objects and then optimisation of ocean route planning.

A single bottom object inspection payload TB 25 provides a capability to inspect mine-like objects on the seabed using sonar and video sensors. This payload is capable of supporting port inspection or EOD tasks.

The surface search radar is a Kelvin Hughes 6000 E/F-band, while a Kelvin Hughes I-band radar is fitted for navigation. Communications facilities are the TS 700 integrated system, which includes two each of VHF, UHF and HF, as well as secure voice. The ships are fitted with an automated message processing system.

Propulsion is provided by four Wartsila-SACM UD 23V12 S5D 2,450 bhp diesels directly driving four Jeumont ARN-53-50 715 kW alternators to power two 2,000 hp (1,150 kW) Jeumont CI 560L DC electric motors, each turning an acbLips FS1000-234 podded Z-drive azimuth thruster fitted with a five-bladed fixed-pitch propeller. Electrical services are provided by a Wartsila-SACM UD19 diesel powering a 300 kW alternator and generator. For emergency use, a Wartsila-SACM UD60 105 kW diesel prime mover is fitted.

Self-defence is provided by a 40 mm Bofors AA gun and two 12.7 mm machine guns.

Minesweeping equipment includes the SLQ-38 wire sweep which is capable of being used in single or double oropesa or team sweep configuration.

Currently only seven MCM payloads are budgeted, four route survey, one ROV and two mechanical minesweeping systems.

Operational status
Twelve units are now operational.

Specifications

Class	Kingston
Displacement:	
standard:	713 t
full load:	962 t
Dimensions:	
length:	55.3 m
beam:	11.3 m
draft:	3.05 m
Electronics:	
navigation system:	Kelvin Hughes
sonars:	AN/SQS-511 sidescan
radar:	Type 6000
Weapons:	
wire sweeps:	Minesweeping module
underwater vehicles:	Trailblazer 25
guns:	1 × 40 mm
missiles:	none

Machinery:	
diesels:	4 × Wartsila UD 23V12
power output:	7.2 MW
electric motor:	2 × Jeumont CI 560L
power output:	2.2 MW
thrusters:	2 × LIPS FS 1000 Z drive
shafts:	2
propeller:	2 × fp
Speed:	15 kt (10 kt sweeping)
Range:	5,000 n miles @ 8 kt
autonomy:	18 days
Personnel:	37

Contractor
Halifax Shipyard Ltd, Halifax.

UPDATED

China

Type 312 Futi class

Description
The Type 312 Futi class is a small, remotely controlled mine countermeasures system believed to be for use in harbours and estuaries. It uses a 20.94 m long drone with a displacement of 39 tonnes which is controlled by radio signals from a shore station or mother ship up to 3 n miles (5.55 km) away.

During transit the drone is powered by a 12V 150C 500 hp supercharged diesel engine driving a contra-rotating propeller, giving a maximum speed of 11.6 kt. During minesweeping operations the drone is powered by an electric motor at sweep speeds up to 5 kt. It has a range of 108 n miles at 9 kt. Acoustic and magnetic sensors are used but it is not clear how located mines are destroyed. The navigation system incorporates a laser precision element.

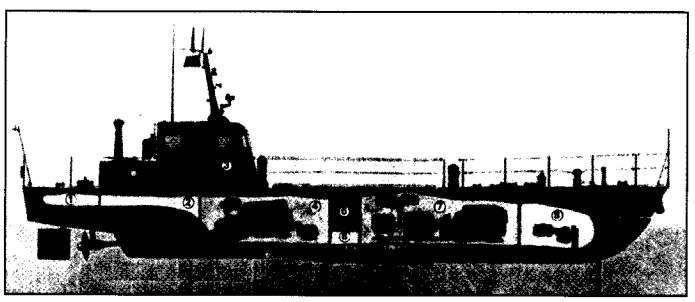
Operational status
In service with Chinese Navy, but many laid up.

Specifications

Class	Futi
Displacement:	
standard:	47 t
full load:	n/k
Dimensions:	
length:	20.9 m
beam:	3.9 m
draft:	2.1 m
Weapons:	
wire sweeps:	None
influence sweeps:	magnetic/acoustic
Machinery:	
diesel generator:	1 × Type 12V 150C
power output:	220 kW
electric motor:	1
power output:	n/k
shafts:	1
propeller:	1 × cp
Speed:	12 kt (-5 kt sweeping)
Range:	144 n miles @ 12 kt
autonomy:	n/k
Personnel:	3 (on passage)

Contractor
China Shipbuilding Trading Company, Beijing.

VERIFIED



Chinese remote-control minesweeper Type 312. Key to diagram: ***(1)*** *steering engine room;* ***(2)*** *special instrument compartment;* ***(3)*** *wheelhouse;* ***(4)*** *main engine compartment;* ***(5)*** *material compartment, this is within the engine room compartment and is not separated from it by a watertight compartment;* ***(6)*** *fuel compartment;* ***(7)*** *auxiliary engine compartment;* ***(8)*** *acoustic generator compartment*

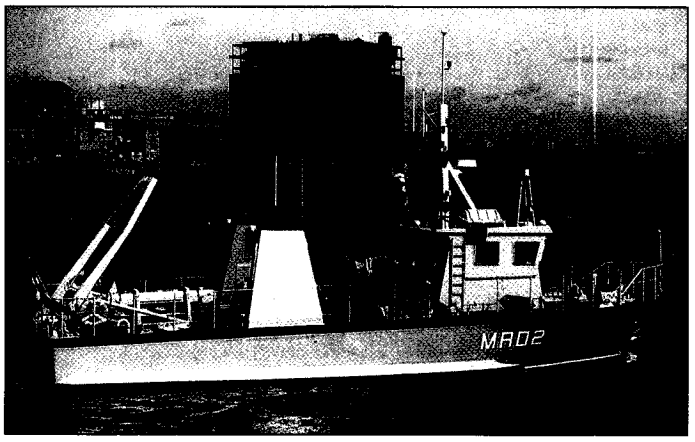
Denmark

Flyvefisken class

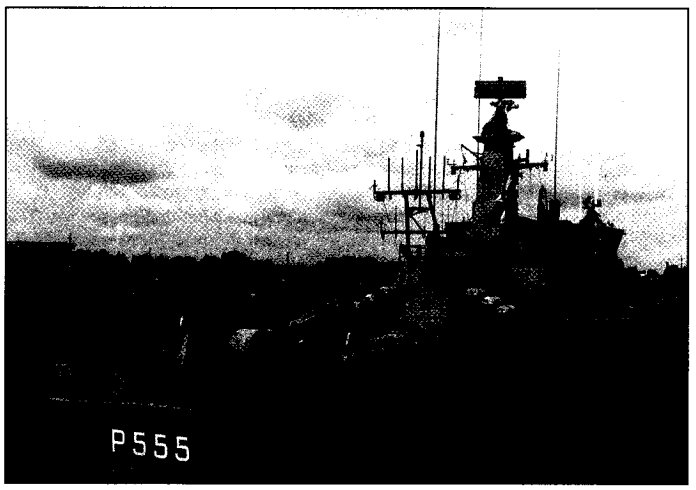
Type
Multirole vessel capable of undertaking a mine countermeasures role.

Description
This multipurpose design can be fitted out as a missile boat, patrol boat, minelayer, minehunter, or minesweeper as requisite. The weapon fit is accommodated in four standardised containers – one forward and three aft – each measuring 3.00 × 3.50 × 2.50 m. All container positions are interchangeable and it takes between one and one and a half hours to install a container. Mobile cranes of the navy can follow the ships around, this releases the ships from the need to enter ports with dedicated facilities for maintenance and installation of different containers. Container slots not utilised are closed by watertight hatches and displacement, draught and trim vary depending on the role. A passive tank stabilisation system has been installed for use at low minehunting/sweeping speeds, when hydraulic drive is used for propulsion in order to minimise the noise signature. At high speeds rudder roll control is used.

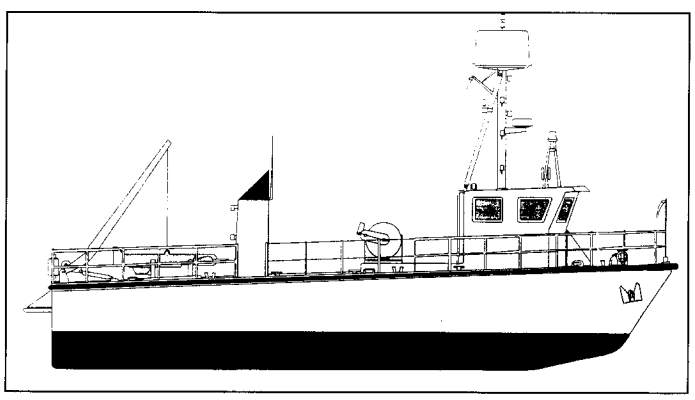
Regardless of role, the machinery, sensor fit and command system is standardised. Main propulsion is by a CODAG arrangement of a General Electric LM-500 gas turbine (on the centreline) and two MTU 16V 396 TB94 diesel engines driving three shafts fitted with Stone Vickers fp (centre shaft) and cp (wing shafts) propellers through Allen double/single-reduction gearboxes. A speed of 12 kt is



The Danish minehunter drone MRD 2 (H & L van Ginderen)



The Danish Flyvefisken class vessel Stoeren, *outfitted with an MCM module* (H & L van Ginderen)



Elevation of the minehunter drone

attained on one diesel engine, 20 kt on two diesel engines, and over 30 kt with all engines online.

The three vessels currently allocated to the mine warfare role (*Hajen*, *Makrelen* and *Laxen*) have had their centreline gas turbines removed to save on maintenance and maintenance associated costs.

Auxiliary slow-speed propulsion is provided by a 500 bhp General Motors 12V 71 diesel engine driving three Rexroth hydraulic pumps powering a 240 shp Rexroth hydraulic motor on each shaft line, and to the transverse thrust unit forward. When operating in the diesel mode, the centreline shaft is windmilled by the hydraulic motor to reduce drag, with power supplied by the hydraulic pumps driven from the diesel engine gearboxes. All main and auxiliary machinery is remotely operated and monitored from central control stations on the bridge and from a compartment forward of the engine room.

The sensor fit comprises: AWS-6 radar in the first seven units, TRS-3D/16 multimode G/H-band phased array surveillance radar and integrated IFF interrogator in the last seven units; Terma Scanter surface search radar and Furuno I-band navigation radar; two CelsiusTech tracking radars fitted with TV cameras and laser rangefinders; and Racal Sabre ESM and Cygnus ECM jammer; all linked to a CelsiusTech 9LV-200 Mk 3 AIO/weapon control system.

For minehunting, a Thales Underwater Systems TSM 2054 side scan sonar is streamed either from the multipurpose boat itself, or from one or two remotely controlled drones (SAV or MSF type), and Double Eagle ROV for classification and disposal; together with the associated Thales Underwater Systems IBIS 43 minehunting command and TSM 2061 tactical systems. Wire, acoustic and electric sweeps – all handled by a centreline crane – will be provided for minesweeping.

An Otobreda Super Rapid 120 rpm 76 mm gun is mounted forward.

Other roles which the design can undertake include: minelaying (rails can be mounted outside the container positions for the carriage of 60 large mines), surveillance, MCM (five outfits are available, three on board ships), combat (with VLS Sea Sparrow), hydrographic survey, oceanographic survey (for which laboratory containers are available) and pollution control (with pollution control containers and equipment available).

Operational status
Fourteen units are operational.

Specifications

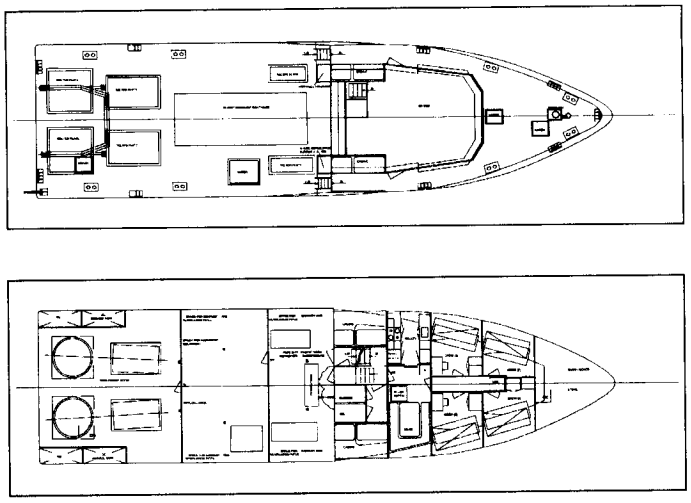
Class	Flyvefisken (as MCMV)
Displacement:	
standard:	320 t
full load:	480 t
Dimensions:	
length:	54.00 m
beam:	9.00 m
draft:	2.5 m
Electronics:	
combat management system:	Ibis 43
navigation system:	TSM 2061
sonars:	TSM 2054
radar:	Scanter Mil 009
electronic warfare:	Sabre, Cygnus
weapon control:	9LV-200 Mk 3
Weapons:	
wire sweeps:	n/k
influence sweeps:	n/k
underwater vehicles:	Double Eagle
guns:	1 × Superrapid 76 mm
Machinery:	
diesels:	2 × 16V 396 TB94
power output:	4.26 MW
auxiliary system:	1 × 12V 71 diesel hydraulic
power output:	375 kW
thrusters:	1 × bow
power output:	n/k
shafts:	3
propeller:	cp on outer shafts fp centre line
Speed:	20 kt, 10 kt on hydraulic
Range:	2,400 n miles @ 18 kt
autonomy:	n/k
Personnel:	4 officers 15-25 crew

Contractor
Danyard A/S, Aalborg. ***VERIFIED***

MSF class

Type
Remote-controlled mine countermeasures drone.

Description
The new 26.5 m mine MSF mine countermeasures drone, built by Danyard A/S, Aalborg, is intended for operation outside Danish waters for which the SAV has proved too small. The MSF is based on a GRP sandwich hull displacing 129 tonnes. It is remote controlled for unmanned operation and can carry out minehunting as well as minesweeping, or can be operated in autonomous mode with a crew of three or four, deploying an ROV for mine neutralising operations.



General arrangement of MSF (Danyard Aallborg) 0131881

The MSFs are powered by two Scania DSI 14 74M 500 bhp (370 kW) diesels driving two Schottell SPJ 82T pump jet propulsors. For towing operations these are replaced by a pair of Schottell azimuth thrusters.

Datalinks are fitted for relaying of position and control orders (INFOCOM) as well as passing sonar data from the TSM 2054 side scan sonar (IN-SNEC). All data gathered during a mission is stored on a large optical disc from which an object database is compiled.

The remote-control system provides for two basic functions:
- Automatic precise navigation and track keeping during sweep operations in accordance with a pre-determined mission plan
- Control and monitoring of platform systems, and visual monitoring of sweep gear behaviour and ship traffic.

The system consists of two major elements - the onboard system and base control system carried by the parent vessel. Communication is conducted using two radio links.

The base control system transmits the following commands to the MSF: heading, track, speed, stop engines, drop anchor and navigation light configuration.

The onboard system on the MSF transmits the following data to the parent vessel: echo sounder readings, DGPS receiver readings, speed log readings, gyro compass readings, alarm signals and TV pictures from the two fixed cameras. A remote-control system computer on the MSF is linked to a radio/modem, the autopilot and the alarm system. The computer manages remote-control radio signals from the parent vessel, and receives and processes system readings communicating commands and relaying data in accordance with its instructions.

The autopilot system provides commands to the two propulsion systems in accordance with commands from the computer, as well as readings from the DGPS, speed log and gyro.

The MSF can be navigated automatically according to a pre-determined mission plan transmitted from the parent vessel, from which automatic navigation can be aborted and reinstated via the radio link.

The main deck features a large, virtually unobstructed working area aft for handling MCM gear. Only the A frame with its two narrow base plates and an access hatch to the payload compartment underneath limits the working deck area.

On The forward part of the working deck are four container foundations for the aft stowage of a standard 20 ft ISO container.

Forward of the working deck is the bridge deck, the bridge house featuring aft facing windows, including a low level window providing a view over the working deck.



MSF1 undergoing sea trials (Naval Team Denmark) 0024813

The tank top deck contains from aft the machinery compartment, with main engines and propulsor units connected via flexible drive shafts.

The next compartment is the payload compartment which also houses some ancillary equipment. This is followed bv the auxiliary machinery compartment with generating sets and switchboards.

Forward is the crew accommodation section with access below to an apparatus room, and above to the bridge. The accommodation comprises washing facilities and so on, galley, wardroom and four 2-berth cabins.

In addition to the sonar the MSF can carry the Double Eagle ROV armed with the Damdic charge for mine disposal.

The MSF also deploys the Australian Mini and Maxi Dyad system together with the ADI acoustic generator. In the future the vessels will also deploy the A/N37U-1 (AN/SLQ-53) system which has been purchased from the united States. However, owing to the fitment location at the stern of the vessel, it can only be fitted with one type of sweep system at a time.

In order to comply with the Standard Flex concept, the drone can accommodate a 30 × 3.5 × 2.5 m Standard Flex container as used by the Flyvefisken class multirole vessels.

A MSF is being acquired by the Swedish Navy to serve as a trials vessel for developing a stand-off MCM system. This craft is configured primarily to tow an influence sweep, but incorporates a tiltable A-frame at the transom for launch and recovery of a towed side scan sonar or similar equipment.

The propulsion system comprises two rudder propellers powered by two Scania DSI 114 74M 8-cylinder diesels rated at 370 kW at 1,800 rpm. The propulsors are Schottel STP 200 rudder propellers mounted in the aft well. These can be replaced by a Schottel pump jet which offers reduced acoustic signature for minehunting operations. Two generating sets are carried: a 170 kVA set and a 60 kVA set.

Operational status
Four units are now in operational service in the Danish Navy and eight more are planned. Evaluation of the number of Dyad systems required by the Navy is currently underway.

Specifications

Class	MSF
Displacement:	
standard:	102 t
full load:	125 t
Dimensions:	
length:	26.5 m
beam:	7.00 m
draft:	2.1 m
Electronics:	
combat management system:	INFOCOM
navigation system:	
sonars:	TSM 2054
radar:	Terma
Weapons:	
wire sweeps:	AN/37U-1
influence sweeps:	Dyad in due course
underwater vehicles:	Double Eagle
guns:	none
missiles:	none
Machinery:	
diesels:	2 × DSI 14.74M
power output:	736 kW
thrusters:	1 bow
propeller:	2 × Schottel STP 200 or 2 × Schottel SPJ.82T waterjets
Speed:	12 kt
Range:	420 n miles @ 10 kt
autonomy:	Approx 4 days
Personnel:	4 (on passage)

Contractor
Danyard A/S, Aalborg.

UPDATED



MSF 1 (A. J. Watts) ***NEW***/0589555

SAV class

Type
Remote controlled minesweeping drone.

Description
Built by Danyard, these Surface Auxiliary Vessels (SAV) are controlled in pairs by the Flyvefisken class as configured for MCMV operations. The GRP-hull design is based on the design of the Swedish Hugin class patrol vessels. Special attention has been paid to reducing the acoustic signature to an absolute minimum. The drones can deploy a Thomson Marconi Sonar SAS TSM 2054 side scan sonar from the stern gantry. The drones are controlled from the parent vessel via a Terma radio link, which is used to relay back to the parent vessel the sonar picture and precise position information. The radio link is also used to carry manoeuvring control signals for the drone and control of the side scan sonar. The drones are fitted with a Furuno I-band navigation radar.

During 1999-2000 SAV drones carried out trials with the Australian Dyad influence sweep system.

Operational status
Six units in service with Danish Navy.

Specifications

Class	SAV
Displacement:	
standard:	32 t
full load:	38 t
Dimensions:	
length:	18.2 m
beam:	4.8 m
draft:	1.2 m
Electronics:	
Remote control:	
sonars:	TSM 2054
radar:	Furuno
Weapons:	
influence sweeps:	Mini Dyad
Machinery:	
diesels:	1 × Detroit
power output:	257 kW
waterjet:	1 × Schottel Type 80
Speed:	12 kt
Personnel:	4 (on passage)

Contractor
Danyard A/S, Aalborg.

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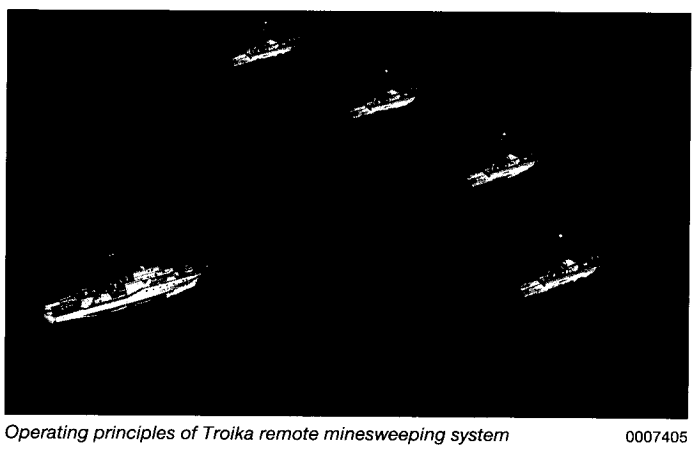
Germany

Advanced Troika MCM System

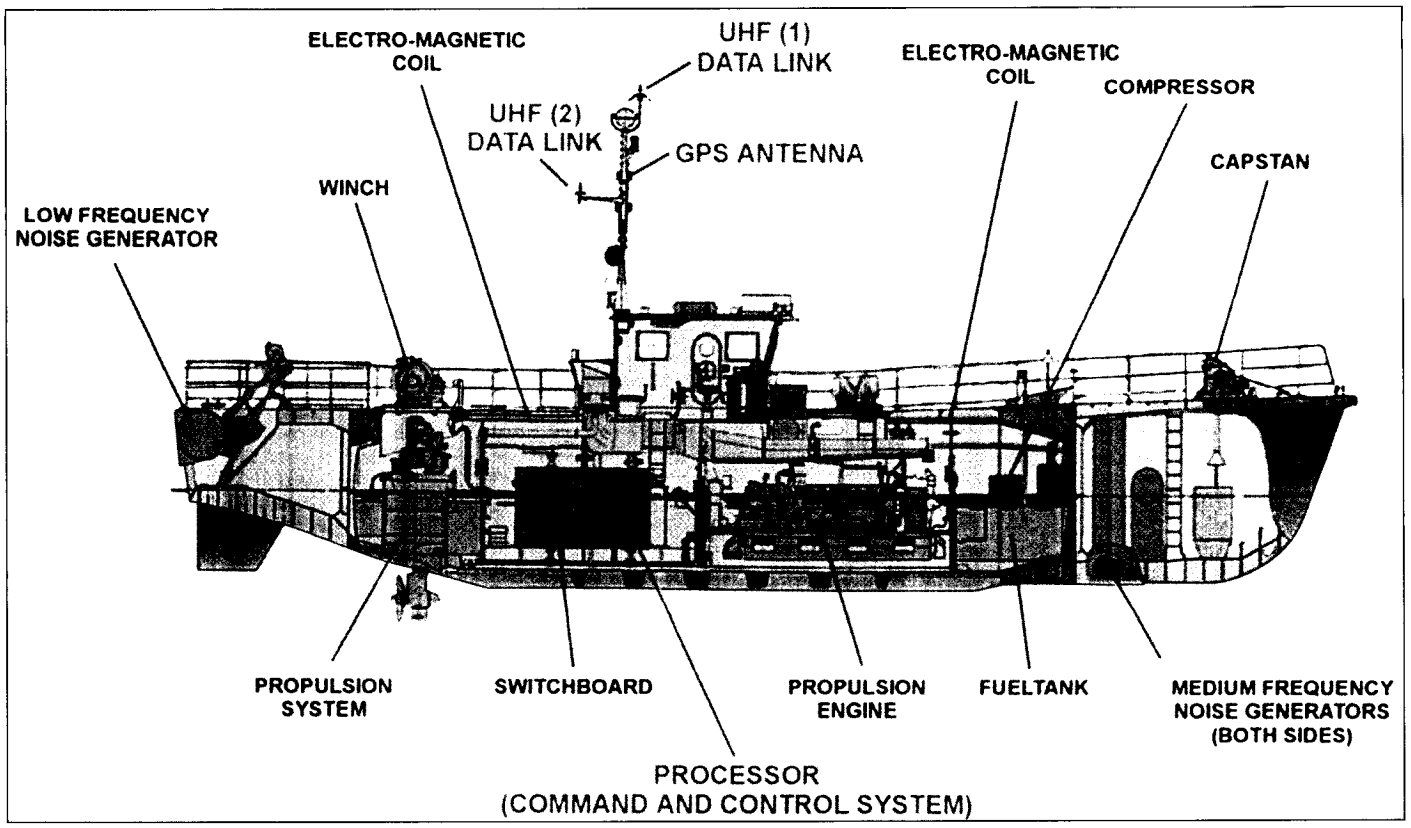
Type
Remote-control mine simulation sweeping system.

Development
Basically the Troika MCM system stands for remote control of minesweeping surface drones to clear an area through influence sweeping measures. Since originally three sweeping drones were used with the system, the name Troika was introduced.

The original Troika system was commissioned in 1980 for service in the German Navy. It was based on a Lindau class MCMV used as a control ship and three remotely operated unmanned sweeping craft called Seehund. In this configuration



Operating principles of Troika remote minesweeping system 0007405



General arrangement of the SSC (Atlas Elektronik) 0114574

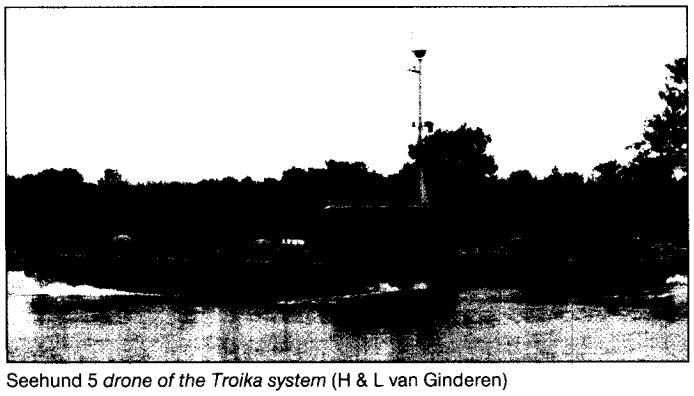
the Troika MCM system proved to be highly effective not only in many NATO MCM exercises, but also in live clearance operations as for example off Kuwait Harbour in 1991, when within five days on task, 17 mines were detonated and swept by only two Troika units.

Description

In 1998-99 the German Navy decided to upgrade the Troika MCM system as part of the German MCM 2000 Programme and continue remote controlled minesweeping with the Advanced Troika MCM system which became operational with the German Navy in 2001. The Advanced Troika MCM System is based on the Type HL 352 (a converted Type SM 343 minesweeper of the Hameln class) that now controls four (instead of three) modernised Seehund Simulation Sweeping Craft (SSC) type.

These Advanced Troika MCM system control vessels are equipped with an advanced command and control system for remote control of Simulation Sweeping Craft (SSC), a mine avoidance sonar MAS 90 and a number of one-shot Seafox mine disposal vehicles for countering moored mines. The Advanced Troika command and control system comprises a single multifunction console for the control of up to four SCCs; one multifunction console for the supervisor; GPS on both the control ship and the SSC for accurate positioning and position control; improved UHF datalink for enhanced data exchange and control of the SSCs; and Loran-C equipment as back-up navigation facility. The advanced C^2 system also provides the capability of MCM mission planning, supervision of execution, mission recording and evaluation, and onboard operator training.

In operation the Type HL 352 Control Ship with her crew, remain safely outside the mined area and controls four unmanned sweeping craft via digital datalink in the sweeping area. The respective link messages may contain details for the simulation sweep programmes; navigational data and other control orders for the craft's steering and propulsion sub-systems. The modern control facilities of the Advanced Troika MCM system incorporate accurate GPS-based way point navigation ensuring precise positioning and track keeping of the four SSC on task. As directed by the Control Ship, the SSC carries out simulation sweeping by producing magnetic and acoustic signatures of possible target ships by simulating a specific warship, a tanker or another high value unit. Thus the sweeping craft influence and trigger the respective firing mechanisms of sea mines and detonate them. The Advanced Troika MCM System is therefore effective against moored, bottom and buried mines that are fitted with acoustic and magnetic firing devices or a combination thereof. The MCM system provides a stand-off capability for MCMVs on task, reduces risk to a minimum, ensures sustained sweeping missions and, due to simultaneous MCM operation of four sweeping craft on task with a sweeping speed of about 10 kt, improves considerably the overall sweeping rate and performance of the Troika units on task.



Seehund 5 *drone of the Troika system* (H & L van Ginderen)

The Troika SSC (German Navy designation HFG-F1) were also fully upgraded to the Advanced Troika MCM standards. The SSC is a self-propelled craft specifically designed to perform simulation sweeping with high reliability and a very high sweep rate. The overall design is characterised by extremely high shock resistance and very good seaworthiness. The main hull of the SSC is a heavy unframed steel cylinder, which houses most of the machinery and sweeping equipment. The propulsion system comprises a diesel driven hydraulic power transmission and a combined rudder propeller unit. Maximum speed is about 10 kt. For optimum sweeping operation even in rough seas an autopilot is provided.

The magnetic sweeping field is generated by two magnetic coils, mounted forward and aft on the cylindrical steel hull. For acoustic simulation sweeping two MF broadband noise generators are positioned to port and starboard in the forward area, and for LF transmission a third noise generator is mounted in the after area of the SSC. The respective magnetic fields and acoustic signatures to be generated by the SSC are programmed by the MCM control officer on board the parent MCMV. Control commands are sent to the SSC in the form of multiplexed data messages using the UHF datalink transceiver with up- and down-link capability.

The operational profile of the Advanced Troika MCM system is characterised by a real stand-off capability and safety of the MCMVs, a high sweeping rate, extended endurance and sweeping range and finally ultimate precision by GPS based navigation and tracking of the SSC, resulting in a vastly increased sweeping efficiency.

Operational status

Five Type HL 352 control ships and 18 Seehund simulation sweeping craft have been operational with the German Navy since 2001.

Contractors

Lürssen Werft, Bremen (for MCMV and SSC drone).
Atlas Elektronik, Bremen (C^2 system and MDV Seafox). ***UPDATED***

Aydin class

Type

Minehunter.

Development

On 30 July 1999, the Turkish Navy ordered six minehunters to be built to a design based on the German MJ 332 Frankenthal class. The lead ship is to be built in Germany by Abeking & Rasmussen and Lürssen Werft, with the remaining vessels being built under licence at the Pendik Naval Shipyard, Istanbul.

Description
The design of the new minehunters is based on the Frankenthal class with the fully welded hull and superstructure completely constructed from amagnetic steel. Plates 4 to 6 mm thick will be used for the hull, welded to web frames at intervals of about 1 m with longitudinals at 300 mm. The longitudinal stiffenings will be offset bulb plate or flat-bar sections. The transverse web frames will be built of girders with single sided web plate. Partitions will be of non-magnetic sandwich construction, elastically mounted, for shock resistance.

The mine countermeasures outfit includes: a Kelvin Hughes Type 1007 navigation radar; Thales Underwater Systems Type 2093 variable depth minehunting sonar; and two PAP Mk Mk 5 mine disposal vehicles. All systems will be integrated by the Alenia Marconi Nautis 3M combat system. The Nautis 3M will re-host a library of software applications on a low cost processing platform based on COTS hardware. It will retain all the functionality of earlier minehunting Nautis variants. A single US Oropesa mechanical sweep will be carried for minesweeping.

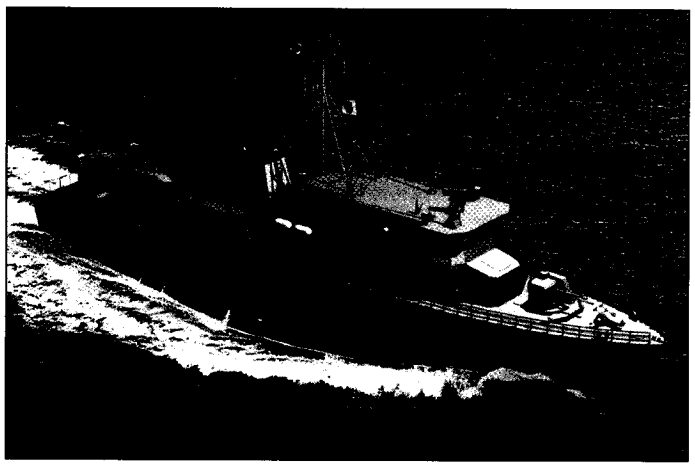
Main propulsion will be provided by two MTU 8V 396 TE84K diesel engines, driving twin shafts fitted with Voith-Schneider propellers. Two Schottel bow thrusters will provide precise manoeuvring capability.

The ships will be armed with a single Otobreda 30 mm gun and two 12.7 mm machine guns.

Operational status
Order placed on 30 July 1999. First vessel under construction and scheduled to be delivered by 2003. The remainder of class are to be in service by 2007.

Contractors
Lürssen Werft, Bremen.
Abeking & Rasmussen, Lemwerder.
Pendik Naval Shipyard, Istanbul.

VERIFIED



Artists impression of the Aydin class (Abeking & Rasmussen) 0593375

Bang Rachan class (Type M48)

Type
Multirole mine countermeasures vessels.

Description
Lürssen built two Type M48 MCMV for the Royal Thai Navy in 1987. The design is based on the proven hull design of the German Type SM 343 minesweeper. The ships are designed for minehunting and conventional minesweeping.

The hull is of laminated wood, with non-magnetic steel frames, tanks and superstructure. As far as is technically and economically possible, all equipment is built of non-magnetic materials. Items which do contain ferromagnetic materials are all compensated and wherever necessary stray magnetic fields caused by electrical equipment and machinery (including cabling) are compensated for by additional magnetic loops. The ships are fitted with a permanent degaussing system comprising horizontal, vertical and athwartships coils to minimise the actual components of the permanent (induced) and eddy (stray) current magnetic fields.

Acoustic signature reduction has also been carefully studied, and the ships are fitted with a five-bladed cp propeller with highly skewed back profile. A cp was chosen in order to meet the requirement for different loads created by high and low speeds. For slow-speed minehunting operations the ships are powered by an auxiliary electric motor driving the cp propeller at very low rpm via a tooth belt drive through gearboxes. All machinery and moving equipment is resiliently mounted, to reduce noise and provide shock resistance, the main engines being double-elastically mounted via an intermediate frame. Additional sound insulation for the engine rooms is arranged to prevent transmission of airborne noise into the structure and to improve conditions for the crew.

The design features a long forecastle deck with a continuous main deck to provide the best longitudinal strength. The high freeboard forward with moderate flare ensures a dry ship with good sea-keeping qualities. A large clear deck aft gives good access and handling for the MCM gear, while a large A-frame hydraulic gantry at the stern greatly eases the job of handling heavy gear of all kinds. In particular it can be used to handle the minesweeping gear or oceanographic equipment. A foldable hydraulic crane is also provided for handling mine disposal vehicles, the inflatable dinghies, marker buoys and provisions. A decompression chamber on the aft deck and diving equipment in a dedicated diver's cabin are arranged to support mine clearance diving.

The twin funnel arrangement was chosen together with the amidships position of the wheelhouse and operations room, to provide the best all-round view, in particular of the sweep deck, and to reduce the effects of motion experienced by operators in the operations room during heavy weather.

The ships are powered by two MTU 12V 396 TB83 diesel engines, each developing 1,610 bhp driving two KaMeWa five skew-bladed cp propellers through a single reduction gearbox. Twin Becker rudders are installed for manoeuvrability.

Onboard systems include an ATLAS Elektronik MWS 80R integrated mine warfare control system and DSQS-11H sonar. Precise positioning is achieved using a Motorola MRS III Miniranger navigational positioning system. Two Gaymarine Pluto ROVs are carried for mine disposal duties. A Draeger decompression chamber is carried to support mine diving operations.

Three 20 mm guns are carried for self-defence. The ROVs are stored and maintained in an interchangeable container between the funnels, being moved out on to the open deck on rails ready for handling by the crane.

Operational status
Two units operational with the Royal Thai Navy.

Specifications

Class	**Bang Rachan**
Displacement:	
standard:	
full load:	444 t
Dimensions:	
length:	49.1 m
beam:	9.3 m
draft:	2.5 m
Electronics:	
combat management system:	MWS 80R
navigation system:	Miniranger MRS III
sonars:	DSQS-11H
radar:	2 × 8600 ARPA
Weapons:	
wire sweeps:	SDG 31
influence sweeps:	Acoustic and magnetic
underwater vehicles:	2 × Pluto
guns:	3 × GAM-BO1 20 mm
Machinery:	
diesels:	2 × 12V 396 TB83
power output:	2.3 MW
auxiliary system:	1 × electric
power output:	
shafts:	2
propeller:	KaMeWa cp
Speed:	17 kt (7 kt minehunting)
Range:	3,100 n miles @ 12 kt
autonomy:	
Personnel:	7 officers, 26 crew

Contractor
Lürssen Werft, Bremen.

UPDATED

Ensdorf/Kulmbach classes (Type 352/Type 333)

Type
Minesweepers.

Development
The 10 Type SM 343 minesweepers of the Hameln class built by Abeking & Rasmussen, Lürssen, and Kröger were designed primarily for minesweeping operations in the Baltic Sea with mechanical, acoustic and magnetic (towed solenoid) sweeps as well as for defensive minelaying. Hull and superstructure are completely constructed from non-magnetic and non-corrosive austenitic steel, fully welded.

Plates 4 to 6 mm thick are used for the hull, welded to web frames at intervals of about 1 m with longitudinals at 300 mm. The longitudinal stiffenings are offset bulb plate or flat-bar sections. The transverse web frames are built of girders with single sided web plate. Partitions are made from non-magnetic sandwich construction, elastically mounted, for reason of shock resistance.

With the change in operational requirements since the ending of the Cold War, the Type SM 343 minesweepers have been modernised and converted.

Description
Under the MA 2000 Programme, the class was converted into minehunters (Kulmbach class Type 333 five units) and Advanced Troika control vessels (Ensdorf class Type HL 352 five units), the latter each controlling up to four remote control minesweeping drones.

The Type HL 352 vessels have received a modern GPS-based control system to remotely control up to four simulation sweeping drones simultaneously. In addition an Atlas Elektronik DSQS-15A mine avoidance sonar and a number of Seafox mine disposal vehicles have been fitted to cope with moored mines in the area. The Double Oropesa mechanical sweep is retained on board the Type 352 vessels. For automated data exchange and establishing a common tactical picture the vessels are also provided with a PALIS command, control and communications system, with an integrated Data Link 11.

The five remaining vessels were converted and designed Type MK 333 minehunters between 1999 to 2001. All conventional sweep gear was removed and the space used to store up to 40 Seafox mine disposal vehicles and other systems required for minehunting. The MCMVs are now all fitted with the Atlas Elektronik hull mounted DSQS-11M sonar, the integrated TAKIS tactical command, control and navigation system and the expendable Seafox mine disposal vehicle. In addition a group of mine clearance divers with associated diving support equipment stored in a container which is carrried astern is available for the hunting task. The PALIS command, control and communications system with integrated Data Link 11 is retained for tactical picture compilation and automated data exchange. Self-defence weapons are two Mauser lightweight guns systems (to be installed in due course).

The remaining sensor fit includes: a Signaal WM-20/2 surveillance and tracking radar; Raytheon SPS-64 I-band navigation radar; Palis datalink; and Thomson-CSF DR-2000 ESM. All systems are integrated into the minehunting control and M-20 weapon control system (the latter removed from the Zobel class torpedo boats).

Main propulsion is by two MTU 16V 396 TB84 diesel engines, each rated at 3,070 bhp at 2,000 rpm and driving twin shafts fitted with Escher Wyss cp propellers through Renk single-reduction gearboxes. Electric power at 400 V 3-phase 60 Hz is supplied by three Siemens 230 kW alternators, each powered by an MTU TBD-601-6S auxiliary diesel rated at 639 bhp at 1,800 rpm.

The craft are armed with two Bofors SAK 40L/70 (2 × 1) guns, two quadruple Stinger SAM launchers, and two Silver Dog chaff rocket launchers, and can stow about 60 mines. The 40L/70 guns are to be replaced by Mauser 27 mm guns.

Operational status
The converted vessels have been operational with the German Navy since 2001.

Specifications

Class	Kulmbach Type 333	Ensdorf Type 352
Displacement:		
full load:	635 t	635 t
Dimensions:		
length:	54.4 m	54.4 m
beam:	9.2 m	9.2 m
draft:	2.5 m	2.5 m
Electronics:		
combat management system:	Palis, TAKIS	Palis
sonars:	DSQS-11M	DSQS-11M, DSQS 15A mine avoidance
radar:	SPS-64	SPS-64
electronic warfare:	DR 2000, 2 × Silver Dog	DR 2000, 2 × Silver Dog
weapon control:	WM20/2	WM20/2
Weapons:		
wire sweeps:	None	SDG 31 Double Oropesa
influence sweeps:	None	None
underwater vehicles:	40 × Seafox	Control 4 Troika drones, Seafox
guns:	2 × 27 mm	2 × 27 mm
missiles:	2 × quad Stinger	2 quad Stinger
mines	60	60
Machinery:		
diesels:	2 × 16V TB91	2 × 16V TB91
power output:	4.5 MW	4.5 MW
shafts:	2	2
propeller:	2 × Escher-Wyss cp	2 × Escher-Wyss cp
Speed:	18 kt	18 kt
Range:		
autonomy:		
Personnel:	5 officers, 42 crew	4 officers, 33 crew

Contractors
Lürssen Werft, Bremen.
Abeking & Rasmussen, Lemwerder.
Krögerwerft, Rendsburg.

UPDATED



The German Hameln class minesweeper Siegburg (H & L van Ginderen)

Frankenthal class

Type
Minehunters.

Description
Twelve Type MJ 332 minehunters of the Frankenthal class were built by Abeking & Rasmussen, Fr Lürssen Werft and Lürssen Rendsburg (formerly Kroger Werft) for the German Navy between 1992-1998. Both the Type MJ 332 minehunters and the Type SM 343 minesweepers of the Kulmbach class (see separate entry) are designed and constructed according to a common platform concept.

The hull and superstructure of the MCMVs are completely constructed from fully welded non-magnetisable (NM) and non-corrosive steel. Plates up to 6 mm thickness are used for the hull welded to webframes at intervals of about 1 m with longitudinals at 300 mm. The transverse webframes are built of girders with single side webplates. Partitions are made from non-magnetic sandwich construction, elastically mounted for shock resistance. The NM steel construction ensures low acoustic and magnetic signatures and provides an extremely shockproof structure.

The propulsion system comprises two MTU diesels of 2,200 kW each, driving two variable pitch propellers through a reduction gearbox to achieve a maximum sustained speed of 18 kt. For minehunting operations an electric slow speed drive is provided.

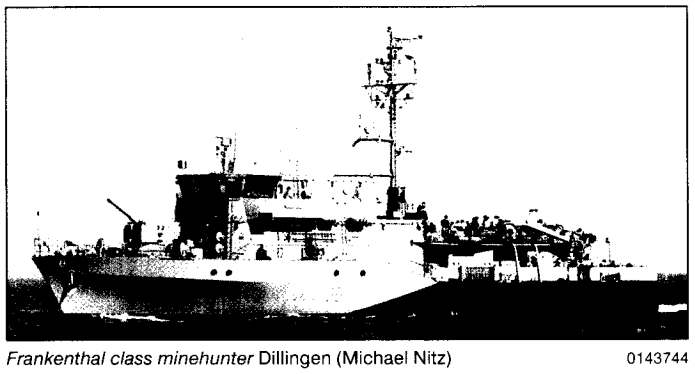
The mine warfare system configuration of the type NMJ 332 minehunters consists of an integrated MWS 80 ATLAS Elektronik minehunting command system, with a hull-mounted DSQS-11M sonar and a SATAM tactical command, control and navigation system. Two Pinguin B3 ROVs are carried for mine identification and mine disposal.

For self-defence in an air threat situation a single 40 mm gun is mounted forward and two quadruple Stinger SAM launchers are provided. The 40 mm gun will be replaced by a Mauser 27 mm lightweight gun in the near future. The vessels are equipped with the Haux Spacestar 1300/5.5 recompression chamber.

Operational status
Class of 12 units is now operational with the German Navy.

Specifications

Class	Frankenthal
Displacement:	
standard:	590 t
full load:	650 t
Dimensions:	
length:	54.5 m
beam:	9.2 m
draft:	2.6 m
Electronics:	
combat management system:	MWS 80-4
navigation system:	
sonars:	DSQS-11M
radar:	SPS-64
electronic warfare:	DR-2000, 2 × 6-round Hot Dog/Silver Dog decoy
Weapons:	
underwater vehicles:	2 × Pinguin
guns:	1 × 40 mm
missiles:	2 × quad Stinger



Frankenthal class minehunter Dillingen (Michael Nitz) 0143744

Class	Frankenthal
Machinery:	
diesels:	2 × 16 V 396 TB84
power output:	4.08 MW
electric motor:	1
power output:	
thrusters:	2 × Voith Schneider vertical cycloidal
power output:	
shafts:	2
propeller:	2 × cp
Speed:	18 kt
Range:	
autonomy:	
Personnel:	5 officers, 32 crew

Contractors
Abeking & Rasmussen,, Lemwerder.
Lürssen Werft,, Bremen.
Krögerwerft, Rendsburg.

UPDATED

MJ 2000 Minehunting System

Type
Remote controlled minehunting.

Description
The German Navy projected MJ 2000 minehunting system aims at improving current minehunting capabilities through the introduction of an advanced remote controlled minehunting system.

At present minehunting sonar systems cannot cope with buried and camouflaged mines. They suffer from a number of shortfalls regarding the detection and classification of seabed mines under unfavourable environmental conditions such as salinity or temperature layers in the water column or high bottom reverberations due to the respective bottom characteristics (mud, gravel, rocks). These limitations result in a rather low area coverage rate, especially in areas with a high clutter density.

The definition phase of the MJ 2000 Minehunting System was completed in 2000. It had the following main objectives: improved minehunting capabilities against buried and camouflaged mines, even under most adverse bottom and water conditions as well as optimum threat and risk reduction in minehunting operations for the crew and the minehunters through remote control of minehunting surface drones at up to 10 miles range.

System configuration

A parent minehunter acts as control ship for two or more Seahorse surface drones. During hunting operations the control ship remains safely outside the mined area and directs the drones in the mined area to carry out sonar operations as required.

The self-propelled surface drones tow a sensor carrier equipped with a special sensor/sonar fit. The sonar data produced by the various sonars are transmitted via a high power radio datalink to the control ship for display, classification, evaluation and recording. The positions of mines are documented for later destruction and disposal. This disposal task can be performed completely separately from mine detection by means of expendable mine disposal vehicles stored on the control ship.

Two different types of remotely controlled underwater vehicles can be employed: the Seafox which will be used for disposal of seabed and moored mines and the new Seawolf expendable vehicle which is used to counter buried mines and for mine disposal in adverse environmental conditions.

Sonar sensors

The heart of the MJ 2000 Minehunting system is the towfish sensor carrier which carries a multibeam/multi-aspect side scan sonar for detection and classification of proud seabed mines. In addition a specific sediment penetrating sonar is operated from the towfish. This sensor is a synthetic aperture multifan beam sonar for the detection of buried mines. The towfish sensor carrier with its sonar equipment will be launched and recovered automatically via remote control from the Seahorse surface drone. In addition to the sonars fitted on the towfish, the Seahorse surface drone itself will be equipped with a mine detection sonar ensuring long range detection of moored mines together with an automatic alarm and target tracking capability.

Seahorse

During the system definition phase a Swath type craft was defined as the preferred platform of the MJ 2000 surface drone with special attention paid to launching and recovery of the towfish sensor carrier as well as the smooth compensation of motion for effective operation of the sonar systems. As the second step in 2002 a German consortium was contracted by the German Federal Office of Technology and Procurement (BWB) for the development of a Seahorse demonstrator drone based on Abeking & Rasmussen Swath technology with an overall length of 25 m and a displacement of some 125 tons. Operational tests and trials including the launching and recovery of the sensitive sonar systems together with the system carrier were due to be carried out in 2004. The project phase of the Seahorse demonstrator is scheduled to be completed by 2005.

Operational status
The demonstrator surface drone is currently under trials, which are due to be completed by March 2005.

Contractors
Arbeitsgemeinschaft (ARGE) Minenabwehr (MA)

Lürssen Werft, Bremen (for MCMV and SSC drone).
Atlas Elektronik, Bremen (C^2 system and MDV Seafox).
Abeking & Rasmussen, Lemwerder.
EADS, Ulm.

NEW ENTRY

International

Tripartite design

Type
Minehunter.

Description
The 'Tripartite' design is a collaborative venture between France, Belgium and the Netherlands. The hull, decks and partitions are constructed of a single GRP skin stiffened by trapezoid section formers. Hull and former joints are reinforced with glass fibre pins. Hull reinforcements are principally transverse, but longitudinal ribs and binding strakes provide resistance to buckling.

Two independent propulsion systems are fitted: a main conventional diesel and propeller shaft (supplied by the Netherlands); and an auxiliary propulsion system for minehunting operations which consists of active rudders (supplied by Belgium). The main engine is a supercharged 1,860 bhp (1.37 MW) Stork-Wärtsilä A-RUB 215 V12 diesel driving, via a flexible coupling, a Rademakers epicyclic reduction gearbox and a LIPS five-bladed cp propeller. The main engine and gearbox is carried on a raft supported by 14 large sandwich mountings in a Vee formation. To counter vertical acceleration/deceleration forces from an exploding mine, large deceleration buffers are fitted between each pair of mountings while two rake and ram buffers at each end of the raft control fore and aft movements.

The sandwich mountings are made from a special compound of natural rubber and incorporate stainless steel end plates for low magnetic signature. Under auxiliary power the propellers are maintained in a 'feathered' position. The auxiliary propulsion system comprises two Acec active rudders with six-bladed fixed-pitch propellers. In addition, a Schottel thrust unit comprising two electric motors each driving a propeller transversely mounted in a tunnel is fitted near the bows. The active rudders and bow thrust unit are driven by three Astazou gas-turbine-powered alternators mounted high up in the ship. When minehunting, one gas-turbine unit powers the auxiliary propulsion system, a second provides electrical power for ship's services and the third remains on standby. A fourth diesel-driven alternator provides electric power for ship services when in port. The machinery can be controlled from the bridge in manual mode, or from the operations room in either manual or automatic mode. In emergency the machinery can be controlled from a soundproofed machinery control room located above the engine room.

The minehunting system comprises the Thomson Sintra DUBM 21B sonar integrated with a Thomson CSF Evec command and control display system. Navigational systems include a Racal Decca 1229 I-band radar, Loran and Syledis and Decca Hifix. Mine disposal is carried out using the two ECA PAP 104 ROVs carried on board. Up to six clearance divers are also carried. Light mechanical and acoustic sweep gear (the AP-4) can be deployed.

The vessels are fitted with comprehensive communications facilities comprising: an SNTI internal communication system; two sets of Signaal HF radio receivers; and a UHF receiver supplied by Belgium. Self-defence armament comprises a Giat 20F2 20 mm gun and a single 12.7 mm machine gun.

Under the Belgian and Dutch modernisation programme STN ATLAS Elektronik was awarded the contract to upgrade 10 Dutch Alkmaar and six Belgian Flower class vessels. The vessels will be equipped with an integrated MCM system combining both minehunting and remote control minesweeping capabilities. This will incorporate tactical command and control with precise navigation and automated vessel control, together with composite broadband minehunting sonar featuring both hull mounted and a PVDS system based on the SAAB Bofors underwater vehicle. STN ATLAS is prime contractor and will also supply the

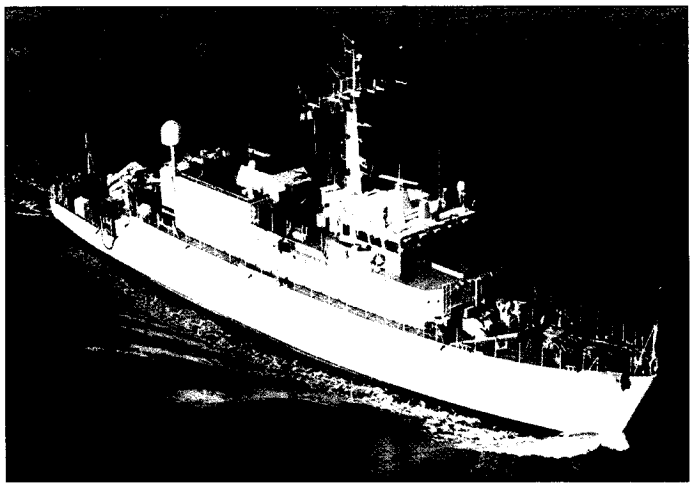


Belgian 'Tripartite' minehunter Narcis (H & L van Ginderen)

Specification—Tripartite design

Class	**Eridan**	**Munsif**	**Flower**	**Alkmaar**	**Pulau Rengat**
Displacement:					
standard:	562 t	562 t	562 t	562 t	562 t
full load:	605 t	595 t	595 t	595 t	568 t
Dimensions:					
length:	51.5 m	51.5 m	51.5 m	51.5 m	51.5 m
beam:	8.9 m	8.9 m	8.9 m	8.9 m	8.9 m
draft:	2.5 m	2.9 m	2.5 m	2.5 m	2.5 m
Electronics:					
combat management system:	Evec 20	Evec 20, TSM 2061 Mk 2*	Evec 20	Evec 20, Sewaco IX	Ibis V, Sewaco RI
navigation system:	HiFix, Syledis, Toran	HiFix, Syledis	Syledis, Toran	HiFix, Syledis, Toran	TSM 2060
sonars:	DUBM 21B	DUBM 21B/D	DUBM 21B	DUBM 21A	TSM 2022
radar:	DRBN-34A (Type 1229)	Type 1229/1007	Type 1229	Type 1229 or MM 950	Type 1229
Electronic warfare:			DR 2000S, Telegon 4 HFDF		
Weapons:					
wire sweeps:	OD-3	mechanical	OD-3	OD-3	OD-3
influence sweeps:	AP-4	Fiskar MKR 400 and MRK 960			Fiskars F-82, Saab AS 203
underwater vehicles:	2 × PAP 104	2 × PAP 104 Mk 5	2 × PAP 104 Mk 5	2 × PAP 104 Mk 5	2 × PAP 104 Mk 4
guns:	1 × Giat 20F2 20 mm	1 × Giat 20F2 20 mm	1 × Giat 20F2 20 mm	1 × Giat 20F2 20 mm	1 × Rheinmetall 20mm
missiles:	None	None	None	None	1 × Simbad
Machinery:					
diesels:	1 × Stork Wartsila A-RUB 215X-12	1 × Stork Wartsila A-RUB 215X-12	1 × Stork Wartsila A-RUB 215X-12	1 × Stork Wartsila A-RUB 215X-12	2 × MTU 12V 396 TC82
power output:	1.37 MW	1.37 MW	1.37 MW	1.35 MW	1.92 MW
auxiliary system:	2 × electric motors	2 × electric motors	2 × electric motors	2 × electric motors	2 electric motors
power output:	179 kW	179 kW	179 kW	179 kW	1.76 MW
thrusters:	2 bow	2 bow	2 bow	2 bow	2 bow
power output:					
shafts:	1	1	1		1
propeller:	1 × LIPS cp 2 × active rudders	1 × LIPS cp, 2 × active rudders	1 × LIPS cp, 2 × active rudders	1 × LIPS cp, 2 × active rudders	2 Schottel propulsors
speed:	15 kt, 7 kt on auxiliary	15 kt, 7 kt on auxiliary	15 kt, 7 kt on auxiliary	15 kt, 7 kt on auxiliary	15 kt, 7 kt on auxiliary
range:	3,000 n miles @ 12 kt	3,000 n miles @ 12 kt	3,000 n miles @ 12 kt	3,000 n miles @ 12 kt	3,000 n miles @ 12 kt
autonomy:	15 days	15 days	15 days	15 days	15 days
Personnel:	5 officers, 44 crew	5 officers, 41 crew	5 officers, 41 crew	5 officers, 37 crew	5 officers, 41 crew

Notes: * In second two only



Netherlands 'Tripartite' minehunter Hellevoetsluis (Michael Nitz) 0143747

command and control system and software (excluding data processing) and sonar surface units and Thales Underwater Systems the wet end of the hull-mounted sonar, the PVDS sonar (TSM 2022 Mk III), and software for data processing. The vessels will be equipped with the STN ATLAS Seafox expendable mine neutralisation vehicle.

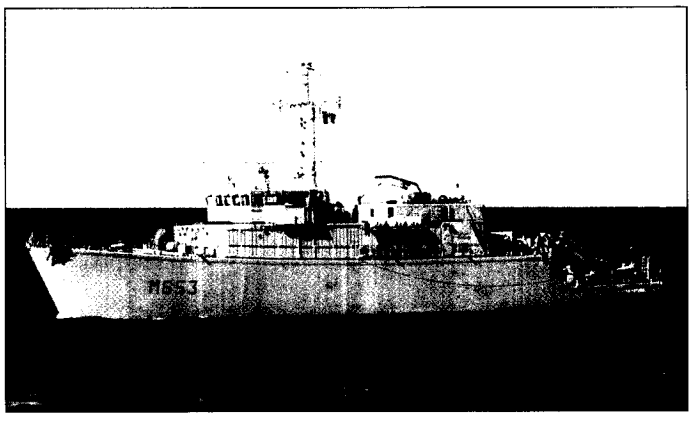
Operational status

Vessels in service with the Belgian, Royal Netherlands and French navies, and units have also been exported to Indonesia and Pakistan.

The seven Belgian vessels (three more were sold to France in 1997) have had their propulsion system upgraded and will have the minehunting capability upgraded between 2001-04.

Three of the Royal Netherlands units began converting to Troika control vessels in 1996. They will receive the new C^2 system being jointly developed by Germany and the Netherlands. The remaining operational units will be upgraded with new command and sonar systems, a new ROV, and propelled variable depth sonar system (in four units).

Commencing in 2000 the French Eridan class began a major mid-life upgrade. Under this the class will be fitted with a new combat system (based on the TSM 2061) and two new sonars (the PVDS system with the Double Eagle Mk II ROV and TUS 2022 Mk III). *Andromède* the first to be modernised was accepted back into



French 'Tripartite' minehunter Capricorne (Michael Nitz) 0143746

service in February 2003. The rest of the class will be upgraded at the rate of four per year.

Contractors

DCN, Lorient, France.
Beliard Polyship, Ostend, Belgium.
Van der Giessen-de Noord, Netherlands. ***UPDATED***

Italy

Gaeta class

Type

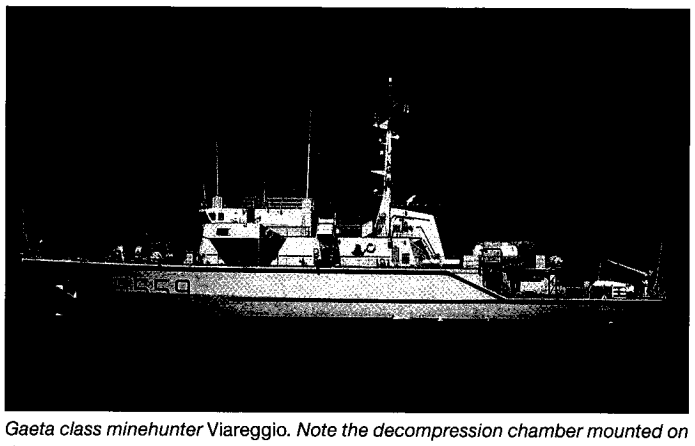
Minehunter.

Description

This is a slightly lengthened version of Intermarine's Lerici class minehunter and is equipped with SMA MM/SPN-728 radar; FIAR SQQ-14(IT) minehunting sonar;

Specifications

Class	Lerici	Gaeta	Mahamiru Jerai	Ohue
Displacement:				
standard:	488 t	665 t	578 t	470 t
full load:	620 t	697 t	610 t	540 t
Dimensions:				
length:	50.00 m	52.5 m	51 m	51 m
beam:	9.9 m	9.9 m	9.9 m	9.9 m
draft:	2.6 m	2.6 m	2.8 m	2.8 m
Electronics:				
combat management system:	SSN-714V(3)	SSN-714V(2)	MTDS	Ibis V
navigation system:	Motorola MRS-III	Motorola MRS-III	TSM 2060	Trident
sonars:	SQQ-14IT, Type 2048	SQQ-14IT, Type 2048	TSM 2022	TSM 2022
radar:	SPN-728V(3)	SPN-728V(3)	Type 1007	Type 1226
electronic warfare:				
weapon control:				
Weapons:				
wire sweeps:	Oropesa Mk 4	Oropesa Mk 4	Oropesa 'O' MIS-4	Oropesa 'O' MIS-4
influence sweeps:	None	None	None	
underwater vehicles:	1 × Pluto, 1 × Pluto Gigas	1 × Pluto Plus, 1 × MIN Mk 2	2 × PAP 104	2 × Pluto
guns:	1 × 20 mm	1 × 20 mm	1 × 40 mm	1 × 2 Emerson 30 mm, 2 × Oerlikon 20 mm GAM-BO1
missiles:	None	None	None	None
Machinery:				
diesels (main):	1 × BL230-8M	1 × BL230-8M	2 × MTU 12V 396 TC82	2 × MTU 12V 396 TB83
power output:	1.46 MW	1.46 MW	1.91 MW	2.3 MW
diesels (minehunting):	3 × ID 36SS	3 × ID 36SS	3 ID 36SS	
power output:	1.1 MW	1.1 MW	1.09 MW	
thrusters:	3 Calzoni SpA	3 Calzoni SpA	2 × Calzoni SpA	
power output:	372 kW	372 kW		
shafts:	1	1	1	1
propeller:	1 × LIPS cp	1 × LIPS cp	1 × KaMeWa cp	2 Turbomeccanica PG2000 waterjets
Speed:	14 kt (6 kt minehunting)	14 kt (6 kt minehunting)	16 kt (7 kt thrusters)	15.5 kt
Range:	2,500 n miles @ 12 kt	2,500 n miles @ 12 kt	2,000 n miles @ 12 kt	2,500 n miles @ 12 kt
autonomy:	12 days	12 days	14 days	14 days
Personnel:	4 officers, 43 crew	4 officers, 43 crew	5 officers, 37 crew	5 officers, 45 crew



Gaeta class minehunter Viareggio. *Note the decompression chamber mounted on the upper deck aft* (Intermarine) 0007406

GEC-Marconi Speedscan side scan route-mapping sonar; one SMIN Consortium MIN 77 or MIN Mk 2 (from *Gaeta* onwards) ROV and one Gaymarine Pluto Plus ROV for mine disposal; and a single Oropesa Mk 4 mechanical wire sweep. Precise positioning is exercised through the POSYS-Miniranger III system. Command and control is exercised through a Datamat MM/SSN-714 command system. Self-defence armament comprises a single or twin Oerlikon 20 mm/70 gun or two Breda/Oerlikon 25/90 mm. Additional 20 mm mounts can be added for overseas deployment.

Main propulsion is by a Fincantieri-GMT B230-8M diesel engine driving a single shaft fitted with a Kamewa cp propeller through a Tosi single-reduction gearbox. Electric power at 440 V 3-phase 60 Hz is supplied by three Ansaldo 420 kW alternators, each driven by a 550 bhp Isotta-Fraschini ID-36-SS-6V auxiliary diesel engine. For slow-speed propulsion there are three 120 shp electrohydraulic motors, each driving a Riva Calzoni retractable/rotatable hydraulic thruster, positioned one forward and two aft. All machinery is resiliently mounted, and constructed of amagnetic material.

To prevent buckling, Intermarine developed a monocoque hull of relatively thick single skin, the thickness of which decreases from keel to deck sides. The material used is Intermarine's patented unsaturated isophthalic resin system which achieves twice the design-lethal limit specified by the Italian Navy and five times the shock resistance of wooden minesweepers. Machinery, equipment and crew are physically isolated from the hull bottom by means of cradles suspended from bulkheads which minimise shock effect on the deck and bulkheads and considerably reduce self-generated noise and vibration, much of which is dissipated before it reaches the hull.

Operational status

The eight unit class is now operational. A modified design has been developed for the Royal Australian Navy (see Huon class entry). Two units have been built for the Royal Thai Navy. The first *Lat Ya* was delivered in June 1999, the second *Tha Din Daeng* was delivered in December 1999 (see 'Lat Ya' entry).

Contractor

Intermarine SpA, Sarzana.

UPDATED

Lat Ya class

Type

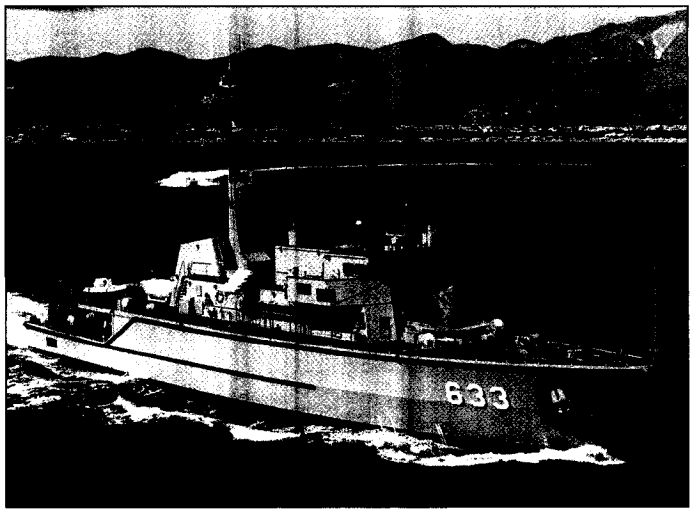
Minehunter.

Description

The Lat Ya class minehunter with combined minesweeping capabilities, uses the same basic hull design as the Gaeta class minehunters of the Italian Navy, namely single-skin monocoque structure. However, the configuration in terms of propulsion and combat system is completely different.

The main propulsion system is similar to that of the Osprey class (built by Intermarine for the US Navy) and features two vertical cycloidal 18 GH 135 Voith Schneider propellers powered by two MTU 8V 396 TE74K diesels developing 1.18 MW. This system is used both for transit and minehunting operations and provides a speed in excess of 14 kt. Two 180 shp hydraulic motors are provided for quiet running when minehunting.

The combat suite is entirely different from that in all other Intermarine minehunters. As such it has required additional engineering effort to ensure satisfactory integration of the basic Intermarine minehunter design with the equipment selected by the Royal Thai Navy. The heart of the system is the ATLAS Elektronik hull-mounted DSQS 11M sonar integrated with the ATLAS Elektronik MWS 80-6 minehunting combat system. The latter incorporates ATLAS tactical command and data system, navigation system (NBD/ADM 90 with Microfix and DGPS) and I-band ARPA radar Type 9600M. The tactical command and data system features two multifunctional consoles located in the control centre, together with the console allocated to sonar management. All three consoles are interconnected via a local bus and are electrically and mechanically identical. Being multifunctional they can be configured according to specific operational requirements. An additional console is located in the control room for control of the



Royal Thai Navy minehunter Lat Ya. *Note two-man recompression chamber on platform aft* (Intermarine SpA) 0099763

ROVs. Most of the functions of this console have been duplicated in one of the tactical command consoles for maximum redundancy.

The ship's communication system has been supplied and integrated by Rohde & Schwarz.

The mine disposal system consists of two Gayrobot Pluto Plus mine disposal vehicles. A two-man recompression chamber is mounted on the platform aft of the funnel. The crew of 50 includes seven ordnance disposal divers.

For minesweeping the vessels are equipped with a Mini-Dyad magnetic influence sweep integrated with a noise generator from ADI of Australia. Mechanical sweeping can be carried out using an Oropesa Mk 4 wire sweep (the Bofors MS 103).

Self-defence is provided by an MSI DS-30B 30 mm cannon mounted on a bandstand forward of the bridge.

Operational status
Two units ordered in September 1996 have now been delivered, *Lat Ya* in June 1999 and *Tha Din Daeng* in December 1999.

Specifications
Class: Lat Ya
Displacement:
- **standard:** 665 t
- **full load:** 697 t

Dimensions:
- **length:** 52.5 m
- **beam:** 9.9 m
- **draft:** 2.9 m

Electronics:
- **combat management system:** MWS 80-6
- **sonars:** DSQS-11M
- **radar:** 9600M

Weapons:
- **wire sweeps:** Oropesa Mk 4
- **influence sweeps:** Mini Dyad, MS 106
- **underwater vehicles:** 2 × Pluto Plus
- **guns:** 1 × DS-30B 30 mm
- **missiles:** none

Machinery:
- **diesels:** 2 × 8V 396 TE74K
- **power output:** 1.18 MW
- **hydraulic motor (minehunting):** 2
- **power output:** 180 shp
- **thrusters:** 1 bow
- **shafts:** 2
- **propeller:** 2 × 18 GH/135 Voith Schneider
- **speed:** 14 kt (6 kt minehunting)
- **range:** 2,000 n miles @ 12 kt

Personnel: 8 officers, 42 crew

Contractor
Intermarine SpA, Sarzana.

UPDATED

Japan

Sugashima class

Type
Coastal minehunter/sweeper.

Description
This new class of wooden-hulled coastal minehunters has been designed to replace the obsolete Takami class, most of which have now been decommissioned. The design differs markedly from the Uwajima class and will be much more capable than the current mine countermeasures vessels in service in the JMSDF. The upper deck has been extended aft to provide additional stowage for mine disposal equipment. Following Japanese experience in minesweeping operations in the Gulf during the Iraq/Kuwait war, the ships are fitted with: an integrated mine countermeasures command system, the Nautis II M command system; a version of the Type 2093 VDS minehunting sonar (ZQS-4); two French ECA PAP 104 Mk 5 ROV; and the Australian ADI Dyad minesweeping system. It is believed that the Japanese decision is based on a desire to compare the latest generation UK and US command and control and sonar systems. Other systems include JRC OPS 39B I-band surface search radar and a 20 mm Sea Vulcan gatling-type gun. Propulsion is provided by two Mitsubishi 6 NMU-TA1 diesels each developing 1,800 bhp (1.33 MW) to give a maximum speed of 14 kt. Bow thrusters are fitted to aid precise manoeuvring during minehunting operations.

Operational status
Programme authorised under the FY95 programme. Seven units are now operational.

Specifications

Class	**Sugashima**
Displacement:	
standard:	510 t
Dimensions:	
length:	54 m
beam:	9.4 m
draft:	3.0 m
Electronics:	
combat management system:	Nautis M
navigation system:	Hyperfix, WRN-7 GPS
sonars:	Type 2093
radar:	JRC OPS-39B
Weapons:	
wire sweeps:	Oropesa Mk 6
influence sweeps:	DYAD influence sweeps
underwater vehicles:	2 × PAP 104 Mk 5
guns:	1 × JM-61 20/76 Sea Vulcan 20 mm
missiles:	None
Machinery:	
diesels:	2 × 6 NMU-TA1
power output:	1.33 MW
electric motor:	2
thrusters:	1 × bow
shafts:	2
propeller:	2 × cp
Speed:	14 kt
Range:	2,500 n miles @ 10 kt
Personnel:	5 officers, 32 crew

Contractors
Universal Shipbuilding Corporation, Tsurumi.
Hitachi, Kanagawa.

UPDATED

Uwajima class

Type
Coastal minehunter/minesweeper.

Description
This wooden-hulled design is a slightly lengthened (by 2.7 m) version of the Hatsushima class MCMV, the increased length being used to provide improved accommodation facilities. The sensor fit includes a JRC OPS-39 I-band surveillance radar and NEC/Hitachi ZQS 3 high-frequency hull-mounted minehunting sonar.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

Mine destructor equipment is based on the remote-controlled Type S-7 equipped with a countermining charge. The ships are armed with a General Electric 20 mm Sea Vulcan gatling-type gun mounted forward.

Main propulsion is by two Mitsubishi 6-NMU-TA1 diesel engines each developing 1,400 bhp (1.03 MW), driving twin shafts fitted with Kamewa cp propellers through Mitsubishi single-reduction gearboxes; electric power is provided by one 1,450 kW gas-turbine DC generator (for the electric sweep), and two 160 kW AC diesel-alternator sets (for ship services). The last two vessels in the series have diesels developing 1,800 bhp (1.32 MW).

Operational status
Nine units operational.

Specifications

Class	**Uwajima**
Displacement:	
standard:	490 t
full load:	510 t
Dimensions:	
length:	58 m
beam:	9.4 m
draft:	2.9 m
Electronics:	
sonars:	ZQS 3
radar:	JRC OPS-9/OPS-39
Weapons:	
influence sweeps:	S-2 acoustic, S-6 electromagnetic
underwater vehicles:	S-7 Mod 1 (ZQS-3 sonar)
guns:	1 × JM-61 20mm/76 Sea Vulcan 20
missiles:	None
Machinery:	
diesels:	2 × Mitsubishi 6NMU-TA1
power output:	1.03 MW
shafts:	2
propeller:	2 × cp
Speed:	14 kt
Range:	2,400 n miles @ 10 k
Personnel:	45 (40 in 675 onwards)

Contractors
Universal Shipbuilding Corporation, Tsurumi.
Hitachi, Kanagawa.

UPDATED

Yaeyama class

Type
Ocean-going minehunter/minesweeper.

Description
These wooden-hulled ocean minesweepers are powered by two Mitsubishi 6 NMU-TA1 diesel engines, each developing 1,200 bhp (1.76 MW), driving twin shafts fitted with cp propellers through single-reduction gearboxes for a maximum speed of 14 kt. Precise manoeuvring is aided by a 350 hp (257 kW) bow thruster hydrojet unit. The ships are being retrofitted with an integrated tactical command system. They deploy the Type S-7 deep water minehunting system and the Type S-8 deep water mechanical minesweeping system and are equipped with the influence mine sweep system such as Type S-2 acoustic minesweep and Type S-6 eletromagnetic minesweep systems, JRC OPS-39B I-band surveillance radar; Raytheon SQQ-32 variable depth minehunting sonar and Klein Associates AQS-14 side scan sonar. Armament consists of a single General Electric 20 mm Sea Vulcan gatling-type gun.

Operational status
Three units operational, but plans for a further three abandoned.

Specifications

Class	**Yaeyama**
Displacement:	
standard:	1,000 t
full load:	1,275 t
Dimensions:	
length:	67 m
beam:	11.8 m
draft:	3.1 m
Electronics:	
sonars:	SQQ-32, AQS-14
radar:	JRC OPS-39B
Weapons:	
influence sweeps:	S-6 electromagnetic, S-2 acoustic
underwater vehicles:	S-7, S-8
guns:	1 × JM-61 20mm/76 Sea Vulcan
missiles:	none
Machinery:	
diesels:	2 × Mitsubishi 6 NMU-TA1
power output:	1.76 MW
thrusters:	1 × hydrojet bow thruster
power output:	257 kW
shafts:	2
propeller:	2 × cp
Speed:	14 kt
Personnel:	60

Contractors
Universal Shipbuilding Corporation, Tsurumi.
Hitachi, Kanagawa.

UPDATED

Korea, South

Swallow class

Type
Minehunters.

Description
The Kang Kyeong (Swallow) class is of single skin GRP construction with deck and superstructure stiffened with transverse and longitudinal reinforcements. The single skin hull is moulded complete without transverse or longitudinal reinforcements, the thickness of the hull varying according to shock requirements. The main deck and hull are bolted together and sealed internally by a secondary GRP bond. The main bulkheads are reinforced with stiffeners to meet sub-division requirements, and these are extended to the main deck. The GRP is manufactured using a Kangnam-developed laminating and automatic impregnator system. The basic laminate composite consists of a woven roving/resin matrix with cushion materials inserted in areas where the hull and deck join and where the hull and bulkheads connect. Internal tanks do not form a structural component of the hull, nor do they add any longitudinal strength to the hull. Instead they are attached directly to the hull using special isolation techniques. Engines and machinery are elastically mounted to the deck through foundations attached to the hull.

The mine countermeasure system comprises: a Racal Mains 500 combat system; Thomson Marconi Sonar Type 193M Mod 1 or Mod 3 (in later units) minehunting sonar; Type 2048 Speedscan; Raytheon SPS-64 I-band navigation radar; and two Italian Gaymarine Pluto ROVs. The ships are also fitted with a single wire sweep system, which can be towed at 8 kt. Self-defence is provided by an Oerlikon 20/70 mm light AA gun and two 7.62 mm machine guns.

The machinery system comprises two MTU 1,020 bhp diesels driving two independent vertical Voith-Schneider cycloidal propellers through a gearbox and universal joint shaft. A 102 hp thruster is transversely mounted in the bow for precise manoeuvring. Machinery control is exercised through a control and monitoring system sited in the machinery control room. A microprocessor-based semi-automatic manoeuvring system co-ordinates the movements of the cycloidal propellers. In addition the engines can be controlled from the wheelhouse or from a local position in the engine room.

A 3-D degaussing system is fitted to protect the entire vessel.

Operational status
Six units operational in South Korean Navy.

Specifications

Class	Swallow
Displacement:	
standard:	470 t
full load:	520 t
Dimensions:	
length:	50.00 m
beam:	8.3 m
draft:	2.6 m
Electronics:	
combat management system:	Mains 500
sonars:	Type 193M, Type 2048
radar:	SPS 64

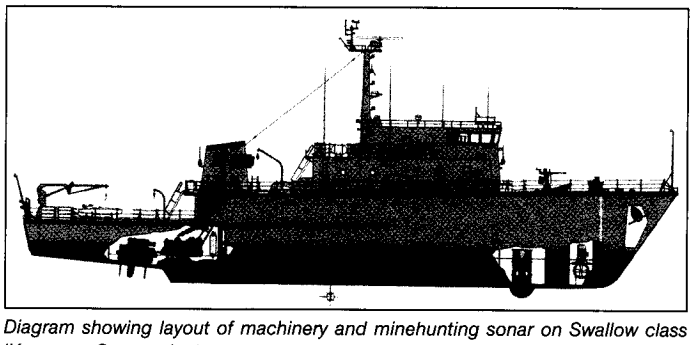


Diagram showing layout of machinery and minehunting sonar on Swallow class
(Kangnam Corporation) 0114377

Class	Swallow
Weapons:	
underwater vehicles:	2 × Pluto
guns:	1 × 20 mm Oerlikon
missiles:	None
Machinery:	
diesels:	2 × MTU
power output:	1.5 MW
thrusters:	1 bow
power output:	75 kW
shafts:	2
propeller:	2 × Voith Schneider
Speed:	15 kt (8 kt minesweeping)
Range:	2,000 n miles @ 10 kt
Personnel:	5 officers, 39 crew plus 4 divers

Contractor
Kangnam Corporation, Pusan. ***UPDATED***

Yang Yang class

Type
Minehunters.

Description
The Yang Yang class design is an enlarged version of the earlier Swallow class (see Swallow class entry) using the same construction technology and layout as the earlier vessels.

The minehunting capability is centred on: the Thomson Marconi SAS TSM 2061 Mk 3 combat system integrating a Thomson Marconi 2093 variable depth minehunting sonar; Raytheon I-band navigation radar; and two Italian Gaymarine Pluto Gigas ROVs. The ships are also fitted with the BAE Systems Wire Sweep Mk 9 deep wire sweep system and CIS combined influence sweep. Self-defence is provided by a Sea Vulcan Gatling 20 mm light AA gun and two 7.62 mm machine guns. A Kongsberg Simrad integrated navigation and dynamic positioning system is fitted to aid in precise manoeuvring during minehunting and route survey operations.

The machinery system comprises two MTU 2,000 bhp diesels driving two independent vertical Voith-Schneider cycloidal propellers through a gearbox and universal joint shaft. A 134 hp thruster is transversely mounted in the bow for precise manoeuvring. Machinery control is exercised through an Integrated Platform Management System (IPMS) supplied by CAE of Canada and sited in the machinery control room. The digital IPMS monitors and controls the ship's entire hull electrical and mechanical systems as well as the propulsion, electrical distribution, steering, damage control and navigation system. A microprocessor-based semi-automatic manoeuvring system co-ordinates the movements of the cycloidal propellers. In addition the engines can be controlled from the wheelhouse or from a local position in the engine room.

Operational status
One unit operational in South Korean Navy and seven more anticipated.

Specifications

Class	Yang Yang
Displacement:	
full load:	880 t
Dimensions:	
length:	59.4 m
beam:	10.5 m
draft:	3.0 m
Electronics:	
combat management system:	TSM 2061 Mk 3
sonars:	Type 2093
radar:	Raytheon I-band
electronic warfare:	none
Weapons:	
wire sweeps:	BAE Systems CIS
underwater vehicles:	2 × Pluto Gigas
guns:	2 × 20 mm Sea Vulcan
missiles:	None
Machinery:	
diesels:	2 × MTU
power output:	2.98 MW
thrusters:	1 bow
power output:	100 kW
shafts:	2
propeller:	2 × Voith Schneider
Speed:	15 kt
Range:	3,000 n miles @ 12 kt
Personnel:	7 officers, 49 crew and 5 divers

Contractor
Kangnam Corporation, Pusan. ***UPDATED***

Norway

Oksøy/Alta classes

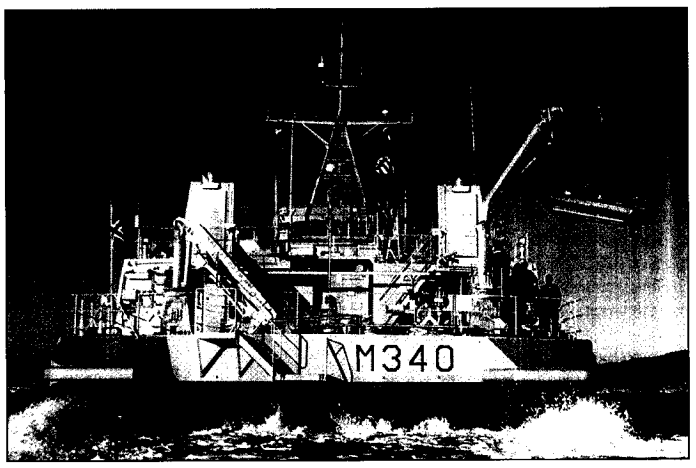
Type
Minehunter (four units), minesweeper (five units).

Description
One of the main features of this design is the high transit speed requiring less power than comparable conventional designs, which will facilitate deployment over the lengthy Norwegian coastline. By using a catamaran design built in advanced composite sandwich structure, it is claimed that lower magnetic and acoustic signatures will be exhibited due to the small wet area of the hull, leading to safer operation and less susceptibility to shock, and reduced disturbance of the water leading to improved sonar response, particularly in shallow water. Other advantages claimed are improved manoeuvrability, reduced draught, improved view from the bridge – an important element in minesweeping operations, increased deck area (approximately 70 per cent more compared to a monohull) and greater comfort and improved sea-keeping qualities due to a much lower roll acceleration compared to other catamaran-type designs and a much reduced roll angle compared to standard displacement hulls (approximately 2 to 3° in Sea State 3).

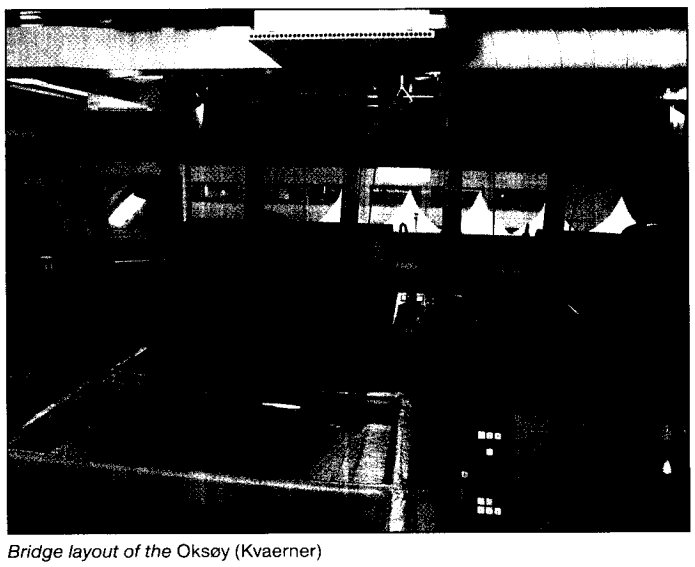
The minehunter version is equipped with an integrated minehunting sonar comprising the Thomson Sintra TSM-2023N classifier and Simrad detection sonar, the combined system being carried on a retractable cantilever amidships inside the air cushion. Two Gaymarine Pluto Plus ROVs are carried for mine disposal, being handled by two deck cranes. Minehunting operations will be controlled by the Simrad/Thomson Sintra Micos integrated MCM system. The minesweepers are fitted with the Simrad SA 950 mine avoidance sonar, a standard Oropesa sweepgear and Agate acoustic sweep and Elma magnetic sweep. Extensive navigation equipment is fitted including a Racal Decca RN88 navigation radar and Doppler log, Seatex GPS, wind sensors and so on. These are linked to the Norcontrol Databridge 2000 ARPA and SeaMap electronic chart system.

An Aeromaritime Systembau integrated computerised distributed communications system is fitted, incorporating a comprehensive message handling system. The company is also responsible for the EMI environmental control on the craft.

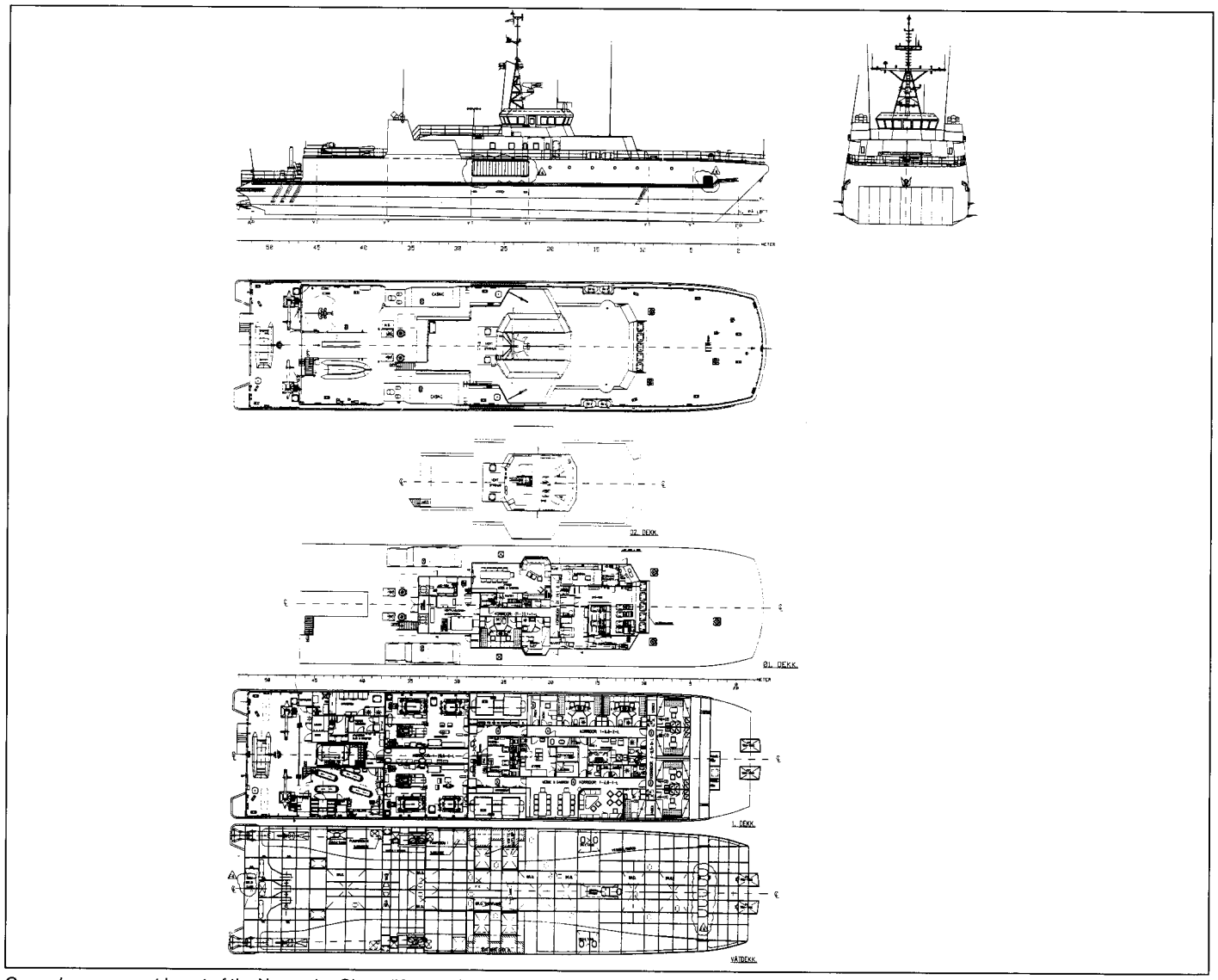
Main propulsion is by two raft-mounted MTU 12V 396 TE94, 1,920 bhp (1,400 kW) diesel engines powering twin Kvaerner Eureka waterjets through ZF BW465 single-reduction gearboxes. The waterjets are controlled by the dynamic



The Norwegian MCMV Oksøy (Kvaerner) 0007407



Bridge layout of the Oksøy (Kvaerner)



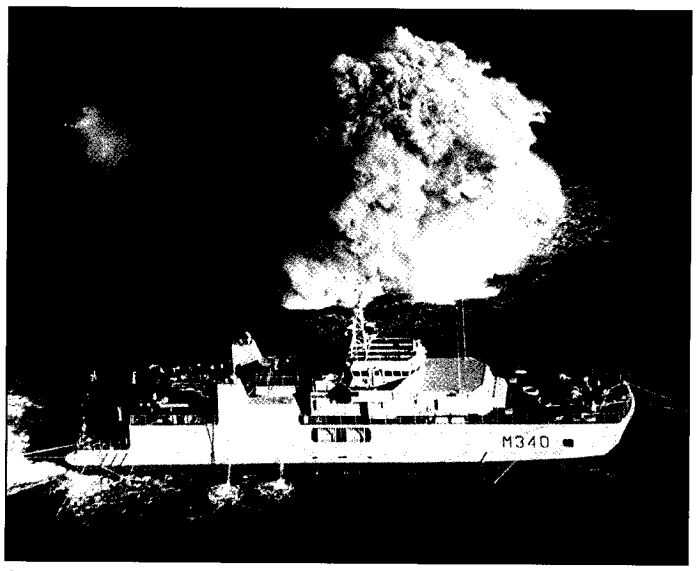
General arrangement layout of the Norwegian Oksøy (Kvaerner)

positioning system. Two MTU 8V 396 TE54, 950 bhp (750 kW) auxiliary diesel engines power the lift fans for a draught of 0.90 m when on-cushion. Hotel services are provided by two MTU 12V 183 TE51 diesel generators. Machinery and ship control is exercised through a Norcontrol Automation Ship Technical Control system (STC) and a Surface Surveillance System (SSS).

Self-defence capability includes a single Rheinmetall 20 mm, two 12.7 mm machine guns and a Simbad Mistral SAM launcher.

Operational status

Four Oksøy class and four Alta class. The Alta class *Orkla* was totally destroyed in a fire off Ålesund on 19 November 2002.



Oksøy *undergoing shock trials* (Kvaerner) 0024794

Specifications

Class	Oksøy	Alta
Displacement:		
standard:	343 t	343 t
full load:	375 t	375 t
Dimensions:		
length:	55.2 m	55.2 m
beam:	13.6 m	13.6 m
draft:	2.5 m	2.5 m
Electronics:		
combat management system:	Micos	Micos
navigation system:	Simrad Albatross	Simrad Albatross
sonars:	TSM 2023N	SA 950
radar:	2 × RN 88	2 × RN 88
Weapons:		
wire sweeps:	None	Oropesa Mk 4
influence sweeps:	None	Agate, Elma
underwater vehicles:	2 × Pluto Plus	None
guns:	1 or 2 × 20 mm	1 or 2 × 20 mm
missiles:	twin Sadral	twin Sadral
Machinery:		
diesels:	2 × 12V 396 TE84	2 × 12V 396 TE84
power output:	2.72 MW	2.72 MW
diesels (for lift):	2 × 8V 396 TE54	2 × 8V 396 TE54
power output:	1.28 MW	1.28 MW
propeller:	2 × Eureka waterjets	2 × Eureka waterjets
Speed:	20.5 kt	20.5 kt
Range:	1,500 n miles @ 20 kt	1,500 n miles @ 20 kt
autonomy:	n/k	n/k
Personnel:	12 officers, 26 crew	10 officers, 22 crew

Contractor

Umoe Mandal, Mandal.

UPDATED

Poland

Kormoran class (Project 257)

Type
Minesweeper/minehunter.

Development
A Polish Navy funded study accepted in May 2001 by the Polish MoD recommended the development of a new class of minehunters based on low-magnetic steel technology provided by Lürssen of Germany.

The design phase with a foreign partner was launched late in 2001 and a formal selection of the design is due in 2002. The keel of the first unit will be laid down in 2003.

Description
The Polish Navy intends to acquire a new class of minesweepers designated Project 257 (unofficially named Kormoran). Two of these new vessels are to be introduced by 2006. The vessels will be equipped with a new hull-mounted minehunting sonar SHL-101/T under development and using technology from the Thales Underwater Systems TSM 2022 Mk III. The sonar is being developed by Centrum Techniki Morskiej (CTM).

The vessels will be powered by two diesels each of 1,850 bhp and an auxiliary electric drive of 80 hp to power the vessels at 6 kt for minehunting.

Self-defence will be provided by a twin 23 mm mount and a SA-N-5 (Grail) SAM system.

The vessels will displace some 400 tonnes full load on a length of 43.5 m, beam of 7 m and draught of 3.85 m. They will be manned by a crew of 36.

Operational status
Under development, first unit to be in service around 2006. Up to 14 units are to be acquired in two batches of six and eight.

Specifications

Class	Kormoran (Project 257)
Displacement:	
full load:	400 t
Dimensions:	
length:	43.5 m
beam:	7.0 m
draft:	3.85 m
Electronics:	
sonars:	SHL-101T
radar:	Bridgemaster
Weapons:	
guns:	1 × 2 23 mm
missiles:	1 × 4 Fasta 4M, SA-N-5
Machinery:	
diesels:	2
power output:	2.76 MW
electric motor:	1
power output:	80 hp
shafts:	2
Personnel:	36

***Precise details are uncertain**

Contractor
Stocznia Marynarki Wojennej, Gdynia.

VERIFIED

Krogulec class (rebuilt)

Type
Minehunter/sweeper.

Development
Originally built in the mid-1960s as minesweepers, the three vessels of the Krogulec class were taken out of service in 1997 for conversion to minehunter/sweepers. It was decided to rebuild the vessels for a dual role, as this would be much more cost effective than seeking to acquire two separate designs. The objective was to acquire some modern mine warfare units that could remain in service until around 2010 when it was hoped that a new design would be entering service.

Description
Under the major rebuilding programme, during which some 90 per cent of the vessels have been modernised, the upper deck has been completely rebuilt with a new superstructure and redesigned bridge accommodating new equipment and a new mast. The after sweep deck has also been redesigned and much of the internal layout redesigned and refurbished to accommodate new electronics, including sonars and a command, control and communications system.

As rebuilt, the minehunter/sweepers are fitted with the Polish-designed Pstrokosz integrated mine countermeasures command, control and communications system. This system links the new sensor systems which consist of a Polish-manufactured SHL-100MA HF hull-mounted sonar and an SHL-200 VHF towed side scan sonar; processes data from any of the 10 ZHH 230 sonobuoys carried; a new communications and datalink system which enables the vessels to operate with NATO forces; and a new ROV, the Ukwial, designed by the Polish Naval Technical Centre at Gdynia. The sonars are claimed to have a detection range of 1,600 m against moored mines, and a 600 m range against seabed mines.

The new ROV is housed in the after section of the new superstructure, together with a new two-compartment decompression chamber. A semi-rigid inflatable has been installed aft for the transport of mine warfare divers.

For minesweeping, the vessels have been equipped with the MT-2 mechanical sweep fitted with the Saab Bofors Underwater Systems T Mk 9 explosive cutter. The TEM-PE-2MA magnetic sweep has been upgraded to enable it to be used simultaneously with a new Polish-designed MTA-2 acoustic sweep system, both deployed from a new smaller winch on the aft deck.

The vessels are also capable of minelaying, carrying between 8 and 16 mines, according to type, of the Polish-manufactured MMD-1, MMD-2, OD, OS or JAM types.

Self-defence systems include a twin 23/87 mm Russian ZU-23-2MR cannon with two SA-N-5 Strela SAMs carried on the mount. Two quad Fasta-4M SA/N/5/8 missiles are also carried and these will be replaced by two SA-N-10 (Grom) weapons. Electronic warfare systems include a PIT Bren system, which is being fitted, and two sets of 3 × 9-barrelled Jastrzab decoy launchers.

Other new systems fitted to the vessels include a NATO-compatible IFF, a new degaussing system, new NBC capability and NATO-compatible refuelling connectors.

The two Cegielski/Sulzer 6AL 25/30 diesels have also been thoroughly overhauled. These develop 3,740 bhp to drive two shafts fitted with acbLIPS controllable pitch propellers.

Operational status
The three vessels were recommissioned in their new role in 1999, 2000 and 2001. The replacement of these units with a modern minehunter is the Polish Navy's next major project. Bids were circulated for the technical outline of the new design, and submissions were tendered in August 2000. Construction of the new vessels is scheduled to commence early in 2002.

Specifications

Class	Krogulec
Displacement:	
full load:	550 t
Dimensions:	
length:	58.2 m
beam:	7.7 m
draft:	2.1 m
Electronics:	
combat management system:	Pstrokosz
navigation system:	
sonars:	SHL-100MA, SHL-200
radar:	Bridgemaster
electronic warfare:	Bren, 2 × 6-9 Jastrzab decoy
Weapons:	
wire sweeps:	MT2W
influence sweeps:	MTA-2, TEM-PE-2MA
underwater vehicles:	Ukwial
guns:	1 × 2 ZU-23-2MR 33 mm
mines	8 to 16
missiles:	2 × quad Fasta 4M
Machinery:	
diesels:	2 × 6AL 25/30
power output:	1.62 MW
shafts:	2
propeller:	2 × LIPS cp
Speed:	17 kt
Range:	2,000 n miles @ 12 kt
autonomy:	12 days
Personnel:	6 officers, 46 crew

Contractor
Gdynia Shipyard, Gdynia.

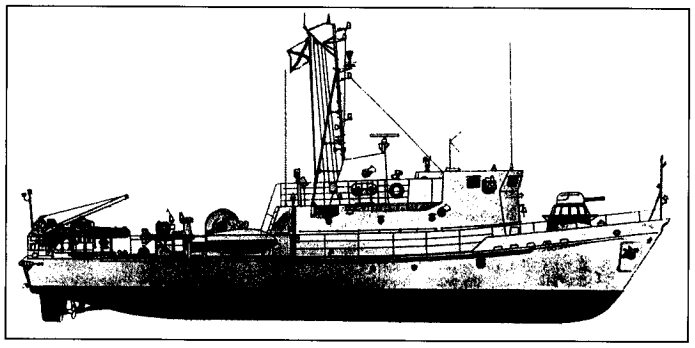
VERIFIED

Russian Federation

Lida class

Type
Coastal minehunter.

Description
This class of coastal minehunter was designed as a follow-on to the Yevgenya class, to which it is similar in appearance. The ships are powered by three 900 hp



Outboard profile of the Lida class 0007408

(690 kW) 3D-12MM diesels driving three shafts for a speed of 12 kt. The vessels are armed with a 30 mm six-barrel gatling-type gun and minesweeping equipment comprises the AT-6 acoustic, PEMT-4 and ST-2 magnetic and GKT-3MO wire sweeps, the latter with a swept path of 50 to 120 m and a depth of 2 to 120 m. In addition, the vessels carry the IT-3 ROV equipped with underwater TV camera for mine identification. A Kabarga-AI hull-mounted high-frequency minehunting sonar is carried. The radar outfit comprises a Pechora I-band surveillance radar which may be complemented by Bass Tilt fire-control radar in due course.

The hull is of GRP with low magnetic steel and aluminium-magnesium alloy in parts. Transverse framing is employed with frames spaced at 400 mm. All equipment is shockmounted with flexible connections on all pipework.

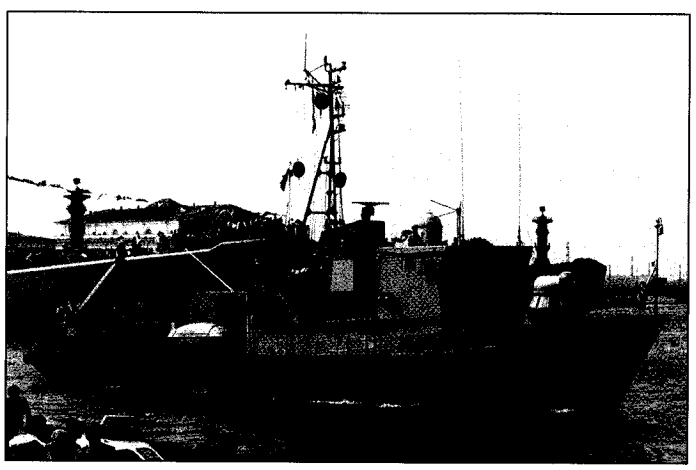
Operational status
Nine units are in service.

Specifications

Class	'Lida'
Displacement:	
standard:	131 t
full load:	135 t
Dimensions:	
length:	31.5 m
beam:	6.5 m
draft:	1.6 m
Electronics:	
combat management system:	None
sonars:	Kabarga I
radar:	Pechora
Weapons:	
wire sweeps:	GKT-3MO
influence sweeps:	PEMT-4, SEMT-1, AT-6
underwater vehicles:	IT-3
guns:	1 × AK 630 30 mm
missiles:	5 × SA-14/16
Machinery:	
diesels:	3 × D12MM
power output:	690 kW
shafts:	3
propeller:	3
speed:	12 kt
Range:	650 n miles @ 10 kt
autonomy:	5 days
Personnel:	1 officer, 13 crew

Contractor
Kolpino Yard, St Petersburg.

UPDATED



A Russian Lida class minesweeper (H & L van Ginderen)

Natya class

Type
Ocean-going minesweeper/hunter.

Description
The low magnetic aluminium/steel-hulled Project 266ME (export *Natya* class) ocean-going minesweeper deploys: the GK-2 wire sweep with a sweep width of 260 to 280 m and maximum sweep depth of 200 m, minimum sweep depth of 10 m; the AT-2V acoustic sweep (with a towing speed of 5 to 12 kt in up to Sea State 4 and a minimum depth of 15 m; and the TEM-3 coil sweep with a towing speed of up to 10 kt at Sea State 4 and a minimum depth of 15 to 20 m with a length of 455 m. Control of influence sweeping operations is carried out by two sets of Micron control equipment.

For mine detection, the ships are fitted with the MG-89 minehunting sonar with a detection range of 1,000 to 1,200 m against moored mines and 350 to 400 m against seabed mines. Angular resolution is 1.5°. The ship is also fitted with the MG-35E underwater sound communications sonar used to maintain non-directional HF/LF telephone and telegraph communications.

Self-defence is provided by two AK-306 30 mm six-barrel automatic gun mounts sited at the ship's bow and stern. Two Igla-1 portable air defence missile systems are also carried, located on either side of the ship, and two RBU-1200 ASW mortars mounted to port and starboard just aft of the forward 30 mm mount. The ship is also capable of minelaying, a total of eight being carried and secured on special mine rails aft.

The ships are powered by two M503B-37 four-stroke diesels with a total output of 5,000 bhp. These drive two VR226 AE-TM three-bladed cp propellers with a diameter of 2.1 m through a reduction gearbox. The export variant differs from the Russian Navy version in having the main engines and cp propellers electrically controlled instead of pneumatically.

Degaussing equipment consists of three coils (horizontal main, frame course and keel course) and control equipment.

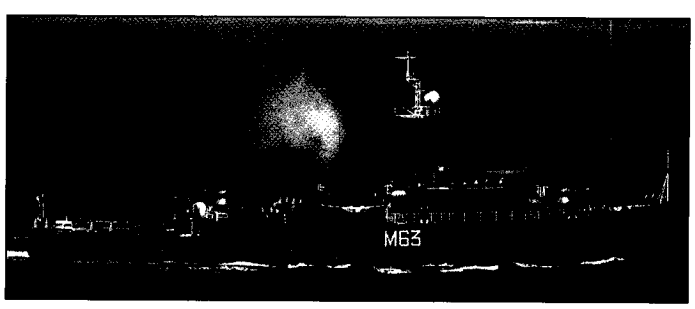
Operational status
In widespread service around the world.

Specifications

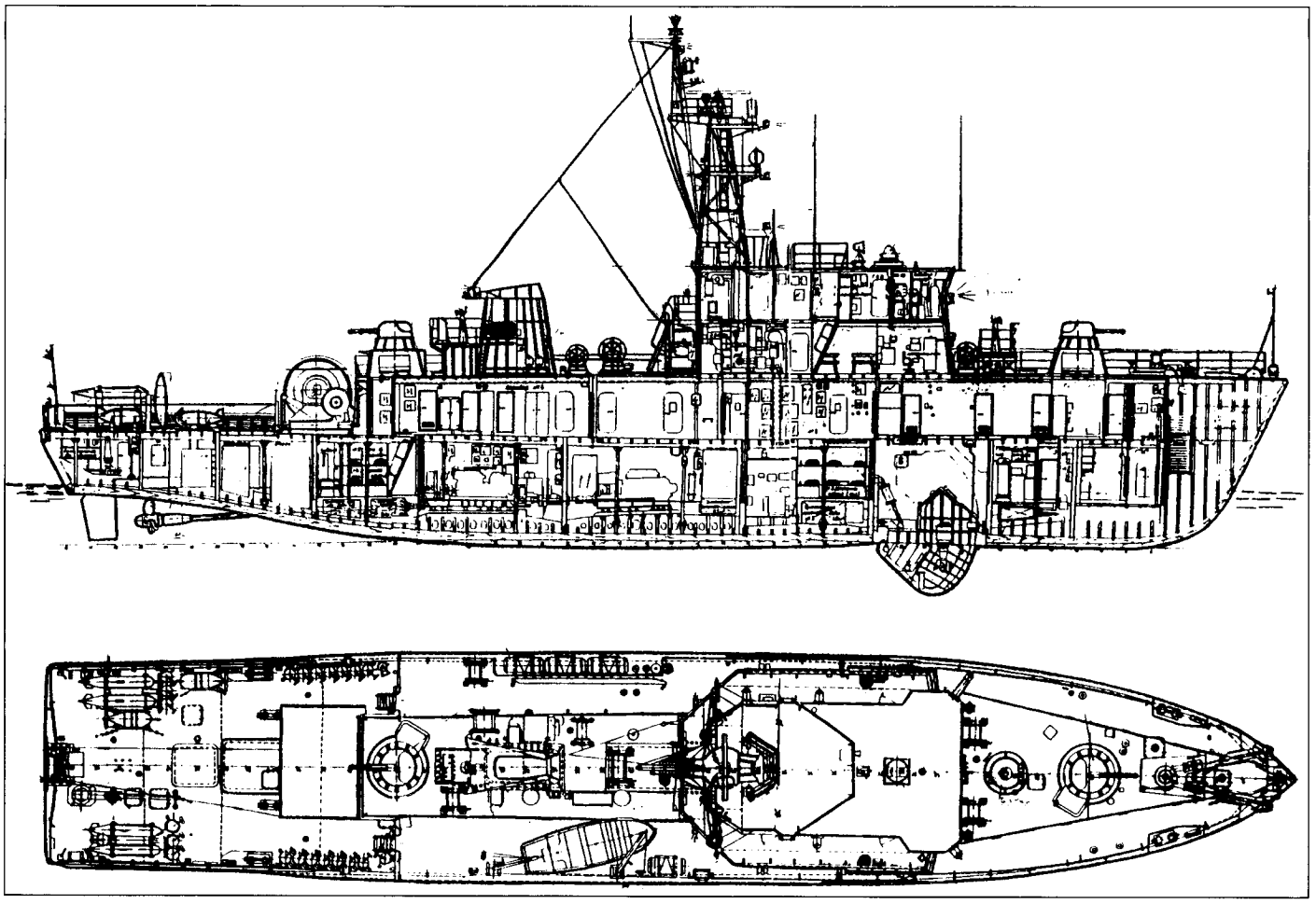
Class	Natya I
Displacement:	
standard:	735-750 t
full load:	804-812 t
Dimensions:	
length:	61.00 m
beam:	10.2 m
draft:	3.00 m
Electronics:	
combat management system:	
navigation system:	
sonars:	MG 79/89
radar:	1 or 2 Don 2
electronic warfare:	
weapon control:	Drum Tilt
Weapons:	
wire sweeps:	1/2 × GKT-2
influence sweeps:	1 × AT-2, 1 × TEM-3
guns:	2 × twin AK 230 30 mm 2 × twin 2M-3M 25 mm
missiles:	2 × SA-N-5/8 quad
A/S mortars:	2 × RBU 1200
Machinery:	
diesels:	2 × M503B-3E
power output:	3.67 MW
shafts:	2
propeller:	2 × shrouded cp
Speed:	16 kt
Range:	3,000 n miles @ 12 kt
autonomy:	10 days
Personnel:	8 officers, 59 crew

Contractors
Kolpino Yard, St Petersburg.
Khabarovsk Yard, Khabarovsk.

UPDATED



Natya I class minesweeper Bedi *of the Indian Navy* (H & L van Ginderen)



General arrangement of the Sonya class

0007409

Sonya class

Type
Coastal minesweeper.

Description
The Project 1265-E *(Sonya)* coastal minesweeper features a wooden hull sheathed in GRP. The ships are equipped to handle the GKT-2 wire, AT-5 acoustic, PEMT-4 and ST-2 magnetic sweeps. It is designed to detect and mark seabed mines. For minehunting a MG-89 minehunting sonar is also fitted in export variants, standard variants being equipped with the MG 69/79. The ship is also fitted with an IT-3 mine detector exploder with a hunting swath of 20 to 30 m and an operating depth of 10 to 60 m and a towing speed of 3.5 to 6 kt. The exploder is towed at a distance of 70 m astern of the ship from a large crane mounted at the stern of some units. In addition to the sonar, the ship is also fitted with the MG-35E underwater communication system, which maintains non-directional HF and LF telephone and telegraph communications and also measures ranges using the interrogation-response methods. The operating range is 10 km for telephone communications and 20 km for telegraph communications.

For self-defence the ships are fitted with two AK-630 30 mm automatic six-barrel gun mounts.

Propulsion is provided by two DRA-210A (alternative designation 12ChPN 18/20) four-stroke diesel engines rated at 1,000 bhp each (at 1,550 rpm) driving two three-bladed VR1265E-TM5 cp propellers with a diameter of 1.7 m. Electrical supplies are provided by three diesel generators each rated at 110 kW and one 50 kW diesel generator.

Degaussing equipment consists of three coils (horizontal main, frame course and keel course) and control equipment.

Operational status
Numerous units in service around the world.

Specifications

Class	Sonya
Displacement:	
standard:	401-427 t
full load:	430-460 t
Dimensions:	
length:	48.00 m
beam:	8.8 m
draft:	2.00 m
Electronics:	
sonars:	MG 69/79
radar:	Don 2 or Kovach or Nayada
Weapons:	
wire sweeps:	GKT-2
influence sweeps:	ST-2, AT-5, PEMT-4
underwater vehicles:	IT-3
guns:	2 × AK 630 30 mm or 2 × 2 30 mm and 2 × 2 25 mm
missiles:	2 × 4 SA-N-5 (in some)
Mines	8
Machinery:	
diesels:	2 × Kolomna DRA-210-A/B
power output:	1.47 MW
thrusters:	2
shafts:	2
propeller:	2 × TM5 3 bladed cp
Speed:	15 kt
Range:	3,000 n miles @ 10 kt
autonomy:	15 days
Personnel:	5 officers, 38 crew

Contractors
Petrozavodsk shipyard.
Vladivostok shipyard.

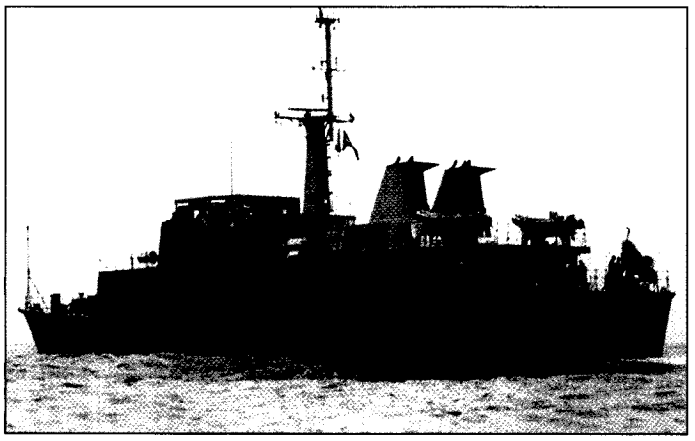
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Spain

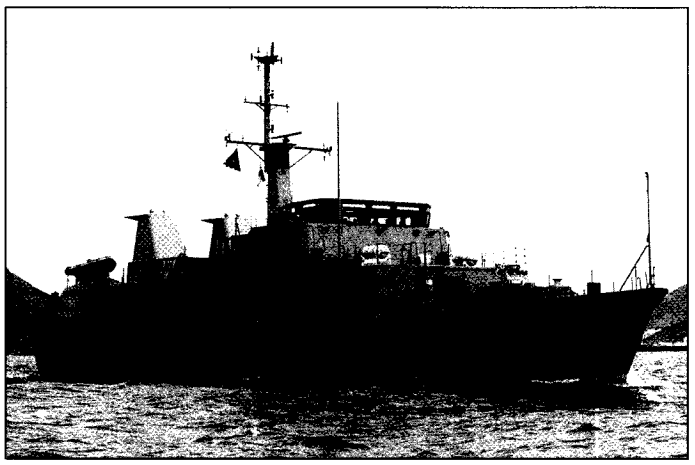
Segura class

Type
Minehunter.

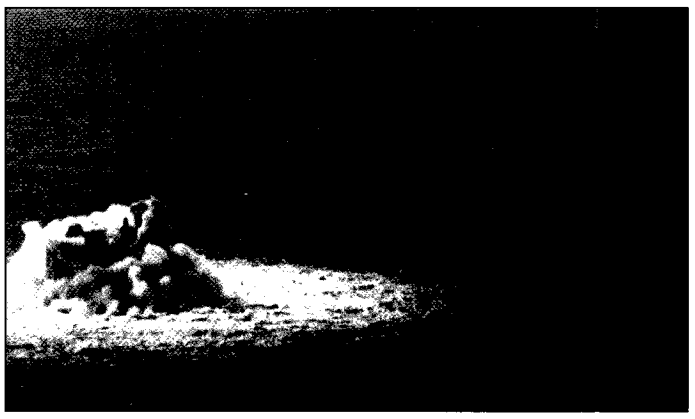
Development
On 4 July 1989, IZAR signed a technology transfer agreement with Vosper Thornycroft for the shipyard to design a new MCM vessel based on the British Sandown design. This technology transfer agreement was followed by another agreement signed in November 1993 between DCN and IZAR which provides for personnel at IZAR to be trained in GRP technology. A class of 12 vessels is envisaged, eight minehunters and four minesweepers.



Segura *undergoing contractor's sea trials* (IZAR) 0131456



The first of the Segura class minehunters undergoing contractor's sea trials (IZAR) 0033298



Sella undergoing shock trials (Izar) 0593067

Description

The hull is constructed of single-skin GRP with longitudinal stiffeners in the bottom and transverse frames along the side. Fastening and mounting systems are of stainless steel and aluminum and copper alloys.

The degaussing system comprises 25 coils for the entire hull and superstructure with additional local coils for specific equipments.

Collectively known as the CME (Caza Minas Espanol), the new design is fitted with the SMYC CM (Sistema de Mando Y Control para CazaMinas) minehunting system (NAUTIS) manufactured by FABA-IZAR under licence. The minehunting sonar is a multifunction, high-frequency VDS SQQ-32(SP) sonar manufactured by ENOSA under licence from Raytheon. The sonar incorporates a CAD facility using two AN/WYK-44 computers to filter false targets, a side scan sonar and a towed body underwater tracking and positioning system; an Australian Nautronix Ltd ATS. The sonar features high-resolution transmit/receive capabilities through narrow beamwidth and dynamic focusing which offer near-picture quality target identification. Search and classification data can be displayed simultaneously or independently on two high-resolution operator consoles. For mine neutralisation the ships carry two Gaymarine Pluto Plus ROVs.

The navigation system includes a navigation processor running algorithms and filtering for high precision positioning, DGPS with HF to UHF differential links, and Doppler log with rotated beams. The manoeuvring and positioning control system manufactured by Sistemas de Control IZAR performs automatic control of bow and aft propellers to maintain track and station.

The communication system is FABA's ICCS4 integrated communications control system. The system uses a fibre optic network supporting digital ISDN switching nodes and 27 user voice terminals located throughout the vessel.

The vessels are powered by two MTU-IZAR 6V 396 TB83 diesels (560 kW each) built by IZAR and driving two Voith Schneider 18GH cycloidal propellers for a speed of 14 kt. Two 55 kW transverse bow thrusters are also mounted for precise manoeuvring during minehunting operations. Slow speed propulsion for minehunting is provided by two 125 kW low magnetic field electric motors which feature compensated stray fields. Hotel services are provided by three 270 kW diesel alternators. These are mounted on the main deck to minimise noise below the waterline.

Armament comprises a single Oerlikon 20 mm GAM-BO1 gun. Fire control is exercised through an optronic directors and the vessels incorporate an ESM system.

Operational status

Five units are in service and one more is under construction.

Specifications

Class	Segura
Displacement:	
full load:	530 t
Dimensions:	
length:	51 m
beam:	10.7 m
draft:	2.2 m
Electronics:	
combat management system:	Nautis
sonars:	AN/SQQ-32
radar:	Type 1007
electronic warfare:	none
Weapons:	
wire sweeps:	None
influence sweeps:	None
underwater vehicles:	2 × Pluto Plus/Minesniper
guns:	1 × 20 mm GAM-BO1
missiles:	none
Machinery:	
diesels:	2 × MTU/Izar 6V 396 TB 83
power output:	1.12 MW
electric motor:	2
power output:	200 kW
thrusters:	2
power output:	110 kW
shafts:	2
propeller:	2 × 18 GH Voith Schneider
Speed:	14 kt
Range:	2,000 n miles @ 12 kt
Personnel:	7 officers, 34 crew

Contractor

IZAR, Cartagena.

UPDATED

Sweden

Landsort class

Type

Multirole mine warfare vessel.

Description

This is an extremely compact multipurpose minelaying/minehunter/minesweeper design. For minesweeping duties the class is equipped with mechanical, acoustic and magnetic sweeps; and for minehunting with the Bofors Double Eagle ROV for mine disposal. The ships can control two slave 18 m SAM GRP catamarans fitted with acoustic and magnetic sweeps. In the minelaying role the vessels are fitted with rails laid along each side of the aft deck, but merging at the stern to form a single track over the transom.

The sensor fit includes: Terma Scanter navigation radar; Matilda ESM; Thomson Marconi Sonar SAS TSM 2022 minehunting sonar; TVT-300 electro-optic director fitted with TV camera and laser range-finder which feed the CelsiusTech 9MJ-400 AIO system and the 9LV-100 weapon control system. The armament comprises a Bofors 40 mm DP gun, two 7.62 mm GP (2 × 1) machine guns, Saab Manpads RBS-70 and four nine-barrelled Saab Missiles Elma ASW rocket launchers.

Main propulsion is by four SAAB-Scania DSI-14 diesel engines driving two Voith-Schneider cycloidal propellers with the engines coupled in pairs by an especially quiet clutch cone belt transmission system. Electric power at 440 V 3-phase 60 Hz is supplied by two 180 kW alternators, each driven by a 337 bhp SAAB-Scania DSI-11 auxiliary diesel engine; and a 108 kW alternator driven by a 183 bhp SAAB-Scania DN-11 auxiliary diesel engine. All diesel-alternator sets are mounted on the upper deck to reduce the noise signature; while slow-speed propulsion is achieved by using only one main engine per shaft.



MCMV Landsort (Kockums) 0007410

Operational status
Seven units operational with the Swedish Navy and four units with the Republic of Singapore Navy.

Specifications

Class	Landsort
Displacement:	
standard:	270 t
full load:	360 t
Dimensions:	
length:	47.5 m
beam:	9.6 m
draft:	2.2 m
Electronics:	
combat management system:	9 MJ 400
sonars:	TSM 2022
radar:	Terma
electronic warfare:	Matilda
weapon control:	9LV 100
Weapons:	
underwater vehicles:	2 × Double Eagle
guns:	1 × 40/70 mm
missiles:	none
other:	4 × ASW-600, 2 × Philax, 2 × SAM drones
Machinery:	
diesels:	4 × Saab Scania DSI 14
power output:	1.17 MW
propeller:	2 × Voith-Schneider
Speed:	15 kt
Range:	2,000 n miles @ 12 kt
autonomy:	14 days
Personnel:	12 officers, 17 crew

Contractor
Kockums AB, Karlskrona. ***VERIFIED***

SAM

Type
Remote-control minesweeping drone.

Development
The prototype SAM, built by Karlskronavarvet in conjunction with the Swedish Navy and Swedish FMV, was delivered to the Swedish Navy in 1973. Delivery of production SAM units began in 1985. Compared with the prototype, these feature new shock absorbers, coils, acoustic transmitter and remote control system. Two units of the Swedish Navy equipped with new cooling electronics and modified software were delivered to the US Navy during the 1991 Gulf War and replaced by two new units featuring a new arrangement for the acoustic transmitter, new diesel engines and new control system software and hardware. A new variant was delivered to Japan in 1994 a featured a new control software and hardware system, more powerful magnetic sweep, echosounder, Microplot navigation system new acoustic sweep gear and revised cooling of the electronics.

In 1992 the Swedish and US navies agreed to collaborate on developing a SAM II, and in 1993 the two countries signed a MoU, with work commencing on developing a system specification. Following increases in the potential cost of the programme beyond what the US was prepared to accept, they withdrew from the programme.

Description
Developed by Kockums (formerly Karlskronavarvet), the remote-controlled SAM uses a diesel-powered rudder propeller to drive the GRP catamaran hull. The craft is fully equipped for power supply, sweeping of acoustic and magnetic mines, navigation and remote control from another ship or from the shore. The MCMV, or any other ship, can control a number of the unmanned sweeps, providing remote control of the diesel engine, steering, minesweeping equipment, control and monitoring. The hull and superstructure are built in saltwater-resistant aluminium with the catamaran pontoons of GRP sandwich material.

The hull of the SAM is fitted with a number of coils in the pontoons, which are used for sweeping magnetic mines, and a towed acoustic transmitter is used to counter acoustic mines. A number of buoys is carried to mark the swept passage. A digital Global Positioning System (GPS) and microplotter is also installed to monitor the sweeping track.

Onboard power is provided by a Volvo Penta TAMD 70D diesel engine with a continuous output of about 159 kW at 2,200 rpm, to give the craft a speed of 8 kt.

Power is fed to a Schottel propeller unit via reversing gear couplings and a shaft. The diesel and reversing gear are mounted on a girder framework, which is shockmounted in an aluminium structure on to the main platform.

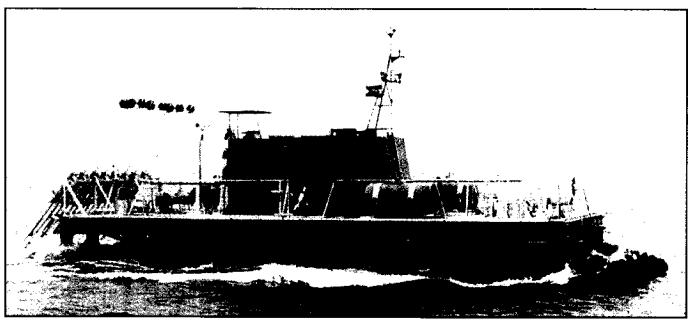
Although the machinery is normally remotely controlled from the MCMV, it can also be controlled at the engine or from the operating platform. Remote-control functions include diesel engine control, steering control, minesweeping equipment control and monitoring.

Operational status
In service with the Swedish and US navies (5 and 2 units respectively).

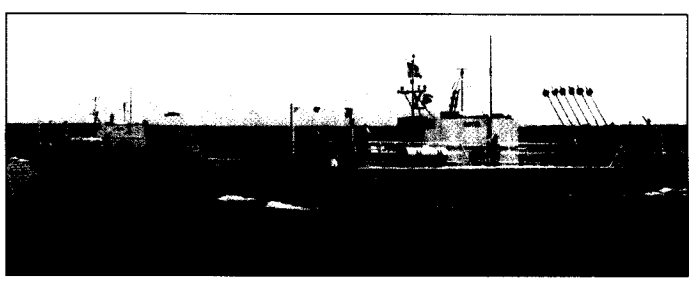
The US units are no longer in service. Six SAM drones have also been delivered to the Japanese Maritime Self Defence Force.

Specifications

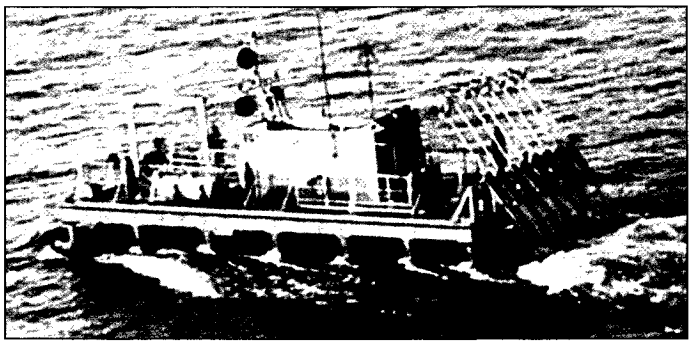
Class	SAM
Displacement:	
standard:	15 t
full load:	20 t
Dimensions:	
length:	18.2 m
beam:	6.2 m
draft:	1.6 m
Electronics:	
combat management system:	None
navigation system:	
sonars:	None
radar:	
electronic warfare:	None
weapon control:	None
Weapons:	
wire sweeps:	
influence sweeps:	
underwater vehicles:	None
guns:	None
missiles:	None
Machinery:	
diesels:	1 × TAMD 70D
power output:	159 kW
electric motor:	None
power output:	
auxiliary system:	None
power output:	
thrusters:	None
power output:	
shafts:	1
propeller:	1 × Schottel
Speed:	8 kt
Range:	33 n miles @ 8 kt
autonomy:	
Personnel:	None



SAM drone (Kockums AB) 0114380



Remote-controlled sweeping drones SAM 03 and SAM 05



SAM drone (Swedish Navy) 0143759

Contractor
Kockums AB, Karlskrona. ***VERIFIED***

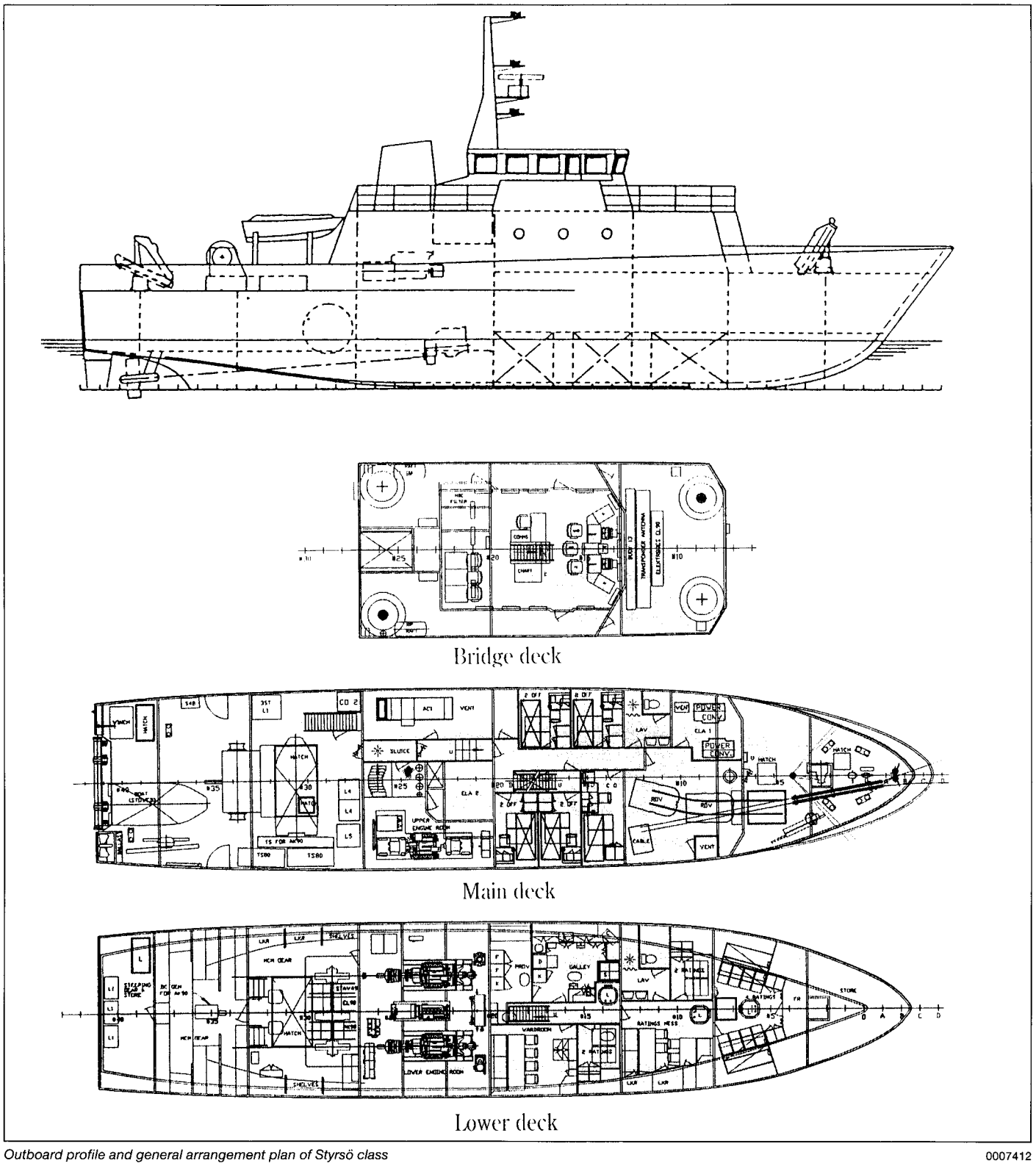
Styrsö class

Type
Inshore mine countermeasures vessel.

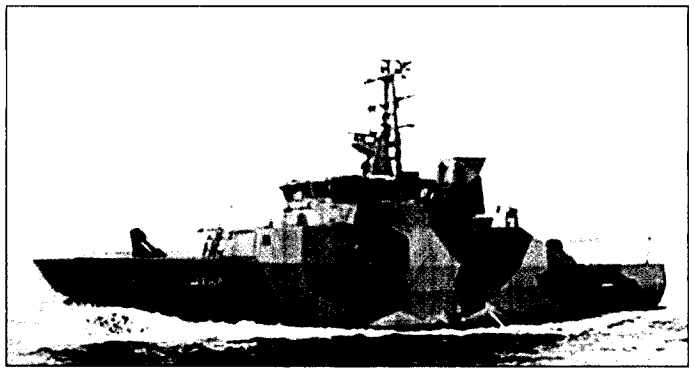
Description
In February 1994, Kockums Karlskronavarvet was awarded a contract to build a new class of MCMV capable of controlling two SAM drones using an Erisoft command and control system. These ships are also designed for use in an inshore surveillance role.

The hull and superstructure is built from an FRP sandwich consisting of two FRP laminate faces separated by a core of rigid PVC foam with closed cells. By careful shaping and running the superstructure flush with the hull the radar cross-section has been reduced to a minimum.

The main MCM systems comprise two Double Eagle ROVs, which are intended for clip-on sonar and mine disposal charges. The ships themselves are fitted with a Reson Sea Bat 8100 mine avoidance sonar and an Edgetech DF 100, dual-frequency, side scan sonar system for route surveying tasks. The navigation radar is a Racal Bridgemaster X-band system. All systems integrate with an Ericsson tactical data system. For minesweeping the ships carry an AK-90 acoustic, EL-90



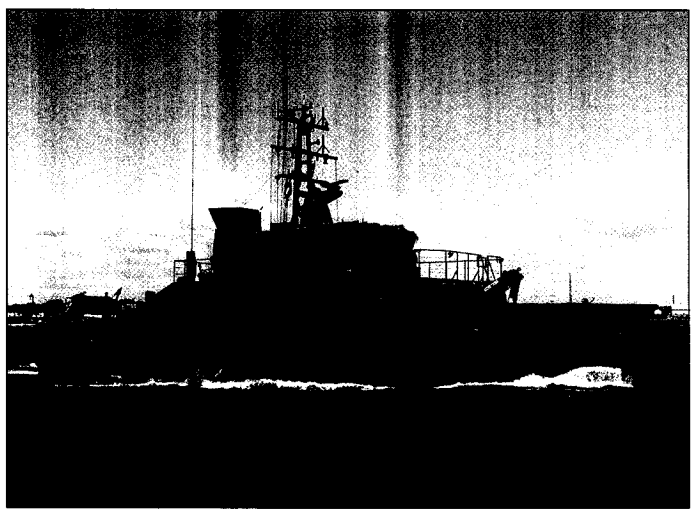
Outboard profile and general arrangement plan of Styrsö class 0007412



Styrsö (Swedish Navy) 0143761



The bridge showing navigation and machinery displays (Kockums) 0033202



Styrsö class MCMV Skaftö (Kockums) 0007411

magnetic and mechanical sweeps. The main combat system is based on COTS PC technology integrating the various mine countermeasures equipments via a LAN system.

The vessels are powered by two SAAB-Scania DSI 14 diesels of 1,104 bhp, driving two fixed-pitch propellers through reduction gears for a maximum speed of 13 kt. A specially designed 'Y' configuration bow water-jet thruster unit is also installed. A hydraulically driven, vertically oriented impellor draws in water through a keel inlet which is then fed to flap-valve controlled outlets to port and starboard near to waterline.

Hotel services are provided by two 160 kVA generator sets each capable of meeting the vessel's total power demand in normal operations.

There is no main armament, but the ships carry two 12.7 mm machine guns.

Operational status
Developed in the early 1990s. Four units in service with the Swedish Navy.

Contractor
Kockums AB, Karlskrona.

VERIFIED

United Kingdom

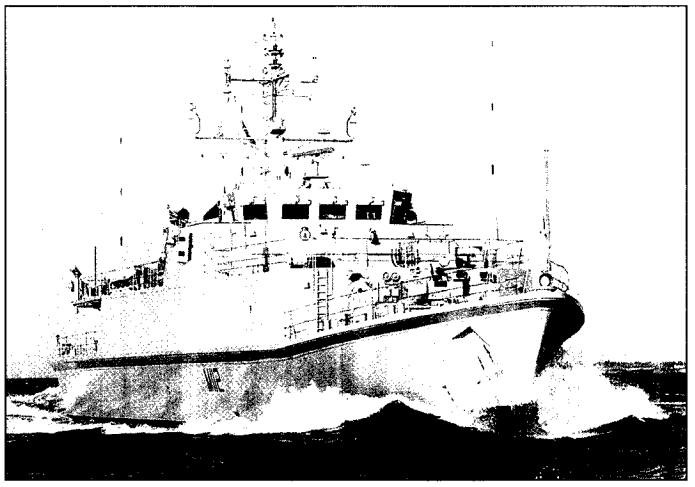
Sandown class

Type
Minehunter.

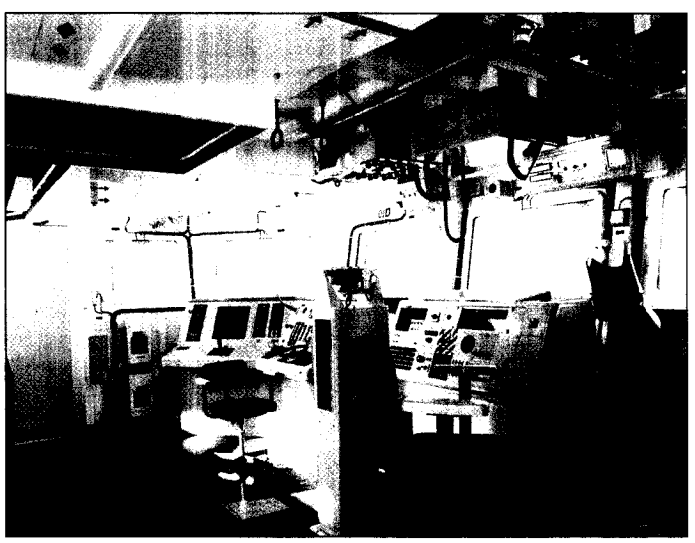
Description
The Sandown class, which has also been acquired by the Royal Saudi Naval Forces, is the third generation of Fibre Reinforced Plastic (FRP) minehunters designed by Vosper Thornycroft to counter the increasingly sophisticated mine threat. To face anticipated future shock levels, new concepts have been realised. Shockwaves affect FRP hull structures in two ways. Firstly, primary shockwaves cause the hull, and particularly the bottom, to undergo high accelerations which can result in delamination and breaking of bonded fixtures. Secondly, bubble pulse pressures cause the hull to whip, through which means the bottom and main deck panels can be severely buckled, possibly leading to the breaking of the ship's back. Any structural connections and their designs therefore play a major part in ship survivability in the face of severe shockwaves.

New design techniques have enabled the builders to dispense with the need for through bolting of hull frames previously required to meet exacting shock standards demanded in MCMV construction. The FRP skin of the hull bottom is longitudinally stiffened, with stiffeners laminated to the hull using flexible resin fillets. The main deck is also longitudinally stiffened, with transverse stiffeners fitted on the sides of the hull. This has eliminated the need for through bolts and crossovers of structural members resulting in a lighter structure, while at the same time achieving the required strength to meet exacting shock standards. The main watertight and transverse bulkheads are of corrugated FRP, while all other bulkheads are of FRP sandwich construction with a balsa wood core. The stern is specially designed to reduce slamming and improve conditions for the launch and recovery of ROVs and results in a much more stable platform.

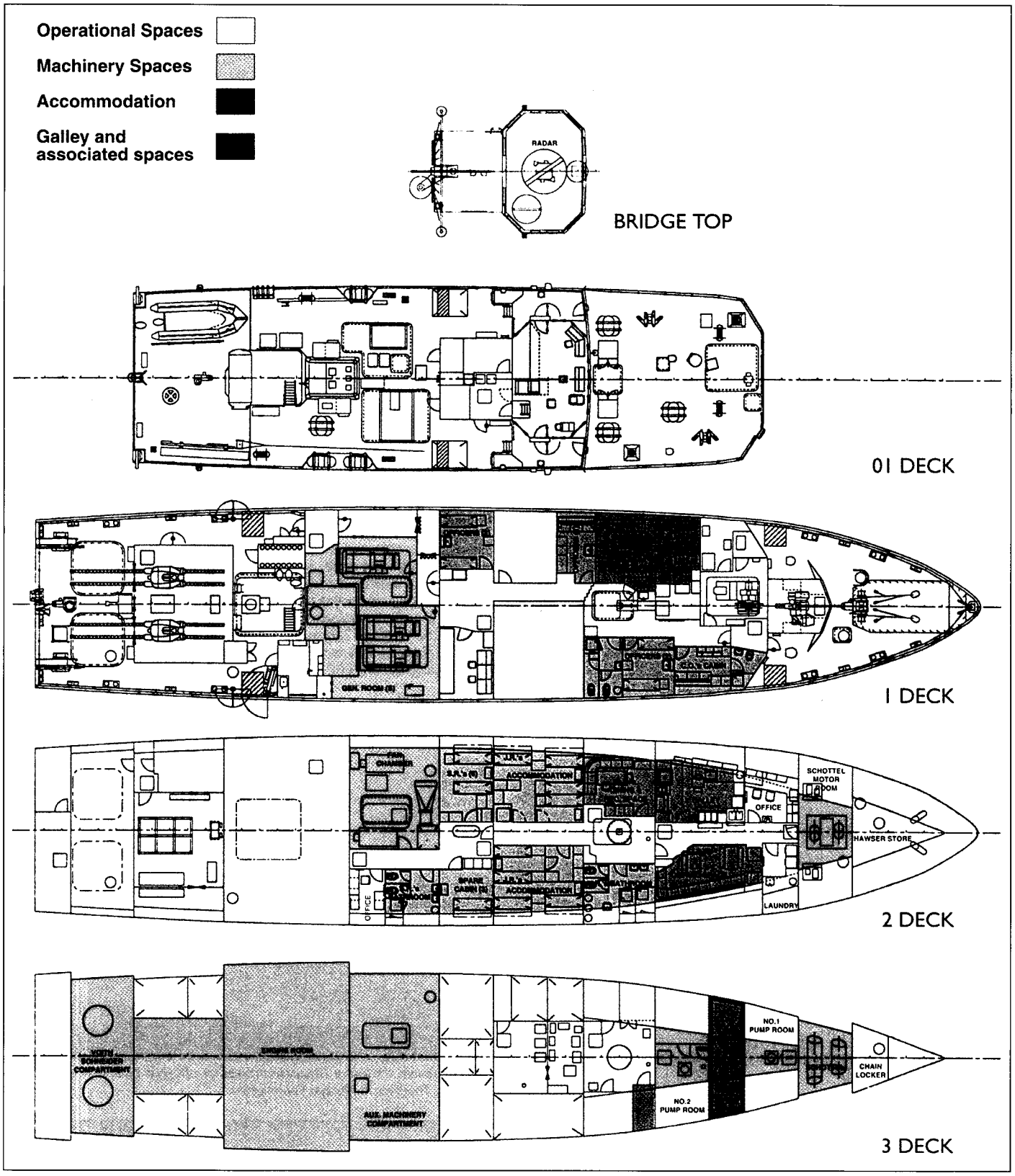
For the second batch of 'Sandowns' built for the Royal Navy, Vosper Thornycroft introduced new construction techniques, including the composite resin infusion moulding process. In this process, the resin is drawn into a sealed mould under a vacuum. The traditional construction process involves laying up the FRP by hand, with resin applied from a bucket. This laying up process results in a quality of FRP far surpassing existing FRP construction and will result in a lighter and stronger laminate.



HMS Shoreham, *the last of 12 Sandown class minehunters built for the Royal Navy by Vosper Thornycroft* (Vosper Thornycroft) 0129133



Bridge layout of HMS Sandown (Vosper Thornycroft)

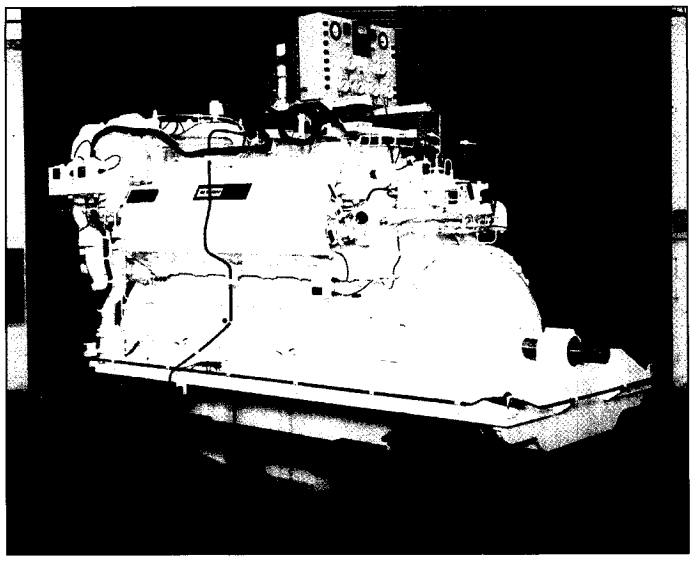


General arrangement layout of a multirole variant of the Sandown

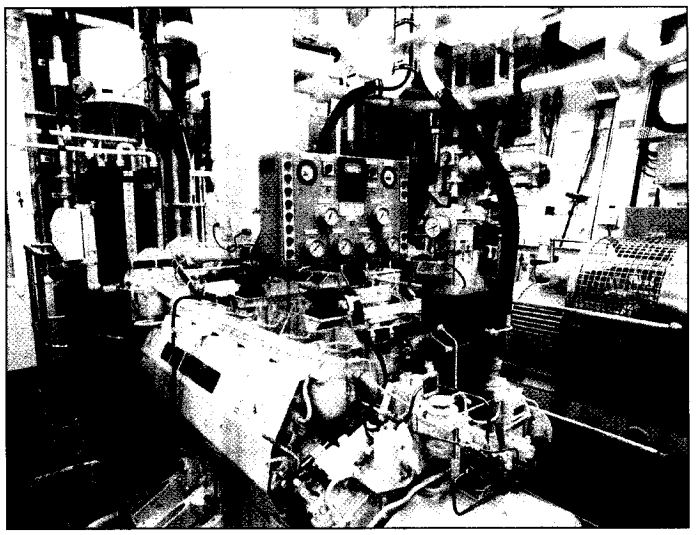
From the safety aspect, the new process virtually eliminated dangerous styrene fumes. Other improvements in construction were applied to the modular construction techniques, resulting in enhancements to three modules, in which outfitting was maximised before module installation in the ships.

Other changes to the design included an increase in the size of the Voith-Schneider propulsors in the second batch (from size 16 (1.6 m diameter) to size 18) which enables the vessels to maintain speeds currently attained by operational units, but with more equipment on board. Accommodation arrangements have been remodelled to cater for the inclusion of female personnel (one officer and five ratings) in the ship's crew. Other changes to the design included tropicalisation to enable the units to conduct operations in out-of-area regions such as the Gulf. This will primarily affect habitability standards, and include air conditioning. A larger, improved compression enhancer for divers has also been fitted. A more powerful crane has also been installed to handle the PAP. Finally, a new telephone exchange has been installed together with a two-man decompression chamber. Apart from the new construction techniques, all the changes are relatively minor, but have improved the effectiveness of the ships considerably.

The minehunting system comprises the Thomson Marconi Sonar Type 2093 variable depth minehunting sonar (which is integrated with the ship's position control system) and the Nautis command and control system combined with highly sophisticated navigation equipments. The sonar can be operated either as a Variable Depth Sonar (VDS), or locked into the hull for operation in shallow water conditions. Navigation equipment comprises a Kelvin Hughes Type 1007 navigation radar with bright raster display for bridge viewing, and a Kelvin Hughes echo-sounder. Other navaids include gyrocompass, AGI log combining EM log with ground correlation, and Evershed Aeolus wind measuring system, which are linked into the command system. Radio fixing aids comprise the Racal Hyperfix and QM14 systems and Decca Navigator Mk 21 (now largely replaced by the Mk 53) and Navstar GPS. Under a contract awarded to Drumgrange of Chertsey in 2003, the precise navigation capability of the Sandown class is to be upgraded. The heart of the new system will be based on two Rockwell Collins/NovAtel GPS receivers which will enhance the accuracy, repeatability and speed to determine the precise position of the ship while minehunting. Operators will be provided with a real-time display together with a data recording system. A similar system is being fitted to the Hunt class MCMVs during their upgrading.



A Valenta 6EM diesel for HMS Sandown (Alstom Engines Ltd) 0024795



Engine room of a Sandown class minehunter (Vosper Thornycroft)

All systems feed to the command system via a PEMS PDM3 dual-redundant serial data highway and embedded microprocessors in each of the equipments. The system architecture devolves data processing functions to individual systems rather than through a central processing unit. This enables each system to exercise effective full local control but at the same time allowing the command to control and integrate more effectively the general functions and operations of the various systems through the command system. This allows system operators to concentrate their efforts on the immediate task in hand.

Communications comprise HF transmitter, LF/MF/HF receivers and V/UHF transceivers and V/UHF FM transceiver.

Main propulsion is by two Paxman Valenta 6-RP-200EM diesel engines each with a continuous propulsion rating of 630 kW at 1,450 rpm driving two Voith-Schneider 18GS cycloidal propellers through fluid couplings and GEC Marine & Industrial Gears single-reduction gearboxes. The low rotational speed of the Voith-Schneider propellers exhibits little or no cavitation and very low noise, providing variable thrust all round. Electric power at 400 V 3-phase 60 Hz is provided by three Mawdsley 250 kW alternators, each powered by a 335 bhp Perkins V8-250G air-cooled auxiliary diesel engine. For auxiliary slow-speed propulsion, each propeller is belt-driven by a 135 shp Mawdsley electric motor, and draw power from any diesel alternator set. Manoeuvrability is further aided by two Schottel electric-powered bow thruster units. To reduce the acoustic signature, which was a design priority, the main engines are raft-mounted, the electric plant is resiliently mounted on the upper deck with air-cooled engines, and hydraulic transmission has been replaced by electric drive in the minehunting mode.

Finally, the ship is armed with an MSI Defence Systems Ltd DS 30B 30 mm gun mounted on the foredeck and two ECA PAP 104 Mk 5 ROVs for mine classification and disposal. These are carried on a trolley in the hangar and moved out on rails. A single hangar and wire sweep winch can replace the double hangar fitted in the UK ships, together with an extra crane for handling the minesweeping equipment.

The units ordered by the Royal Saudi Naval forces are very similar to the UK vessels, except that as they are also to be utilised as patrol vessels the main engines are each uprated to 845 kW for a slightly higher speed, and an electro-optic director fitted to control the light AA gun on the fore deck.

Operational status

Twelve units have been handed over to the Royal Navy, with the last of the class, HMS *Shoreham,* officially accepted in November 2001. HMS *Cromer* was decommissioned in October 2001 for use as a static training ship and the class will remain at 11 ships.

Specifications

Class	Sandown	Al Jawf
Displacement:		
standard:	450 t	450 t
full load:	484 t	480 t
Dimensions:		
length:	52.5 m	52.7 m
beam:	10.5 m	10.5 m
draft:	2.3 m	2.1 m
Electronics:		
combat management system:	Nautis M	Nautis M
navigation system:	Hyperfix, NAVPAC, Navigator Mk 53, QM 14	Hyperfix, NAVPAC, Navigator Mk 53, QM 14
sonars:	Type 2093	Type 2093
radar:	Type 1007	Type 1007
electronic warfare:	2 × Outfit DLK, (Barricade)	Shiploc, 2 × SRBOC Mk 36
weapon control:		Seahawk Mk 2 optronic
Weapons:		
wire sweeps:	none	none
influence sweeps:	none	none
underwater vehicles:	2 × PAP 104 mk 5	2 × PAP 104 mk 5
guns:	1 × MSI DS 30B 30 mm	2 × twin 30 mm
Machinery:		
diesels:	2 × Valenta 6RP200E/M	2 × Valenta 6RP200E/M
power output:	1.14 MW	1.14 MW
electric motor:	2 × Mawdlsey	2 × Mawdlsey
power output:	135 shp	135 shp
auxiliary system:	Perkins V8-250G diesel generator	Perkins V8-250G diesel generator
thrusters:	2 × Schottel bow	2 × Schottel bow
shafts:	2	2
propeller:	2 × Voith Schneider 18 GS	2 × Voith Schneider 18 GS
speed:	13 kt, 6 kt electric drive	13 kt, 6 kt electric drive
range:	2,500 n miles @ 12 kt	3,000 n miles @ 12 kt
Personnel:	5 officers, 29 crew	7 officers, 27 crew

Contractor

VT Group, Woolston, Hampshire.

UPDATED

United States

Avenger class

Type

Ocean-going minehunter/minesweeper.

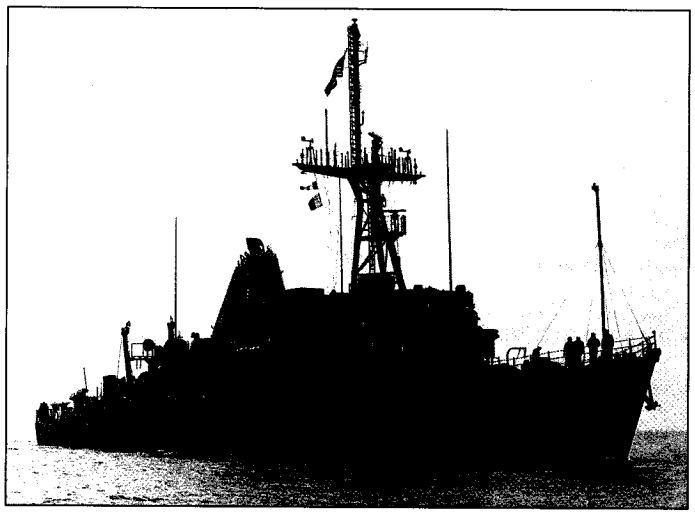
Description

The 14 units of the Avenger class are equipped with: SLQ-37(V)3 acoustic/magnetic influence sweep and Oropesa SLQ-38 mechanical minesweeping equipment; one or two SLQ-48 ROVs for mine classification and disposal; Raytheon SQQ-32 for minehunting; Mk 116 minehunting control system; Cardion SPS-55 surface search radar, Raytheon SPS-66 navigation radar (being replaced by SPS-73) and an IFF interrogator; and two 12.7 mm GP (2 × 1) machine guns and Stinger anti-air warfare missiles mounted for self-defence. The vessels are gradually being refitted with a GEC-Marconi Nautis M system (SYQ-15) integrated with the Lockheed Martin SYQ-13 ICWS (ex-SSN 2 PINS Precise Integrated Navigation System, which it is replacing). The ICWS upgraded core signal processing and display equipment to a COTS console and integrated all systems through a fibre-optic LAN into COTS architecture.

The first two units of the class are powered by four Waukesha LN-1616 diesel engines driving twin shafts fitted with KaMeWa cp propellers through DeLaval twin-input/single-output single-reduction gearboxes. Three more Waukesha LN-1616 diesels drive Tech Systems 375 kW alternators supplying electric power at 440 V 3-phase 60 Hz. In the third and all subsequent units, 655 bhp Isotta-Fraschini ID36SS-6V-AM diesel engines are substituted. In addition, there is a Siemens alternator powered by a Solar gas turbine for the electric sweep. For auxiliary slow-speed propulsion, two Hansome 200 shp electric motors are coupled one to each shaft line while a 350 hp bow thruster is fitted for precise manoeuvring. The hull is built up of four layers of planking glued together and carried over wooden frames. The superstructure is of GRP.

The class is to be re-engined to increase reliability and reduce operating costs by using more reliable modern technology. This will include the use of an electronic integrated fuel system developed for commercial marine diesels. The current diesels experience problems with carbon build-up during sustained low-speed minehunting operations and suffer from excessive part replacement.

Also under consideration is an HF upgrade for the AN/SQQ-32 to improve performance in littoral environments and crane and auxiliary system improvements.



MCM 2, USS Defender *of the Avenger class. Note the large winch forward of the bridge for lowering the minehunting sonar* (H & L van Ginderen)

Operational status
Fourteen units operational.

Specifications
Length: 68.4 m
Beam: 11.9 m
Draught: 3.7 m
Displacement: 1,312 t (full load)

Contractors
Peterson Builders Inc, Sturgeon Bay.
Marinette Marine Corporation.

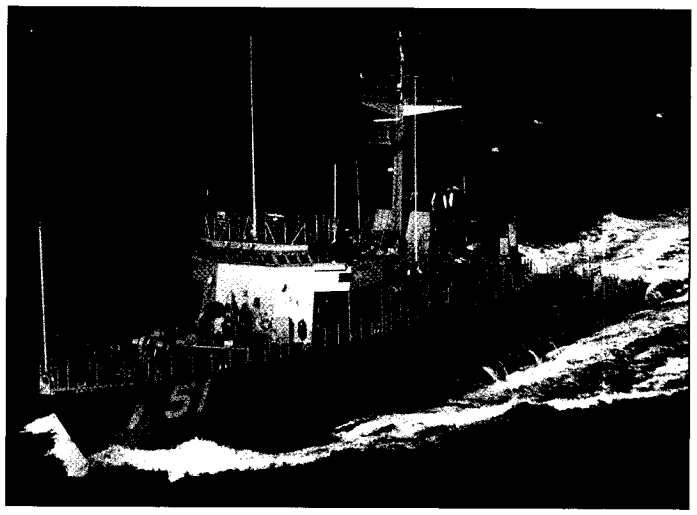
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Osprey class

Type
Ocean-going minehunter.

Description
The Osprey class is an enlargement of the Italian 'Lerici'. The vessels are fitted with the Raytheon/Thomson Marconi Sonar SQQ-32 minehunting sonar and SLQ-48 ROVs for mine classification and disposal; the Raytheon SPS-64(V)9 radar and are armed with two 12.7 mm GP (2 × 1) machine guns. Command is exercised through a Lockheed Martin AN/SYQ-13 command and control system. Precise positioning is controlled by a Microfix system.

The ICWS (Integrated Combat Weapon System) is replacing the existing AN/SYQ-13 command and control system as vessels become due for refit from 2000. The ICWS is upgrading core signal processing and display equipment to a COTS console and integrating all systems through a fibre-optic LAN into COTS architecture. A new search radar will also be installed. The ships are being refitted with equipment to handle minesweeping systems which are currently under development and which include the MIMS (Modular Influence Minesweeping



MHC Osprey. *Note the large winch forward of the bridge for handling the AN/SSQ-32 variable depth minehunting sonar* (Intermarine) 0007414

System) and the AN/SLQ-53 SSDS (Single Ship Deep Sweep). Machinery control is exercised through the SSQ-109 ship/machinery control system.

Main propulsion is by two Isotta-Fraschini ID36SS-8V AM diesel engines driving two Voith-Schneider cycloidal propellers through single-reduction gearboxes; with electric power at 440 V 3-phase 60 Hz provided by three 300 kW alternators, each driven by an Isotta-Fraschini IF 36558V-AM auxiliary diesel engine. These latter units also power hydraulic pumps for the two 180 shp hydraulic motors for auxiliary slow-speed propulsion, and a 180 shp transverse thrust unit forward.

The Osprey combines a relatively stiff hull structure with flexible decks and bulkheads which are connected with flexible attachment details. These have been designed and tested for underwater explosive shock loads. There are no stiffeners to cause stress concentrations on the hull and the attachment of equipment is minimised and located in low-deflection areas.

The class is to be re-engined to increase reliability and reduce operating costs by using more reliable modern technology. This will include the use of an electronic integrated fuel system developed for commercial marine diesels. The current diesels experience problems with carbon build-up during sustained low-speed minehunting operations and suffer from excessive part replacement.

Also under consideration is an HF upgrade for the AN/SQQ-32 to improve performance in littoral environments and crane and auxiliary system improvements.

Operational status
All 12 units now in service. Units are now being upgraded with the ICWS system which is replacing the SYQ-13.

Specifications
Displacement: 959 t (full load)
Length: 57.2 m
Beam: 11 m
Draught: 2.9 m

Contractors
Intermarine, Savannah.
Avondale Industries, New Orleans.

UPDATED

MINE WARFARE

Mine warfare

Mine warfare combat management

Minehunting sonar systems

Mine warfare laser systems

MINE WARFARE

Introduction

There is no doubt that the mine threat is real. One has only to consider the evidence from recent history to see that this is so. Three US ships in the early 1980s were severely damaged by mines in the Gulf. The USS *Roberts* had her keel broken and engines thrown off their mounts; the USS *Princeton* suffered damage and the USS *Tripoli* had a large hole blown in her hull which resulted in a large proportion of her fuel leaking out into the sea. The latter two prevented the US from conducting an amphibious operation into Kuwait during the 1990-91 Gulf War.

These incidents highlight the difficulty facing naval forces today as to where the mine threat is coming from and what form that it might take, and what the strategic and tactical requirements are for mine countermeasures to handle that threat.

In a modern conflict, the low-cost mine threat has the ability to shape not only the underwater battlespace but also the land and air battlespace, as evidenced by the incidents noted above. As such, therefore, the mine threat has the capability to deny an expeditionary force (both amphibious and covering forces) from using parts of a coastline and littoral water. It can also be used to deny sea space, to slow the operational tempo and momentum and direct assaults away from, and into, areas of the defender's choice.

The key to mine warfare, therefore, is the ability to define the threat. The more that is known about the threat, the easier it is to counter. There is little that is not already known about the present day threat covering the moored mine, various types of ground influence mine and the volume threat posed by devices such as rising mines and so on. What is not so clear, however, is where and how such weapons will be used, and in what circumstances.

During the Cold War emphasis on MCM was placed on the need to ensure a safe passage for SSBNs deploying from and returning to their base. While this will remain an important strategic requirement in the future for nations operating SSBNs, other equally important roles for MCM have begun to emerge since the ending of the Cold War.

Primary among these has been the realisation by some navies that expeditionary forces operating in support of an international coalition are extremely vulnerable to the mine threat, especially in the littoral region. Within this type of scenario it has been realised, following the 1990-91 Gulf War that MCM operations must form part of the overall tactical plan and that any MCM units must be fully integrated within the Task Force (TF). This demands that adequate protection be given to MCM units that will, in all probability, be operating in advance of the main TF. Hence, they will, in addition to other forms of protection, require air cover.

Following the situation that arose during the 1990-91 Gulf War, amphibious forces in particular now demand protection and immunity from the mine threat not only during their transit of the littoral but also during the actual assault through the surf zone and on to the beach itself. While previously ensuring that the beach landing area is free of mines has been very much the responsibility of the army/marines, it is now becoming much more the responsibility of naval forces. The US is devoting much effort to developing ways and means of ensuring that the surf zone and immediate beach landing area is free of all types of mines before the infantry go ashore. The experience and lessons of Normandy June 1944 are being relearned.

In 1995 the Chief of Naval Operations of the US Navy directed that mine warfare receive greater emphasis, and that it should become an integral capability within the battle group, as well as providing a dedicated capability. They are distinguished by the fact that the dedicated MCM assets are regarded as strategic in nature, while the organic assets are considered to be tactical in nature. To this end the US commenced development of a series of organic MCM systems to provide five airborne, one surface ship and one submarine based systems to enter service commencing in 2005. These systems are: the LMRS (submarine based), RMS (surface ship based), OASIS, ALMDS, RAMICS and AN/AQS-20X (airborne).

Such detailed integration of small and large units within a TF requires adequate and secure communications at all levels and between all units.

While the threat is likely to be small, of low density and relatively unsophisticated, it nevertheless poses a real threat to maritime operations and the freedom of the seas, particularly in the littoral region. The main objectives will probably be to deny freedom of access to certain areas, with nuisance value or deterrence providing a secondary aim. The purpose will be to hinder and deter hostile maritime operations. The threat will probably constitute a combination of moored, drifting and seabed mines.

From relatively simple weapons smaller nations with access to modern electronic technology will be able to develop mines of much greater sophistication, and the threat will probably extend to encompass mobile and buried mines as well.

Of particular concern in the coming years, and potentially posing the greatest challenge, is the threat to amphibious forces in the very shallow water region and the surf/beach zones. Currently there is virtually no MCM capability to counter this threat, except mine clearance divers who would have to be deployed from swimmer delivery vehicles, and marine mammals such as the Dolphins of the US Navy.

Mine countermeasures techniques fall into two main areas: active and passive.

Active MCM

Active countermeasures can be divided into two main spheres of operation: minehunting and minesweeping.

Minehunting has proved to be the only relatively safe and effective method of dealing with modern sophisticated influence mines. If the minehunter is to be effective in its task then it must be equipped with highly sophisticated equipment. In order to be able to pinpoint the exact location of a mine and to record its position precisely requires accurate navigation systems of the highest order. Next, in order to detect the mine and carry out accurate classification, the vessel must be equipped with an efficient sonar system able to detect the smallest of targets under the most adverse conditions.

Having detected and classified contacts, the next task is to neutralise those classified as mines. The main task of mine destruction is now carried out by small submersibles called Remotely Operated Vehicles (ROVs) deployed from the minehunter. These either position a remotely detonated countermining charge next to the mine, or they are equipped with powerful cutters which sever the tethering wire of moored mines so that they float to the surface where they can be destroyed.

With the advent of the Continental Shelf Mine in the 1980s, which proved extremely difficult to deal with because it was laid in much deeper waters, minesweeping took on a new lease of life. Minesweepers began to deploy the deep-armed sweep designed to operate at much greater depths than the normal Oropesa sweep. To achieve this the minesweepers had to operate at least in pairs. This operation also required extremely accurate navigation and station-keeping, and such vessels were equipped with the most up-to-date navigational aids available so that they could perform their task effectively.

Precise positioning

MCM requires accurate navigation and precise positioning. It is often necessary for vessels to subsequently return to the position of previously defined contacts to re-examine them or, in the case of confirmed mines, to carry out countermining. Precise positioning and plotting are absolutely essential elements if an MCMV is to carry out this task effectively. With such a system a vessel can return to the precise position where a contact was previously found with considerable saving in time and with the sure knowledge that the original contact will be found again.

Route surveying

The most effective form of MCM is that of route surveying. In peacetime this is a primary task not only of the MCM force but also of the hydrographic service. To be effective, route surveying requires that the whole of a proposed wartime shipping route be surveyed extremely carefully to produce bottom contour charts which show in the most minute detail the composition of the seabed and precise data on all objects on it. By regularly surveying and updating the charts, accurate pictures of proposed routes can be maintained which will enable safe ones to be selected in wartime. Furthermore, these routes can be checked by the minehunters much more rapidly and accurately as the vessel then only has to check objects not already marked on the chart.

Command and control

With such volumes of data now being made available to the command, a co-ordinated, effective means of correlating and presenting this wealth of information is essential if the MCMV is to carry out its task effectively and within a reasonable time span. Modern tactical plan displays frequently using colour graphics indicate to the command the route to be swept or surveyed, the ship's position, all objects on the seabed, the format of the seabed with integrated contour lines, the direction of the sonar beam, danger and specified circles around objects, map overlay and alphanumeric tote display. As they are of modular construction and use distributed processing and preprocessing techniques, these systems can integrate with a wide variety of minehunting sonars now available and allow the command to accept only valid data required for the task in hand.

Among features now being incorporated into the latest command systems are window techniques which allow the display of information such as raw sonar data, contact data and track data and the possibility of correlating and extracting radar positional data, ESM data and so on. Other features under study include the capability to automatically control the ship in various attitudes such as hovering and heading using autopilot and propulsion control. The problem with propulsion control is integrating the thrust developed by the various manoeuvring control systems. Development of such an automatic control system will greatly ease the strain on the crew during minehunting operations.

Finally, the Man/Machine Interface (MMI) has to be of the highest order. The presentation of the vast amounts of data required in minehunting demand displays of high resolution and clear definition, the careful use of colour techniques and the possibility of presenting more specific data from various sensors using window techniques.

Passive MCM

Passive MCM involves such techniques as noise reduction (reducing cavitation to a minimum, reducing machinery noise and so on), degaussing (to reduce a ship's magnetic signature to a minimum) and optimising the hydrodynamic shape of the hull with a minimum displacement (to reduce pressure signature to a minimum). Alternatively, it may be possible to modify a ship's signature so that it no longer appears to be what it actually is. Such techniques, however, require that one can precisely define the threat. Mine avoidance is another passive technique which can be employed, but again requires prior knowledge of the precise nature of the threat.

Minesweeping

The ability to generate powerful acoustic, magnetic and electromagnetic energy into the water in a controllable manner over a wide range of frequencies is now a mandatory requirement with regard to influence sweeping. This concept is referred to as the target simulation mode. Target simulation mode has gained considerable

credence in the NATO community. However, the concept is very demanding, both in terms of equipment performance, signature/influence measurement facilities, knowledge and understanding of local environmental conditions and operational doctrine and organisation. In spite of the difficulties, however, many navies have now adopted the target simulation mode as the primary method of minesweeping in national waters.

The philosophy of the target simulation mode concept is to set the sweep system to emulate the target that needs to be protected when passing through a mined area. The aim of MCM in target simulation mode is to clear the area for mines that pose a threat to a specific class of targets, but leaves unaffected mines with settings outside the signatures of the target ships. One of the advantages of the target simulation mode as opposed to standard influence sweeping is that, in principle, no prior knowledge of the actual mine setting and logic that constitutes the threat, is required. Experience in standard influence sweeping operations has shown that the necessary information to set the sweep parameters to effectively counter the mine threat is often missing.

The future

MCM will continue to lag behind the development of the mine. The gap is narrowing, however, and there are limits to the extent to which mines can be developed. The main developments in the future will be the self-propelled mine and mines which can be buried; both of these will pose enormous problems for MCM forces. Other likely developments include increasing the mine's effectiveness against specific targets, in particular minehunters and submarines, and seeking to capitalise on influences so far not developed.

For example, it may be that some mines will be influenced to react to a minehunter's sonar, or for tethering cables of moored mines to react to the operations of an ROV and then to set off a chain reaction of other mines in an attempt to destroy the minehunter.

On the MCM side, more efficient mine detecting sonars, command and control systems will be developed to deal with the mass of data accumulated. Efforts will be made to reduce reliance on human operators, for minehunting can be an extremely tedious task and, when operators become bored or tired, errors can be made that prove fatal. Greater efforts will be made to make MCMVs more immune to mines, and new generations of Unmanned Underwater Vehicles (UUVs) will be developed with much greater autonomy and capacity for dealing with more sophisticated mines, longer mission times, increased speed and range and deeper diving capabilities. Also, smaller one-shot mine destructor vehicles will achieve importance as complementary systems to the larger autonomous vehicles.

The use of datalinks to relay information between vessels on task and the shore-based MCM headquarters is now becoming essential to the speeding up of MCM operations and ensuring that shipping is allowed to use cleared channels at the earliest opportunity. Communications and connectivity will also form a vital element in the management of autonomous UUVs.

Sonar prediction techniques, already widely used in ASW operations, will also become more important as a means of improving effectiveness and safety with the ability to define safety circles more carefully.

Finally, the requirement to keep the MCM platform as far removed as possible from danger zones, particularly in areas which have not previously been route surveyed, will lead to the further development of remote-controlled, autonomous surface and subsurface platforms for minehunting and disposal. Already major studies are underway to develop autonomous small platforms which can be deployed not only from MCMVs but also from larger surface platforms to provide advance warning of a mine threat to an expeditionary force.

The 1990-91 Gulf War highlighted the inadequacies of then current mine disposal systems, and the need to develop more efficient and cost effective means of disposing of floating, moored and seabed mines.

Following intensive efforts by industry and government research organisations, the concept of the single shot mine disposal system evolved to meet perceived future requirements not then defined by the world's navies.

Early efforts in this field concentrated on developing new ways of dealing with moored mines in place of the then existing cumbersome disposal methods. These primarily involved cutting the wires anchoring moored mines and then, when the mine floated to the surface, sinking it by gunfire. To deal with the moored mine target was deemed to be more suitable for such developments as it was relatively easy to relocate using current sonars, and it could also be identified by video camera under suitable conditions. The first prototypes proved the possibilities of the single shot mine disposal concept and potential customers immediately recognised the possibilities for such systems in countering floating and seabed mines. This led to the development of electronically scanned multi-element sonars (for target relocation and identification), the development of shaped charges, improvements in control of propulsion and thrust as more precise manoeuvring was required, and special on-board vehicle navigation systems for tracking.

Further impetus was given to the development of one-shot systems as it became apparent that ROVs were themselves becoming vulnerable to mine counter-countermeasures in the presence of the latest generation of mines.

One-shot mine disposal systems are now at the stage where they are under consideration by a number of navies, and orders are being placed.

The latest developments in mine countermeasures are related to the need for organic MCM capability for non-dedicated MCM vessels. The safety of any surface vessel or submarine has to be a top priority and the need to guard against the mine threat is paramount. The response time of dedicated minehunters to reach an area suspected of being mined and through which a task force or submarines have to pass, is necessarily much slower than the speed of advance of the task force. In the light of the mine threat to such forces some navies are now seeking to develop or acquire some form of organic mine detection/avoidance system which can operate autonomously ahead of the task force. However, integrating such a system into a surface ship or submarine poses many difficulties.

Currently the most promising developments in organic MCM centre on the AUV (Autonomous Underwater Vehicle), typified by the Canadian ISE Dolphin vehicle. The Dolphin is an unmanned near-surface vehicle which tows a small body fitted with a side scan sonar. The system is not designed to carry out mine destruction, although this might be a possibility if two vehicles are used, one of which is fitted to deploy/control a one-shot mine disposal system such as the British Archerfish, German Seafox or Norwegian Minesniper.

The newest concept to emerge is the Norwegian network-centric concept for mine clearance based on the Hugin UUV and the Minesniper mine disposal weapon. In mine clearance network-centric warfare the mine destructor is deployed with reference to a large scale tactical picture produced by a wide range of sensors, some of which will be offboard sensors. This compares to the current practice of platform-centric mine clearance where either the parent vessel's sonar or an offboard vehicle sonar carries out the initial detection. In the network-centric mine clearance concept the parent vessel sonar is used only to track a transponder on the mine destructor vehicle, sending it the co-ordinates of the target which have already been identified by a remote off-board sensor. Minesniper is then guided to the position of the co-ordinates. If, however, these are not completely accurate, the Minesniper carries its own onboard sensors allowing it to carry out the terminal homing phase to the target.

UPDATED

MINE WARFARE COMBAT MANAGEMENT

Table XXII

Operational Command and tracking systems

System	Manufacturer	Country	Class installed on	Navy	Units*
AN/USQ-119(V)[1]		USA	Osprey	US	12
			Avenger	US	14
9 MJ 400	CelsiusTech Systems	Sweden	Landsort	Sweden	7
Chart V	Kelvin Hughes	UK	Ammiraglio Magnaghi	Italy	1
EVEC 20[2]	Thales Underwater Systems	France	Tripartite	France	13
EVEC 20[3]	Thales Underwater Systems	France	Tripartite	Netherlands	12
IBIS II	Thales Underwater Systems	France	Lerici	Malaysia	4
IBIS V	Thales Underwater Systems	France	Tripartite	Indonesia	2
	Thales Underwater Systems	France	Lerici	Nigeria	2
	Thales Underwater Systems	France	MWV 50	Taiwan	4
IBIS 43	Thales Underwater Systems	France	Flyvefisken	Denmark	3
MACTIS	Datamat	Italy	Gaeta	Italy	8
MAINS	Racal	UK	Landsort	Sweden	7
MAINS 500	Racal	UK	Swallow	South Korea	6
MICOS	Kongsberg Defence	Norway	Oksoy	Norway	4
	Kongsberg Defence	Norway	Alta	Norway	4
MWS 80-4	ATLAS Elektronik	Germany	Frankenthal	Germany	12
MWS 80R	ATLAS Elektronik	Germany	Bang Rachan	Thailand	2
MWS 80-6	ATLAS Elektronik	Germany	Lat Ya	Thailand	2
NAUTIS-M	AMS	UK	Sandown	Saudi Arabia	3
	AMS	UK	Sandown	UK	11
	AMS	UK	Avenger	USA	14
	AMS	UK	Huon	Australia	5
	AMS	UK	Sugashima	Japan	7
NVC	ATLAS Elektronik	Germany	Frankenthal	Germany	12
Satyr	Kongsberg Defence	Norway	Tyr	Norway	1
SMYC	FABA/INISEL	Spain	Segura	Spain	4
SSN 2 PINS[1]	Hughes	USA	Avenger	USA	14
System 880	Racal	UK	River	Bangladesh	4
TCD	ATLAS Elektronik	Germany	Frankenthal	Germany	12
TRAC V	Kelvin Hughes	UK	Ammiraglio Magnaghi	Italy	2
TRAC	Kelvin Hughes	UK	Alliance	NATO	1
TSM 2061	Thales Underwater Systems	France	Flyvefisken	Denmark	3
TSM 2061 Mk II	Thales Underwater Systems	France	Tripartite	Pakistan	3
TSM 2061 Mk II	Thales Underwater Systems	France	Landsort	Singapore	4
TSM 2061 Mk III	Thales Underwater Systems	France	Yang Yang	South Korea	1
TSM 2061[3]	Thales Underwater Systems	France	Tripartite	France	13
Type 2059	Simrad	UK	Hunt	Greece	2
Type 2059	Simrad	UK	Hunt	UK	11

* In service or on order
[1] Being replaced by ICWS
[2] Being replaced by TSM 2061
[3] Replacing EVEC 20

UPDATED

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

Australia

ATS (Acoustic Tracking System)

Type
Underwater acoustic tracking and positioning system.

Description
This series of Acoustic Tracking Systems (ATS) is particularly relevant to minehunting and mine clearance operations. It is also used for underwater vehicle tracking, equipment handling and for tracking towed objects such as variable depth sonars. By using a sophisticated eight-chirp signal in the 15 to 18 kHz frequency range, ATS offers high accuracy, for example better than 0.25 per cent of slant range in X and Y co-ordinates.

The ATS II is able to track objects in depths up to 2,000 m.

ATS is designed to provide solutions in harsh acoustic environments where other systems will not function, such as in shallow water, highly reflective conditions around underwater structures, and for operations near the water surface. It minimises problems such as background noise, reverberation and multipathing effects particularly in shallow waters.

The ATS series is rack-mounted and easy to operate, and needs only a minimum set up time with maximum flexibility. It is available in three very short baseline models: S04 and S08 are selected according to the number of beacons being tracked; D08 also provides riser angle information for the offshore drilling market. All models use the same hydrophone and beacons.

The hydrophone incorporates all receiving and transmitting acoustic elements in a compact self-contained unit. The ATS operates in a full hemisphere below the hydrophone and tracks two, four or eight fixed or moving beacons simultaneously, depending on the model.

Operational status
In operational service. ATS has accurately and reliably tracked Scarab work vehicles to depths of 2.6 km. ATS II is used to track the VDS and mine disposal vehicles in the Australian Huon class and Spanish Segura class minehunters.

Contractor
Nautronix Limited, Fremantle, Western Australia.

VERIFIED

MINTACS

Type
Tactical command software suite.

Description
MINTACS, developed for Windows NT, is designed to enable a mine warfare force commander and operations staff to plan missions, monitor tasking and conduct detailed assessment of mission progress.

The software suite consists of a number of modules including:

- Tactical display
- Force planning module
- Force scheduling module
- Mine hunting
- Minesweeping
- Clearance diving
- Planning and assessment tools

The tactical display presents the operator with cleared channels, suspected minefields and detected mines, which can be plotted. As the mission progresses clearance levels are displayed and colour coded. Raster and vector charts produced by hydrographic offices in standard formats are imported to provide detailed chart data. Environmental data is displayed as selectable layers.

The modular software suite carries out complex calculations to plan and assess mission effectiveness. These calculations are based on mathematical algorithms developed by the DSTO and integrated with a Windows user interface, a performance database and the tactical display.

MINTACS combines several aspects of mine warfare operations such as databases of seabed information, sonar performance and mine types, calculations of threat, sweeping and hunting planning and operational control. The system has proved to be a valuable tool for clearance diving management, providing divers with real time information to show where all the diving units are and what they are doing throughout the day.

In the succeeding software phase implementation, MINTACS will expand current capabilities and provide new modules including those to support tactical development, umpiring and route survey.

The software has been installed in the RANs mine warfare clearance diving headquarters based at HMAS Waterhen in Sydney. It is also available on a laptop computer for use in forward locations in support of mine warfare forces.

Operational status
The suite of software was installed in November 1999 and has since been used in a number of situations including Operation Crocodile 99 in November 1999, in support of Australian peace keeping Operations in East Timor in December/January 1999-2000, and in MCM operations in the clearance of Umm Qasr in 2003. MINTACS has been selected by the RN as its replacement mine warfare tactical support system.

Contractor
Solutions from Silicon Pty Ltd, Chatswood, New South Wales.

UPDATED

Denmark

Command and control systems

Type
MCM command and control system.

Description
The MCM command and control system are customised to provide all on-board command and control functionality required by an MCM system. The system provides facilities for typical MCM tasks comprising:

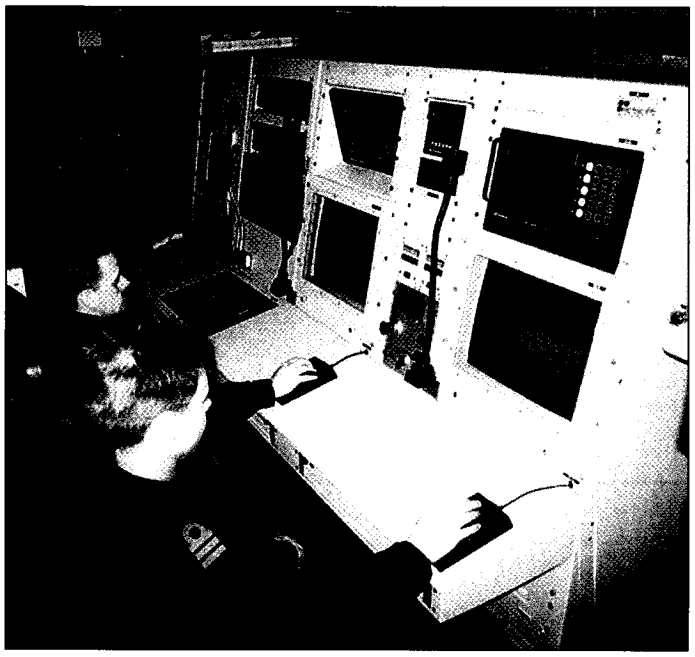
- Planning
- Preparation
- Mine search
- Detectoin/classification
- Identification
- Disposal

The heart of the MCMV system is a number of networked workstations, communicating with the navigation, positioning and radar subsystems, as well as with minesweeps, sonars, and ROVs.

The basic system structure is independent of the number of workstations and of the number and types of peripheral subsystems connected. For these reasons the MCMV system allows for easy adaptation to different requirements as well as upgrade of existing installations when the need arises. The system allows for integration with hydrographic survey systems utilising existing sensors and equipment for dual purpose operation. The survey systems are designed to meet IHO Standards for Hydrographic Surveys Special Publication No 44 Edition 4.

Operational status
A version is operational onboard the Swedish Styrsö class MCMVs.

Contractor
Eiva A/S, Hasselager. ***UPDATED***



MCM console on the Swedish Styrso class MCMV (Eiva A/S) 0077777

France

EVEC 20

Type
Data handling system.

Description
The data handling system developed for the 'Tripartite' minehunter is the EVEC 20. The EVEC 20 samples and processes data from the sonar, radio navigation systems, navigation radar, gyrocompass and Doppler log to present the operator

with a continuously updated display of the minehunting area showing position of own ship, located targets, radar contacts, tracks and lines representing specified zones. All or part of the displayed images can be recorded on cassette for subsequent recall, updating and maintaining an up-to-date permanent record of operations relating to a specified zone. A repeater on the bridge displays point co-ordinates from the minehunting sonar derived by the EVEC 20 and transmitted to the repeater.

The computer in the EVEC 20 also assists the automatic pilot, providing command inputs and error generation, and helps to control the automatic radar navigation systems providing location computations, error corrections, location of tracking windows and so on.

The automatic pilot is used to keep the ship on a predetermined track during minehunting operations, receiving necessary data from the gyrocompass and Doppler log.

The navigation radar and automatic tracking system integrate with the EVEC 20 to provide a buoy location system.

The horizontal plotting table uses an 80 cm² screen on which up to 200 sonar contacts can be displayed. The table receives data from the central processing unit which has a 20 kbyte random access memory.

Operational status
Operational in French Eridan class MCMVs and the three Tripartite units acquired by Pakistan. Under the Tripartite upgrade programme EVEC is being replaced by the TSM 2061 combat management system (not in the first Pakistani vessel).

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED

IBIS systems

Type
Mine countermeasures data handling system.

Description
IBIS III integrates the TSM 2021B (DUBM 21B) dual-antenna sonar with a TSM 2060 NAVIPLOT tactical plotter for navigation, plotting the precise location of detected targets and the recording of all relevant data. The NAVIPLOT uses the 15M 05 computer.

Data are displayed on a large four-colour CRT which is mounted at an angle to enable the operator to work in a sitting position, giving greater safety in the event of a mine exploding close to the ship. For operations in the vicinity of complex geographical formations (such as archipelagos and fjords) the raw radar video can be overlaid on the graphic symbology. In all cases, coastlines are presented in the synthetic mode.

The IBIS III system provides a continuous simultaneous display of the ship's planned and actual track, fully labelled display of up to 256 contacts, complete recording of all operational data and storage in the computer's memory. This enables a continuous comparison to be made between previously recorded data and the current situation with regard to the area being surveyed. New underwater contacts are thus instantaneously identified and located, providing increased safety for the ship and resulting in considerable saving in time on minehunting operations.

Associated subsystems of IBIS III are the ship's Doppler sonar log (Thales Underwater Systems 5730), radio navigation system (for example TRIDENT III), navigation radar (for example Racal/Decca 1229), compass, log, SATNAV, echo-sounder, radio datalink and SWEEPNAV, an acoustic location system for mechanical sweeps. As optional extras the IBIS III can be integrated with the ship's autopilot for automatic track following course to a point and hovering.

The IBIS III Mk II is an upgraded version of IBIS III which comprises the TSM 2021D (DUBM 21D) sonar and the TSM 2061 tactical system. The TSM 2021D is a fully digitised minehunting sonar equipped with Computer-Aided Detection (CAD)/ Computer-Aided Classification (CAC) sonar processing.

The IBIS V is a lightweight system suitable for retrofit, as well as new construction. The sonar associated with the IBIS V is the TSM 2022 single-array system, which takes up less space in the hull than the TSM 2021. The TSM 2026 NAVIPLOT is the second main component of the IBIS V. Whereas the 2021 can provide simultaneous detection and classification in different directions, the 2022 performs detection and classification in sequence and requires only a single operator.

IBIS V weighs 1.5 tonnes, the array having a span of about 1.5 m but pivoting to retract vertically into the sonar well, which is 75 cm in diameter. IBIS V Mk II is an upgraded version of IBIS which comprises the TSM 2022 Mk II sonar and the TSM 2061 tactical system. The TSM 2022 Mk II uses a new 19 in high-resolution Colibri colour console with sonar processing such as CAD, CAC and PI (Performance Indicator).

The latest system to be developed in the IBIS series is the IBIS 43. Using sophisticated computing equipment and the TSM 2054 side scan sonar, with antenna incorporated in a towfish, IBIS 43 produces high-quality images of the seabed with a high resolution, enabling operators to identify underwater mines. The computer system ensures real-time optimisation of sonar operating parameters depending on the speed of the towed body, its height above the seabed and the automatic compensation for roll, pitch and yaw. Computerised aids are used in conjunction with an image management system to ensure real-time detection and classification of unknown objects and to compare images obtained in successive missions in a given sector.

The towfish can be navigated manually or automatically at constant depth between 6 and 200 m with an altitude in relation to the seabed from 4 to 15 m, programmable from the sonar console keyboard. It can automatically follow seabed terrains with gradients of more than 15 per cent with high precision. It also has an obstacle avoidance capability for obstacles up to 10 m high at maximum speed.

Operational status
IBIS II is operational aboard the Malaysian 'Lerici' type minehunters. The IBIS V is in service on board the Indonesian Tripartite minehunters and Nigerian Lerici class minehunters, and the four Yung Feng class minehunters of the Republic of China Navy.

The IBIS 43 is installed in the STANFLEX 300 multirole vessels of the Royal Danish Navy.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Minetac

Type
Command and control system for minehunters.

Description
Derived from the SENIT 8.01 combat management system, Minetac has been developed by DCN International to equip the five Edincik class minehunters (ex-French Circe class sold to Turkey in 1997).

The Minetac is based around a single operator console integrated into the ship's navigation system, the DGPS navigation radar (a DGPS replaced the existing plotting table on the ex-Circe class when they were refurbished for sale to Turkey), and the DUBM-20B hull-mounted search and classification minehunting sonar.

The system architecture comprises an interface with other data-gathering systems on board the vessels, as well as a data storage service and a tactical computer based on COTS technology.

Operational status
In service aboard five Edincik class minehunters of the Turkish Navy.

Contractor
DCN , Paris.

VERIFIED

TSM 2061

Type
Command and control tactical system.

Description
The TSM 2061 system has been developed to integrate and display operational data from a variety of individual or combinations of sonar systems for surveillance, minehunting and minesweeping. The system has been designed to allow the operator to select the sensor/s best suited to the current mission in order to achieve optimum results.

The system comprises a compact multifunction display console with one or two 19 in high-resolution colour raster scan flat panel display screens (1,024 × 1,280 pixels). The operator desk features alphanumeric keyboard, numeric keypad, and roller ball and function keys. An X-Window graphics controller manages the display. The modular concept of the operator station allows multidisplay configurations. The desk also incorporates a mass storage unit with removable magneto-optical disc and colour printer (A3 or A4 size). Additional peripherals (plotter, 42 in colour display for mission synthesis and so on) can be installed to meet specific customer requirements.

A repeater flat colour display is also available on the bridge for the steering position.

The console performs a wide variety of functions including:
- mission planning and task management
- geographical positioning of detected targets and underwater equipments such as ROVs, remote controlled mine disposal equipments, divers and so on
- precise location of MCMV using integrated data from a variety or combination of navigation sensors
- display and recording of current data and display of pre-recorded data for purposes of comparison
- mission control
- real time mission evaluation
- reporting and mission debriefing
- chart and object database management
- electronic chart display (ECDIS IHO 552 and 557)

- NATO messaging tool
- OBT for the operator.

Operational status
Selected by the French Navy for the Eridan class upgrade and fitted to the second two units of the Pakistan Navy and the Singapore Landsort class. Also being fitted to the South Korean Yang Yang class minehunters.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Germany

MCM 2000

Type
Fully integrated mine countermeasures weapon system.

Description
The MCM 2000 is designed for MCM operations against modern types of mines in all kinds of waters. A further development of the MWS 90 system (of which more than 30 systems are in operational service), the MCM 2000 is an open architecture system whose modular design allows it to be configured for all MCM applications or tailored as a mine hunting (MWS) or minesweeping system (MSS).

The system is configured around a comprehensive tactical command and control system integrating a hull-mounted sonar (DSQS-11M), a self-propelled variable depth sonar (DDQS-11M), and the integrated navigation and vessel control system (NVC) including the automatic dynamic manoeuvring system (ADM), a navigation radar with extended ARPA functionality and ECDIS.

For remote simulation sweeping applications, the system comprises a drone control system.

The open architecture and modular design, combined with standard interfaces, enables the MCM 2000 to offer considerable growth potential, together with the option of integrating other sensors and communication systems.

Data is distributed from the various subsystems via a common redundant high-speed data network, offering access to all data anywhere in the system.

The MCM 200 is capable of carrying out the following tasks:

- planning of minehunting, minesweeping and survey operations and conduct of post mission analysis
- tactical and operational data management
- precise navigation and vessel control
- minehunting in shallow and deep waters and in areas of high clutter density or strong layering
- final identification of mine-like objects and neutralisation of mines
- conduct of minesweeping independent of the sweeping procedure and sweeping system
- route and pilot survey of seabed areas
- monitoring of surface targets
- weapon control
- documentation of all data gathered during an MCM mission
- onboard simulation for operator refresher training

The MCM 2000 is based around multi-function common consoles incorporating powerful local processing capabilities.

Operational status
MCM 200 is on order for updating the Belgian and Netherlands navies Tripartite minehunters.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

NVC (Navigation and Vessel Control) equipment

Type
Integrated navigation and vessel control equipment.

Description
The NVC (abbreviation in German Navy MWS 80 configuration is NBD) integrated navigation system forms a part of the MWS 80/MWS 90/MCM 2000 minehunting weapon systems (see MWS80 and MCM 2000 entries). It combines the functions of precise navigation, vessel control and precise speed measurement, performed by an integrated Doppler log. Data is accepted from a wide range of navigational sensors such as GPS, radio location system, Decca, inertial platform, gyro, echo-sounder, anemometer and radar. From these inputs the NVC computes optimal values for position, heading, course, longitudinal and transversal speed over ground and through the water, set, drift and water depth by Kalman filtering. Sensor data quality is continuously monitored. In case of sensor failures degradation modes are automatically selected. By providing datum transformations the NVC will accept and output navigational data in most of the commonly used reference systems. Using track and waypoint data from the tactical database or entered directly at the control and display unit, the NVC automatically steers the vessel along the planned search pattern. A manual vessel control mode via joystick is available.

The NVC equipment comprises the electronic cabinet containing all interfaces, the control and display unit (multifunction console), and the transducer for the Doppler log.

Operational status
In operational service in the Australian, German and Thai navies.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

TCCR (Tactical Command and Control system for Remote Control minesweeping)

Type
Tactical command and control system for remote-control minesweeping.

Description
Developed under a joint development contract between Germany and the Netherlands, the TCCR is based on independent GPS position determination and digital datalink of the control vessel and drones.

The open architecture, modular TCCR system can either be interfaced to existing systems, operated in a stand-alone configuration with appropriate sensors or as an integrated part of the comprehensive MCM 2000 system (see separate entry).

The system provides for the automatic control of up to four minesweeping drones under a preplanned mission plan or a transit sailing mission using a single-drone operator. The system includes the automated control of the acoustic and magnetic sweep gear.

The supervisor function is supported by ECDIS display and full ARPA functionality on the navigation side.

Support functions are available to monitor the progress of the mission during operation or to perform an overall evaluation at the end of a mission.

Additionally, the TCCR with its supervisor and operator console can be integrated in a standard ISO container for shore-based operation or based on any available ship for MCM drone control.

The TCCR can carry out a number of tasks including:

- geographical planning of area to be swept and tracks
- planning the number of runs and sweeping method per track
- calculation of time required to complete sweep mission
- planning based on anticipated mine threat

The TCCR consists of a number of sub-systems including: a dual display operator console for remote control of up to four minesweeping drones; a dual display supervisor console for surveillance and tactical display; an electronic cabinet with modules for navigation interfaces, radar track processing, UHF radio interface processor, and a LAN server; and a UHF datalink radio for digital data exchange between the control platform and the four drones. Equipment mounted on the drones includes an operation and display unit for local drone operation; electronic cabinet with modules for navigation interface/drone track control and UHF radio interface processor; and a UHF datalink radio for digital data exchange with the control platform.

Operational status
In operational service aboard the German Navy five Type 352 Ensdorf class Advanced Troika vessels since April 2000.

Contractor
ATLAS Elektronik GmbH Bremen.

UPDATED

TCD (Tactical Command and Documentation) equipment

Type
Action information system.

Description
The TCD forms an integral part of the MWS 80/MWS90/MCM2000 minehunting weapon system (see MWS80 and MCM 2000 entries).

The TCD provides comprehensive facilities to the commanding officer and the minehunting director to prepare, control and document all phases of MCM operations.

A variety of functions is available on the two consoles including:

- track planning for the selected search area, taking into account tactical considerations such as sonar performance data and environmental conditions
- presentation of tactical, navigation and status information, including radar video (on commanding officer's console) and live sonar displays
- presentation of manoeuvre data to the helmsman
- control of sonar and navigation equipment
- contact management with correlation of detected and stored sonar targets
- documentation of all results for evaluation and follow-on missions
- data logging of selected parameters including BITE messages relating to all connected MWS subsystems.

Virtually all these functions are linked by the TCD's comprehensive tactical database management system. The TCD also offers an emergency navigation function using GPS.

The TCD multifunction console presents both surface and subsurface tactical scenarios on two high-resolution displays with keypads for direct system operation. Additionally, the operation is supported by easily accessible menu guidance on both graphic displays. The peripheral equipment includes the mass memory unit, printer, plotter, the manoeuvre display and the minehunting sight.

The new STN ATLAS MCM 2000 suite (see separate entry) comprises either a TCC or a TCCR, or both functionalities. The TCC (Tactical Command and Control system) is based on the TCD and is designed for command and control of the entire mine warfare mission, whereas TCCR (Tactical Command and Control system for Remote control minesweeping) allows for state-of-the-art high precision remote control of MCM drones.

Operational status

In operational service with the Australian, German and Thai navies. TCCR is in service with the German Navy HL352 Advanced Troika vessels.

Contractor

ATLAS Elektronik GmbH, Bremen.

VERIFIED

MWS 80

Type

Minehunting weapons system.

Development

MWS 80 was developed for the German Navy's MJ 332 class minehunters by STN ATLAS Elektronik.

Description

STN ATLAS Elektronik has developed the MWS 80 as an integrated multirole MCM system which performs search, detection, classification, identification and neutralisation of ground and moored mines, precision navigation and vessel control, full control and co-ordination of all MCM operations, and maintains an accurate record of all areas searched, targets located and their geographic position and details of classification results.

MWS 80 integrates the DSQS-11M minehunting sonar, the NVC (Navigation and Vessel Control equipment) (NBD in German Navy configuration), the TCD tactical command and control system for co-ordinating and documenting MCM operations and the mine disposal system and the AIS 11 active identification sonar installed on the ROV.

The DSQS-11M provides independent and simultaneous detection and classification modes through 360° azimuth. The stabilised sonar beams simultaneously cover a 90° horizontal sector and a 60° vertical sector for three-dimensional target location. An LF linear array provides long range detection and classification with an HF array for high resolution detection for use in conditions of severe clutter and echo/shadow mode classification. The variant for the Australian Bay class MCMVs is fitted with a longer linear array and specific signal processing technologies to cope with conditions encountered by the RAN and an extra LF range for the detection of buried mines (designated MWS 80-5/VLF). Functions include performance prediction, computer-aided detection, classification and tracking with full-colour display to improve detection, performance and discrimination between targets. The man/machine interface features function keys and interactive, colour-coded control displays.

The TCD assists the operator in controlling all phases of an MCM operation by providing means for display, plotting, storage and retrieval of tactical data using two consoles. The equipment employs a comprehensive database which is continuously updated during operation.

The navigation sensors such as GPS, radio location systems, gyro or inertial platform and so on, and the integrated Doppler log DLO 3-2 enable the NBD to compute with a very high degree of accuracy the various navigational parameters such as ship's geographical position, groundspeed, speed through water, course, heading and drift.

All data handled are recorded on hard disk, tape and printer to enable missions to be stopped and started at will, provide recall of data for comparison and evaluation, maintenance of a permanent record of the seabed for MCM survey and for training purposes ashore.

The new MCM weapon system MCM 2000 is functionally based on MWS 80. It is a totally integrated system which, in addition, can include a Self-propelled Variable Depth Sonar (SVDS) and Tactical Command and Control System for Remote Control minesweeping TCCR (remote control of minesweeping drones).



MWS 80 mine countermeasures system

Operational status

In operational service. MWS 80-4 is in service on the 12 Type 332 Frankenthal class (12 units). The MWS 80-6 is installed in the Thai Lat Ya class minehunters/sweepers (two units) while the MWS 80R is installed in the Thai Bang Rachan M48 class (two units).

Contractor

ATLAS Elektronik GmbH, Bremen.

UPDATED

International

MWCSS

Type

Mine Warfare Command Support System (MWCSS).

Description

Developed by Saab Tech of Sweden in association with General Dynamics Company Ltd of the UK for the Royal Australian Navy, the MWCSS undertakes responsibility for the conduct and support of all aspects of planning, tasking, modelling and evaluation for the entire Australian Mine Warfare Force. Management of environmental data is a vital part of support for operational planning and mission assessment.

Advanced information technologies are applied to the strategic and operational assessment of the mine warfare environment and the strategic and operational planning, command and control, and communications with, forces carrying out mine warfare operations and exercises. The MWCSS also assesses the effectiveness of mine warfare operations and conducts detailed training exercises at individual, group and organisation level.

A range of integrated software applications is provided within a consistent graphical user interface. Many of these applications are used in conjunction with electronic chart systems.

The main function of the system is to plan, prepare and provide:

- the modelling of equipments (for example sonar), assets (minehunters) and tactics
- an awareness of the tactical situation using the electronic chart
- assessments of the threat and monitor the progress of the mission
- reports on assets, intelligence and the mine warfare environment and schedule tasks
- tapes for mine warfare missions
- plans for logistic support, and provide estimates and actual cost schedules
- predictions and calculations on the availability of equipment and its tactical and operational effectiveness
- post mission analyses using the electronic chart
- act as umpire in mine warfare exercises and plan and conduct mine warfare wargames
- computer based specialist training courses
- control and distribution of messages, documents, files and media
- system management.

The MWCSS provides computer support for the command and control of mine warfare forces either in the form of a mine warfare system centre or a local headquarters deployed to forward operating locations. Modern database technology enables the tactical information to be automatically replicated between remote sites via data networks. Data can be exchanged with mine warfare vessels and other assets.

The entire system is based on a large network of open architecture system workstations based on rugged commercial computers and commercial software supplemented by specially developed program functions in a Windows

environment to provide an effective Man/Machine Interface (MMI). The software is constructed in a layered fashion making extensive use of commercially available products. The latest software integration incorporates the MINTACS software (see separate entry on MINTACS).

Operational status
In service with the Australian Navy and a similar centre is on order for the Turkish Navy.

Contractor
SaabTech AB, Järfälla, Sweden.
Saab Systems Pty Ltd, Australia
General Dynamics Company Ltd, St Leonards-on-Sea, UK.

VERIFIED

Italy

MACTIS MM/SSN-714(V)2

Type
Minehunting data processing system.

Development
The MM/SSN-714(V)2, digital navigation and plotting system has been developed for the Italian Navy's Gaeta class mine countermeasures vessels.

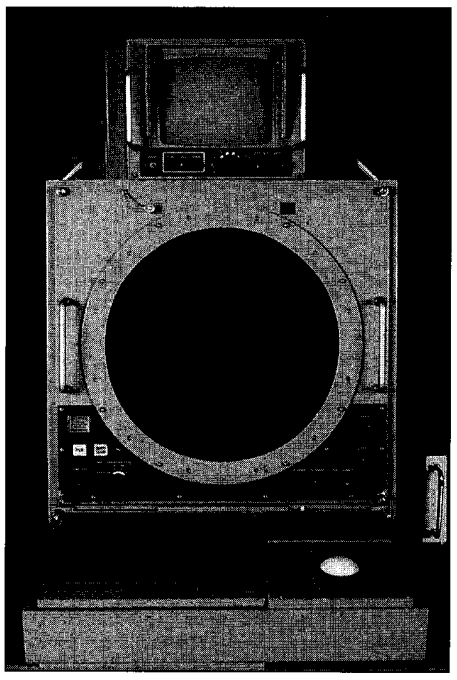
Description
The main functions of the MM/SSN-714(V)2 MACTIS (minehunting action information subsystem) are:
- operations planning;
- automatic computation and presentation of the ship's current position; navigation control (through autopilot interface);
- display of the tactical situation;
- location of surface and underwater targets;
- analysis and presentation of target characteristics;
- guidance of surface and underwater craft;
- event recording.

The system is based on a computer of the same or similar type to that employed in the SACTIS submarine combat information system, namely a Rolm MSE 14 machine. In the MM/SSN-714(V)2 system this is interfaced with recording units, display units, controls, printer/plotter and ship's sensors. The principal items in the last of these categories are radar, sonar, compass, log and various navigation aids. The operator's display has a vertical screen CRT, an alphanumeric display, a keyboard for communications with the system, supplementary data readout display units and associated input controls on the bridge and in the operations room.

The following units comprise MACTIS: an operator station with one 16 in graphic video screen; a functional keyboard and a trackerball; two display units (bridge and CIC/OPs room) for data display and navigation; processing signal distribution; and power supply units.

Analysis and presentation of target characteristics is achieved using the Italian manufactured version of the SQQ-14 fully solid-state mine-detection and classification sonar. The sonar is a dual-frequency, variable depth, beam-steering sonar enabling simultaneous detection and classification of targets. Separate search, classification and memory display consoles are provided. Comprehensive navigation equipment, in addition to the MM/SPN-703 navigation radar, is provided to ensure precise positioning of the ships and accurate plotting of underwater objects encountered.

The latest variant of the system (V)3 has been developed to upgrade the Lerici class. This provides a new open architecture combat management system configuration allowing for easy integration of future upgrades. It also provides for the system to meet new CMM NATO standards and overcome problems associated with the earlier version of the system. Among the most important innovations are an increased level of integration with the autopilot and an improvement in the navigation sensor availability and precision in computation of ship position. The system is based on COTS hardware and software, which incorporates an Ethernet LAN, Pentium-based CPUs, Windows NT, C++ and Visual Studio. The open architecture system is based on a main console with high resolution colour display, standard MMI, a secondary console with high resolution colour display and a set of fixed action keys, a bridge display, a dedicated unit for interfacing navigation and environmental sensors, an autopilot card to control ship motion automatically, and an Ethernet BUS for full integration of consoles, autopilot and SDDU to increase system availability and reduce manning requirements.



Graphic display for MM/SSN-714(V)2 system

Operational status
(V)2 in service with Italian Navy Gaeta class minehunters and (V)3 with the Lerici class. Production of the system has now ceased.

Contractor
Datamat Ingegneria dei Sistemi SpA, Rome.

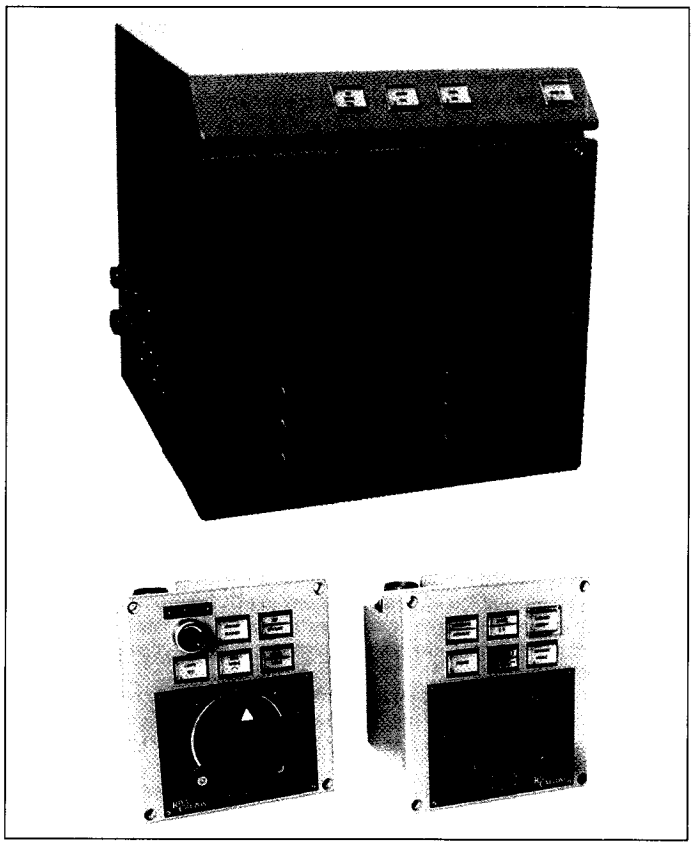
UPDATED

MHAP-20

Type
Autopilot for minehunting automatic manoeuvring.

Description
Specifically designed for minehunters, MHAP-20 is a family of dynamic positioning systems which assures precise dynamic positioning and dynamic tracking on search and contact circling patterns for minehunters and special vessels. MHAP-20 enhances the minehunter combat effectiveness, in the areas of:
- mine detection, classification and identification
- confidence in the area covered by the sonar
- platform stability for ROV launch, operation and recovery
- personnel task effectiveness through reduced burden of operation.

The basic manoeuvres that are performed include:
- station-keeping – hovering on a specified position with specified heading



MHAP-20 autopilot (Calzoni SpA) 0069495

- track-keeping - following a track defined by way-points at a specified speed
- station-changing - transit to a final waypoint with a fully specified ship motion (including speed and heading) on the reference track. This is typically used for short paths around sonar contacts.

The reference track can be set at the local panel or received through the interface, typically the combat system, or an ECDIS. Manoeuvring is handled in one of three ways:

- Manual, using a dedicated joystick and knob which allows the operator to set total thrust and torque to be applied to the ship's centre of gravity. This mode permits complex manually controlled ship rotational translation motions
- Dynamic positioning, in which automatic control of all three ship motions (surge, sway and yaw) to allow station keeping or station changing
- Dynamic tracking with automatic control of the track and speed by means of surge force and yaw moment. The transverse displacement is basically achieved by yaw angle control as in rudder steering.

MHAP-20 has been integrated on various platforms with different propulsion arrangements (for example Voith-Schneider, Schottel, and Calzoni).

As an option, MHAP-20 may be combined with a user friendly joystick/knob control, for optimal allocation of the thruster settings (man-in-the-loop control).

Operational status
In service with the Italian Navy Lerici and Gaeta class minehunters the Royal Australian Navy Huon class minehunters.

Successfully tested on board the US Navy Osprey class minehunters.

Contractor
Calzoni Srl - Automation Systems Division, Milan.

UPDATED

Mine Data Centre

Type
MCM mission planning centre.

Description
The Mine Data Centre (MDC) has been developed to support the operational activities of MCM vessels.

It enables operators to plan MCM missions through the analysis of data stored in the system files and the extraction of information pertinent to the missions. MCM missions can also be evaluated through the analysis of information acquired during the MCM mission. It also enables MCM missions to be fully exploited by the updating of information stored in the system files.

The input to the centre consists primarily of data recorded by MCMVs during missions using their combat information system (in the Italian Navy the MM/SSN-714(V)2).

Input data are recorded both manually and automatically on magnetic support. Various types of outputs can be obtained including reports on missions, statistics, content of the database and planning information for future missions. Various output formats can be used including map display on graphic workstations or large screen projector, plots and listings.

Planning data are delivered to the MCMV on magnetic support, the data being directly input to the combat information system.

The system is based on a DEC mainframe (VAX 8250) equipped with disk and tape units and running the ORACLE Rdbms. User interaction is via graphic workstations (VAX stations) connected through Ethernet LAN, PCs and terminals. Peripherals include colour plotter, printers, digitiser and large screen projector.

All the application software is written in Ada, and has been designed with the HOOD methodology; database design used the Entity-Relationship approach.

Operational status
The system has been in use at the Italian Navy mines and mine countermeasures centre since July 1991 and was used to support Italian MCMVs deployed in the Persian Gulf.

Contractor
Datamat Ingegneria dei Sistemi SpA, Rome.

VERIFIED

MWS

Type
Minefield planning and laying support system.

Development
A naval mine is not really effective unless it is deployed within a well designed minefield. The real weapon is not the mine, but the minefield, as the limited effective range of a mine would not justify the operational use of a single weapon. The MWS (Mine Warfare planning System) has been developed to provide naval forces with a support system for planning, assessing and laying minefields.

Description
The heart of the MWS is its capability to design a minefield based on the type of mine, type of target, nautical and environmental characteristics of the selected area according to NATO doctrine and instructions.

The map function allows the acquisition of the environmental information map from hydrographic raster/vector charts and manual acquisition from a nautical map. The electronic map of all saved nautical maps shows coastal and depth lines according to the standard notations defined by the IHO.

The minefield design function processes all the data relevant to environmental conditions, type and characteristics of the mines to be used, type and characteristics of the targets to be countered, type and characteristics of the minelayer, specific environmental conditions, and desired position and dimension of the minefield in order to design the most effective minefield. The system is able to design offensive, defensive and protective minefields against surface or submerged targets. The resulting field is presented in graphical form displayed on the electronic map.

In designing the minefield the MWS takes into account the characteristics of the sensors available and the program selected for SEIs mines. If the operator needs to use different mines from those of SEI, the system allows the operator to insert data of other mines and set their damage and activation radius.

The effectiveness of the designed minefield against the desired target is measured by means of statistical algorithms, which take into account the results of the simulations of multiple passages of ships in the minefield. The type of target can be changed, and as a consequence the effectiveness of the same minefield against different types of targets can be compared.

After the operator has identified the most effective minefield for the selected area and the relevant cost-effectiveness figure, the system produces a detailed report, including position of the mines, deployment routes, deployment order and priority, and suggested 'ship count' values for every mine.

Operational status
In production.

Contractor
SEI SpA, Ghedi.

VERIFIED

Norway

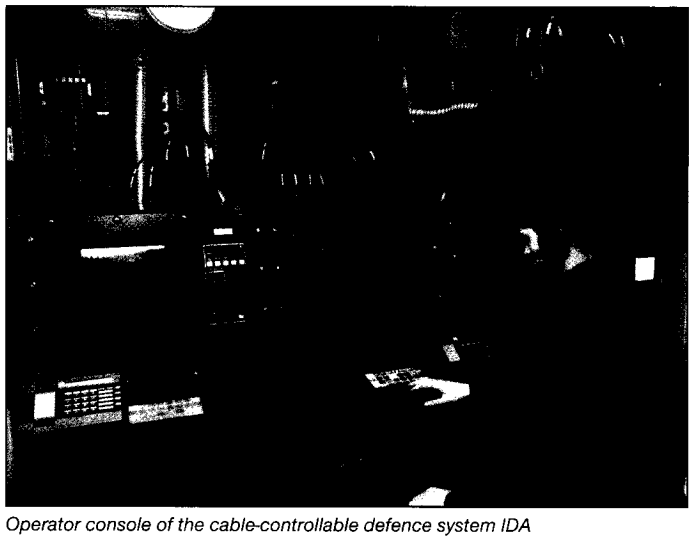
IDA

Type
Command, weapon control and information system for cable controllable minefields and torpedo batteries.

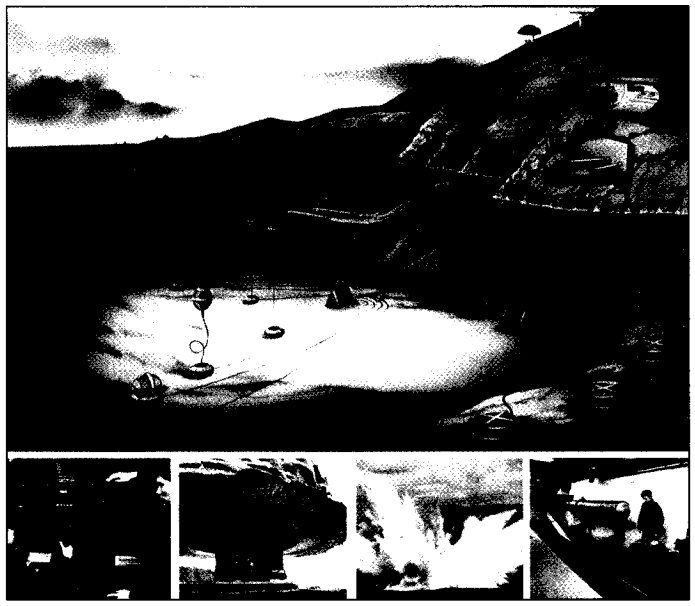
Development
In 1990 it was decided to undertake a comprehensive modernisation of existing minefields and torpedo batteries which form part of Norway's coastal defences. These comprise a series of fortresses which form an essential part of the country's anti-invasion defence system. The fortresses consist of a combination of cable-controllable minefields, fortified torpedo batteries and artillery installations.

Description
The modernised minefields and torpedo batteries will have identical and completely new weapon control systems and sensors. The existing torpedoes and mines will be upgraded and new mines are to be developed.

The central part of the system is the fire-control centre with the operator console and weapon control panels. The console accommodates two operators — one fire-control operator and one sensor operator.



Operator console of the cable-controllable defence system IDA



Artist's impression of the cable-controllable defence system IDA

Operational functions such as target tracking, track correlation, threat evaluation and weapon allocation are fully automatic but provide for operator interaction at certain preselected stages.

Target detection is based on radar and Electro-Optic (EO) sensors, which may be located at a distance from the weapons control room and linked to it by fibre optic cable. The EO sensors, which include a TV camera, laser rangefinder and thermal camera, are protected by a hydraulically elevated, camouflaged armoured steel cupola.

Mines can also be equipped with sensors that send information to the control room. Consequently, maximum operational efficiency is obtained through this extensive system of surface surveillance that contributes threat evaluation and target data for engagement analysis.

The minefields consist of both ground and moored mines. Supervision and control are executed via a new concealed distribution system. The main cable from the control room leads to a hidden surface 'mine well' housing an electronic unit and connections for the underwater cable to a distribution box fixed on the seabed, from which cables are routed to the individual mines. The mines are controlled individually or in groups. Extensive safety measures are employed in order to prevent unintended firings including new safety and arming units in each mine. The system must also ensure that friendly shipping can traverse these minefields without risk during a crisis and, of course, that absolute safety is assured during peacetime.

The torpedo system consists of wire-guided torpedoes that are fired against targets from an underground torpedo hall via sloping tubes that protrude below the waterline. The use of new technology will significantly improve the equipment, systems and procedures used in the preparation and loading of torpedoes, as well as the overall working environment in the torpedo hall.

The torpedo system employs the same radar and EO sensors as the minefield system. Data signals between the weapons control room and the torpedo hall are conveyed via fibre optic cables. Before engagement, torpedo initialisation data is sent from the fire-control system to the torpedo control system. During the engagement phase, command messages are sent to the torpedo hall and guidance data to the torpedo. Messages on the status of the control system, ramps and torpedo are then returned to the fire-control system. After firing, the torpedo sends back course data on its way to the target.

Components and units are standardised so that they may be used in any of the modernised fortresses. The fire-control system will also be standardised so that it is suitable for both the controllable minefield and torpedo systems. This will result in lower operative and maintenance costs and a simplified logistics system.

The coastal fortresses will also be equipped with integrated tactical and administrative radio communications, a new digital telephone exchange, and an integrated alarm/command system.

Operational status

The first two systems became operational in March 1995 and delivery of systems was completed in March 1999.

Contractor

Kongsberg Defence & Aerospace AS, Kongsberg. ***VERIFIED***

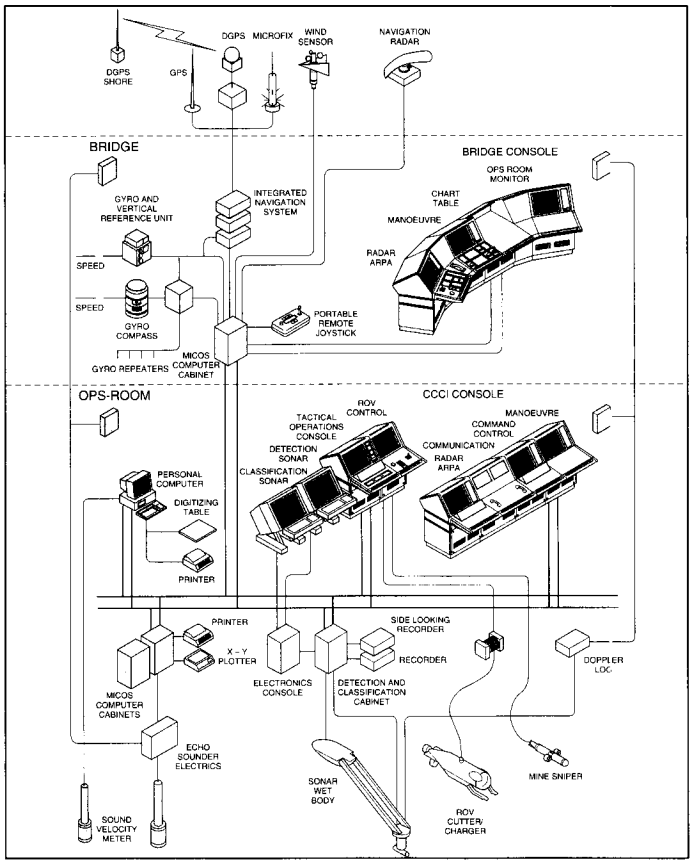
MICOS

Type

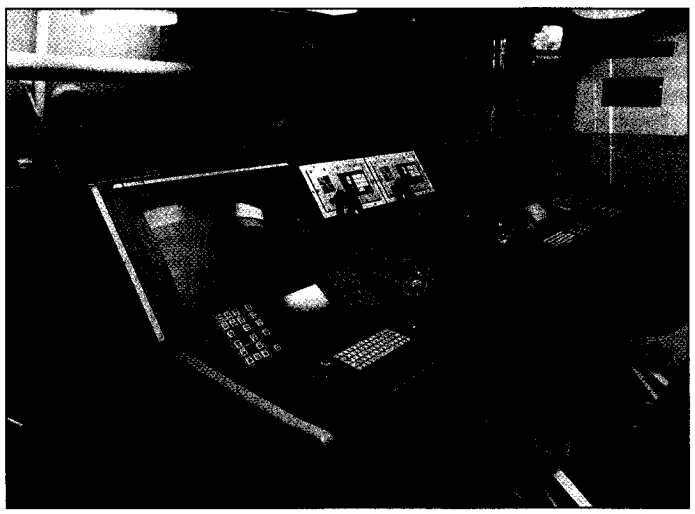
Minehunting command and control system.

Description

The MICOS command and control system has been developed for the Norwegian mine countermeasures programme. MICOS is an integrated mission control system which can be configured for either minehunting or minesweeping. The configuration on board the Oksoy class minehunters comprises: an integrated bridge system; an MCM command and control system; the sonar system; and ROV and mine disposal system. The configuration on board the Alta class minesweepers comprises: an integrated bridge system; an MCM command and control system in the operations room; the sonar system; interfaces to the sweep gear.



MICOS configuration 0114378



Console arrangement of the MICOS MCM system

The integrated bridge system comprises a Simrad ADP 701 navigation and dynamic positioning system for high-precision navigation and automatic control of the vessel, and a Norcontrol DB 2000 officer-of-the-watch ARPA system for surface surveillance. The MCM command and control system comprises two Simrad ATC 900 multifunction tactical consoles, two operator consoles for the Simrad/ Thomson Sintra TSM 2023 detection and classification minehunting sonars and a control console for the ROV operator. The system components are all integrated via a dual-redundant Ethernet LAN. Micos is based on an open architecture design using a high degree of COTS.

The command and control system has a wide range of functions for planning, operation and reporting and documentation of an MCM mission. The system comprises a database containing two-dimensional electronic charts, three-dimensional bottom terrain models, previous observations of bottom objects, navigation routes and so on. Also available are functions for performing MCM calculations for coverage and system performance analysis, including updating of the MCM database.

The dynamic positioning system is based on Simrad's ADP 701 which is in service with a great number of offshore vessels. It includes functions for automatic control of the vessel comprising a full three-axis manual mode, autopilot (for transit), hovering mode, auto-track and auto-sail modes. The two latter modes are

used to steer the vessel automatically on a planned course with minimum cross-track error.

The dynamic positioning system is interfaced to the sweep gear for automatic calculation of the gear's position and coverage and for measuring and counteracting the forces induced by the gear on the vessel.

Operational status
A total of nine MICOS systems has been ordered for the Royal Norwegian Navy's surface effect ships of the Oksoy class (minehunters) and Alta class (minesweepers). The minehunting systems are in service.

Contractor
Kongsberg Defence & Aerospace AS , Kongsberg.

UPDATED

Satyr

Type
Minefield inspection, control and maintenance command and control system.

Description
The Satyr system is an adaptation of the MICOS (see MICOS entry) command and control system developed by Simrad for the Norwegian mine countermeasures programme. It is an integrated mission control system comprising: a Simrad tactical command and control system; a Simrad ADP 701 dynamic positioning system; a Simrad HPR 410 hydroacoustic reference system; a Simrad EA 300 echo-sounder; the Artemis surface position reference system; and a windspeed/direction sensor.

The system components are all integrated via a dual-redundant Ethernet LAN. Satyr is based on an open architecture design using a high degree of COTS equipment.

The command and control system has a wide range of functions for planning, operation and reporting and documentation of missions for minefield laying, inspection and maintenance. The system comprises a database containing two-dimensional electronic charts and high-resolution three-dimensional bottom terrain models.

The DP system is based on a Simrad design currently in service on a large number of vessels worldwide. The ADP 701 system installed in the *Tyr* includes, in addition to the standard DP functions, a 'Follow ROV' mode where the vessel automatically follows an ROV, maintaining an operator-defined distance between the ROV and the vessel.

Operational status
In service on board the Norwegian Navy KNM *Tyr*.

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

VERIFIED

South Africa

MTDS

Type
Minehunting Tactical Data System (MTDS).

Development
African Defence Systems of South Africa has developed the MTDS as an upgrade to replace the TSM 2060 system which the South African Navy can no longer economically support aboard its River class minehunters.

MTDS has been developed from core technology derived from similar AIO systems developed for the South African Navy. The pilot system was fitted aboard SAS *Umhloti* in 1995, with an engineering development model fitted and trialled on SAS *Umzimkulu* in 1996.

Description
The MTDS is destined to integrate sensor information, compile a real-time tactical picture and facilitate, co-ordinate and control minehunting operations. As part of its operating capabilities MTDS is designed to assist the command team in the compilation and maintenance of a mission plan, defining search track parameters for a predefined search area. As part of this process the MTDS manages own-ship position data including a differential GPS input to provide the helmsman with tactical directions as to courses to be steered. Other capabilities include: control of own-ship sensors during search operations; tactical plot record and replay for post-mission analysis; and a hard-copy printout for mission planning and debriefing.

In its basic configuration, MTDS consists of a single-operator console with a graphics printer, together with a helmsman's indicator display and an optional remote plot display for the commanding officer.The console houses two 20 in colour raster displays. One of these displays the tactical situation as a plot, the other is a tabular display for totes and stateboards and for function access and data entry.

Applications software is executed inside the console chassis using Intel Pentium processor cards.

Operational status
A preproduction model was installed in 2000 and production was due to commence during 2002. Four systems derived from MTDS were delivered to the Malaysian Navy for the Mahamuru class coastal minehunters.

Contractor
African Defence Systems, Midrand.

VERIFIED

Spain

SMYC

Type
Mine warfare combat control system.

Description
Developed by Fabrica de Artillerias (FABA), the systems and weapons division of IZAR, the SMYC (Sistema de Mando Y Control para Cazaminas) combat system uses certain of the technology from the British Nautis system, but further developed and modified to meet Spanish Navy requirements.

The SMYC is a modular system based on a dual Ethernet LAN. The primary subsystems include three CM-1 operator consoles, the FABA PN/UDDB navigation system and three LAN access modules MAR (Modulos de Acceso a Red).

Two of the consoles are sited in the operations room and are fitted with two BARCO MPRD 9651 CRT displays. The third console, designated CM-1S and sited on the bridge, is fitted with a single display. The application software (more than 350,000 lines of code plus a further 100,000 lines of code for simulation and test software) was developed by FABA. Nautis technology incorporated in the SMYC includes external and structural console design as well as some shock resistance and EMC capability, together with the same graphics subsystem hardware as Nautis. The MMI is different, being based on Spanish Navy requirements.

Much of the hardware (up to 90 per cent) is VME-standard COTS equipment, including central processing units and memory boards.

Operational status
Four systems are operational on Segura class minehunters of the Spanish navy.

Contractor
IZAR Systems Division FABA, San Fernando.

UPDATED

Sweden

9 MJ 400

Type
Integrated navigation and combat information minehunting system.

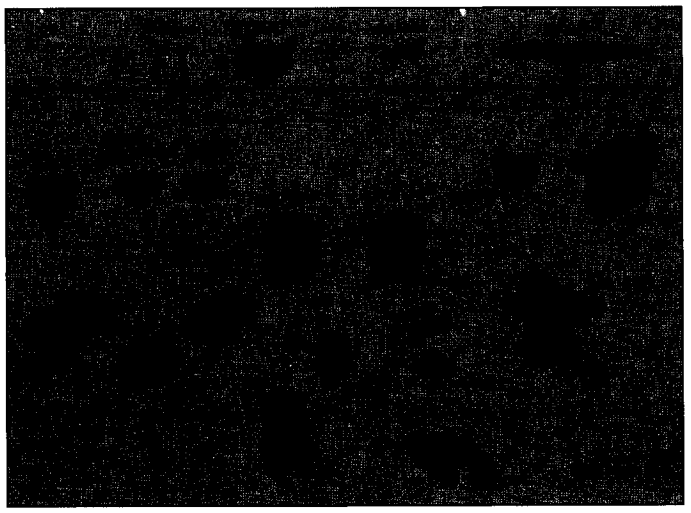
Development
Developed as a joint project between SaabTech and Racal (UK) the 9 MJ 400 integrated navigation and combat information system provides a wide range of navigation and MCM functions together with sensor interfaces.

Description
The 9 MJ 400 enables the operator to plan in minute detail all manner of MCM tasks. The system computes and displays the navigation plan to and from a search area, and during the MCM task displays computerised search tracks, taking into account the type of sonar fitted and environmental conditions.

The sonar search is planned using two types of search plan displayed on the conference-type combat information console. The operator then defines an area or route to be searched and enters the anticipated sonar coverage and required percentage overlap. The system then computes and displays a search plan, the sonar being controlled in one of two remote-control modes (search or target indication). The search plan and actual tracks, together with the position of located targets, are automatically drawn on the X-Y plotter.

During a search the operator can track other ships and aircraft operating in the area, the system tracking 16 targets automatically or 30 targets semi-automatically.

Data on mine contacts are stored in the direct-access memory of the computer (up to 100 contacts) and 'dumped' on to magnetic tape, as well as being fed to the plotter and/or the printer. The magnetic tape can store data on 1,000 mine



SaabTech Type 9 MJ 400 minehunting system

contacts, which can be read into the direct-access memory when planning the operation. All data recorded on tape or printer are available as a permanent record for subsequent comparison when carrying out searches of specific channels.

'Own ship' position and true speed are continuously calculated from each sensor input which includes Decca Navigator, transponders, navigation radar and dead reckoning. The operator selects the most reliable source for input to the system. The computer can store up to four range-measuring beacons when using a microwave transponder system.

In addition to its MCM function, the 9 MJ 400 system provides an ASW capability and weapon control function for depth charges and mortars. When linked with the SaabTech 9 LV 100 FCS, the 9 MJ 400 offers an upgraded self-defence capability for the ship as well as improving MCM tracking functions.

The 9 MJ 400 also features an integrated datalink for the onward transmission to shore-based control centres of important MCM data, as well as to other units in the operating area.

Operational status
In service with the Swedish Landsort class MCMV.

Contractor
SaabTech AB, Järfälla,

VERIFIED

United Kingdom

NAUTIS-M

Type
Third-generation integrated command, control and navigation system for shipborne mine countermeasures.

Development
NAUTIS is a modular family of naval command and control systems for air, surface and underwater requirements.

NAUTIS-M was originally developed for the Royal Navy's new single-role minehunters, the Sandown class. Requirements included the integration of the new Type 2093 variable depth sonar, the remotely controlled mine disposal system, multiple navigation and environmental sensors, radar and ship control with the combat management system. Functional requirements for NAUTIS-M cover all phases of the minehunting operation including mission planning, route surveys, minehunting, classification, disposal and mission reporting.

The first NAUTIS-M production system successfully completed Royal Navy acceptance trials in HMS *Sandown*, and a total of 12 systems entered operational service. This first generation NAUTIS-M system was also fitted to the USN Avenger class (14 ships – where NAUTIS was given the US Navy nomenclature of AN/SYQ-15), the Saudi Arabia Al Jawf class minehunters (three ships) and the Japanese Sugashima class minehunters (via a licensing and supply agreement with the NEC Corporation of Japan).

The second generation NAUTIS-M was jointly developed in the UK and Australia for the RAN Huon class coastal minehunters and was also built under licence by FABA, Empresa Nacional Bazan (now Izar) for Spain's Segura CME class MCMV.

The latest variant is NAUTIS-3M, which uses operationally proven applications software running on the latest COTS technology consoles, with LCD flat screen technology used to reduce space, weight and magnetic signature. NAUTIS-3M systems are entering service on a European NATO minehunter programme (6 ships) and the Royal Navy Hunt class MCMV (eight ships during their Mid Life Update). The NEC Corporation of Japan will also fit the later ships of Japan's Sugashima class minehunters with NAUTIS-3M.



NAUTIS-3M command and control system on HMS Hurworth *a Royal Navy Hunt class MCMV* (AMS) ***NEW***/1037637

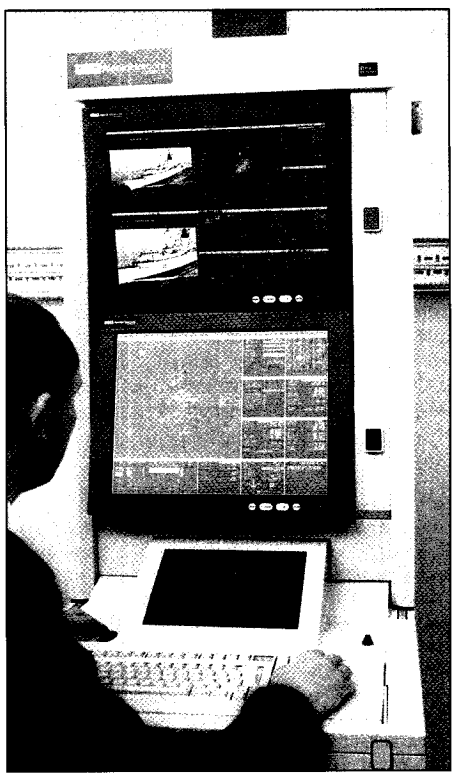
Variants are currently proposed worldwide for a range of other MCM combat systems and ship types.

Description
The basis of each NAUTIS system is a new technology autonomous intelligent console. The console includes interfaces for sensors, weapons and, if required, a datalink, an integral radar autotracker, processors and memory to handle an extensive command system database. High-level system application software and a selection of interfaces determine the functionality of the console for air/surface/underwater warfare roles. High-definition flat panel LCDs present labelled radar pictures together with charts and tactical graphics.

A NAUTIS system comprises a number of fully multifunctional new console designs networked via a dual-redundant digital highway. The highway is used to maintain automatically a replica of the command system database within each console. Each console user has independent access to the database and to interfaced sensors, weapons and peripherals according to his task requirements. User facilities enable tasks to be readily changed to give functional interchangeability between consoles of a system. Should any console be out of use then the other consoles remain fully operational as a system, using duplicated interfaces, and can take up the additional tasks.

NAUTIS-M systems can be configured with one or two networked consoles in a ship's Operations Room (CIC) and, if required, with a further console on the bridge (as in the Sandown class). Further multifunctional consoles can be included in the combat management suite for sonar operators. The number of consoles depends on operational requirements, the performance of the overall combat system and the number of operators required to handle the system data.

The NAUTIS-M online database covers an area of up to 2,000 sq n miles. The data include route plans, above and below water geographic and environmental data, known seabed contacts and other supporting data that will enable a mission to be planned and carried out with best use made of the ship and its combat



Nautis 3 control management system with flat screen (AMS) 0063753



NAUTIS-M command and control system as fitted to HMS Sandown

system. The database is retained in each console, with the system operating program, in non-volatile memory. The MMI also includes a typewriter keyboard, up to 32 assignable special function keys, a trackerball and a touch panel display. There is a comprehensive library of characters, symbols and lines.

Operational effectiveness of the ship's systems is maximised by full integration of sonar, navigation, collision avoidance and ship control systems through NAUTIS-M together with the online presentation of the MCM database.

Advanced display presentations, simplified user controls and operating procedures enable NAUTIS-M to be fully utilised with minimum training.

No specialised technical skills or test equipment are required for onboard maintenance. Comprehensive built-in tests are performed automatically at start-up and during run-time, and any faults are indicated at plug-in module level. Comprehensive command team facilities are included to allow training to take place onboard when alongside or on passage. The modular architecture of NAUTIS-M enables it to be readily adapted for MCM combat system applications with various forms of variable depth and hull-mounted sonars, influence and mechanical sweeps, sweep monitoring equipment, navigation systems, radars, mine neutralisation systems and ship control systems. NAUTIS-M typically comprises one, two or three consoles.

The latest version is NAUTIS-3M, displayed for the first time at UDT Europe 99. NAUTIS-3M supports a wide variety of ship types and roles, including MCM and ASW.

The modular software architecture allows the re-use of existing NAUTIS applications and uses the most recent COTS technology, with a new flat screen. Embedded in the software is an extensive training capability for honing operator skills. The Unix-based NAUTIS-3M introduces the ability to display electronic charts (ENCs) and to run third party applications software in the NAUTIS environment.

Existing Nautis applications can easily be upgraded to NAUTIS-3M standard.

Operational status

In service with the Royal Navy, the Royal Saudi Naval Forces the Royal Australian Navy, and the Japanese, Spanish and US navies. In the US Navy the system is designated AN/SYQ-15.

NAUTIS is also entering service on a European NATO minehunter and the Royal Navy Hunt class MCMV.

Contractor

AMS, Frimley, Camberley, Surrey.

UPDATED

Type 2059

Type

Acoustic tracking system.

Description

The Type 2059 ultra-short baseline acoustic tracking system has been specifically designed to fulfil a number of military applications, including minehunting. The system interrogates an acoustic source and measures the time it takes for a reply to be received. The direction from which the signal came is calculated via the phase differences sensed by an array of receiving hydrophones. The software programme then calculates the range and bearing to the source, simultaneously measuring and compensating for the pitch and roll motion of the ship. The information is then displayed by the control unit in various user-defined configurations. In MCM operations, this information can be transferred to the plotting table via a suitable interface.

The system can simultaneously track and display data for up to five targets. Each acoustic source is interrogated sequentially, with a different interrogation frequency dependant on the transponders in use. The 76 mm diameter transducer operates at 22, 23.5, 25, 26 and 28 kHz and the frequency selected transponder mounted on the ROV replies with a 30 kHz signal.

The system can also be employed with underwater responders; these provide an acoustic reply to an electric signal triggered via an umbilical cable. Alternatively, the system can also track a free-running acoustic pinger. The multifrequency system can simultaneously track up to five transponders.

The 2059 uses MIL-SPEC components to ensure maximum reliability of operations.

Operational status

In service with the UK Royal Navy and Greek Navy on board Hunt class MCMVs to track PAP ROVs and submarine escape and rescue services.

Contractor

Kongsberg Maritime Ltd, Aberdeen.

UPDATED

United States

AN/SSN-2(V) PINS

Type

Integrated navigation system for MCMs.

Description

Magnavox has developed the AN/SSN-2(V) PINS (Precise Integrated Navigation System) for MCMs. The heart of the PINS is a powerful military computer interfaced with an array of commercial and military sensors, control units and data display and recording systems. The PINS uses a Kalman Filter routine to smooth received data and apply appropriate corrections for known error factors. The system integrates and compares data from multiple navigation aids and other sensors to perform precise navigation and position determination, mission planning, plotting and data recording, target location and positioning and post-mission analysis. The TRANSIT SATNAV system is used to provide navigation fixes, interfaced via PINS with the ship's Doppler sonar operating in either groundspeed or water speed modes. Other interfaced systems include LORAN C and Hyperfix.

All contacts and their positions are recorded and displayed, together with the ship's track, on a vertical plotter in the operations room. The high-speed vertical belt-fed plotter provides a hard-copy printout using standard navy charts if required.

Operational status

No longer in production. PINS is in service with the US Navy on board the Avenger class MCMVs but being replaced by ICWS.

Contractor

Magnavox, Torrance, California.

VERIFIED

MINEHUNTING SONAR SYSTEMS

Introduction

Many of the problems associated with sound transmission in Anti-Submarine Warfare (ASW) apply equally to Mine CounterMeasures (MCM), although there are considerable differences between the sonars used in the two forms of warfare. While ASW is essentially a long-range detection problem requiring low frequency, MCM is a very short-range problem which has generally required the use of high frequencies. The use of acoustics in minehunting is further compounded by the problem of multipath reflections from the bottom, experienced in shallow waters and more recently the need to penetrate the top soft layer of a sea bottom to detect buried mines.

Conventional mine detection and classification is carried out using high-frequency side scan imaging sonars. The usual frequency range for these sonars is in the order of 35 to 350 kHz with bandwidths which spread by some 10 to 20 per cent either side of the centre frequency. Within this frequency range it is possible to achieve signals and high-gain arrays in a relatively small package.

However, to detect and provide a high-definition image of small objects these high-frequency systems are practically limited to a range of about 100 m, well inside the danger zone of most modern mines (the danger zone being in the region of 200 m from the mine). Beyond this, the signal is strongly attenuated and the angular resolution is no longer adequate to resolve small objects. In order to carry out search and classification outside the danger zone, that is at ranges much greater than 100 m (in excess of 200 m to provide an adequate guarantee of safety) a substantial increase in array gain and source level is required, both of which are prohibitive. As well as this limitation, sonars operating at these frequencies cannot penetrate the sediment to detect buried or partially buried mines, or penetrate the anechoic coatings now fitted to some modern mines.

Another limitation is the inherent inability of sonars operating at these frequencies to fully classify objects, even at close range. The acoustic images used for classification are fundamentally two-dimensional (for example range and azimuth), and thus no information about the shape of the object in three dimensions is obtained. Although in some circumstances height can be estimated from the length of an object's acoustic shadow, fundamental shape characterisations such as spherical, flat or cylindrical cannot be carried out using this approach.

The approach to defining requirements for MCM sonars is therefore quite different from that of ASW, and very specific. As mines become more stealthy the use of low frequency is becoming even more important as these signals stand a better chance of penetrating anechoic coatings which are being increasingly used on mine casings as well as the mud and sediment in which mines may be buried.

To provide as much detail and data over a very small insonified area (the area covered by a sonar) as possible, high-frequency sonars are currently used. This means either that a Mine CounterMeasures Vessel (MCMV) with an onboard sonar probably has to approach within the mine's danger zone in order to detect, identify and classify it, with the possibility of detonating it, or that the sonar must be displaced from the MCMV in some way so allowing the MCMV to remain well outside the danger radius of any possible mine detonation. In the past the use of hull-mounted minehunting sonars has required a trade-off between the high frequency required for high definition, and the lower frequency required to ensure that the MCMV can standoff at a safe distance.

To overcome this problem most MCM sonars incorporate a dual-frequency capability, using a lower frequency to survey a specific area, before moving in closer to use the high-definition sonar to classify and identify the target. However, to ensure ship survivability against modern mines, most MCMVs now carry an offboard system (the Remotely Operated Vehicle (ROV)) as well, carrying either a camera or small, high-definition sonar (or both), or use a diver to positively identify and neutralise the detected target.

Standoff sonars for MCM

There are three methods of deploying minehunting sonars in a standoff form. One is to use a side scan sonar towed astern of the platform. Alternatively the sonar may be fitted in an ROV, of which numerous examples now abound, or it may be deployed as a variable depth sonar. The latest methods involve the use of AUVs (Autonomous Underwater Vehicles) which can themselves deploy a small vehicle fitted with side scan sonar and so on.

The task of mine countermeasures is becoming increasingly difficult as mines become more sophisticated. It is now recognised that when minehunting, MCMVs must remain well outside the danger zone of any potential mine. As the safety and efficiency of minehunting platforms is now regarded as a high priority, then the sensors used to detect mines must realise greatly improved performance characteristics. One of the technologies now being examined by a number of navies involves deploying a remotely operated vehicle fitted with a highly sensitive minehunting sonar some considerable distance ahead of the parent MCMV platform frequently referred to as the 'dog-on-lead' principle.

Ever since the Second World War, shallow water minehunting has been carried out using hull-mounted minehunting sonars mounted on the MCMV. These sonars were designed to scan ahead of the vessels searching for, detecting and classifying objects at what was then considered to be a safe distance ahead of the ship. However, because of the position of the sonar in relation to the seabed (the angle of incidence of insonification) and the problems of acoustic propagation near the surface where thermal layers can create barriers to the sound propagation, together with the effects of reverberation in shallow water and a high ambient noise factor, these sonars were really only effective in depths down to about 100 m.

To overcome some of the problems associated with hull-mounted sonars, and in particular for operation in deeper waters where mines began to be laid, the Variable Depth Sonar (VDS) was developed. This allowed the sonar to penetrate the inhibiting thermal layers, and to be placed much closer to the level of the potential target. However, the VDS is limited by the fact that being a towed body it necessarily trails in the water, a characteristic which increases with the vessel's speed and the depth of immersion of the body. The towed body could therefore finish up quite some distance behind the towing platform, placing the latter in a vulnerable position in relation to the danger zone of any mine. To overcome this limitation necessitated the sensor having improved detection and classification ranges. These characteristics could only be achieved by use of a lower frequency, which in turn resulted in loss of resolution and contrast, features essential in minehunting.

To overcome the limitations of both the hull-mounted and variable depth sonars requires that a low-priority underwater vehicle be deployed to carry out a continuous search ahead of the parent MCMV platform. Such a vehicle is the self-propelled sonar, or indeed AUV towed small vehicle equipped with sonar sensors, development of which is now reaching the stage where such systems can operate effectively, considerably reducing the danger to high-value MCM platforms.

Route surveillance

One of the most important factors in mine warfare is route surveillance. This requires that areas susceptible to mining must be constantly surveyed well in advance of hostilities. Detailed records of the seabed and all objects on it must be maintained by constantly surveying the area and this will enable routes to be quickly checked for new targets in time of rising tension and hostilities. This will enable routes to be cleared more quickly, or alternative routes to be assigned. Surveillance such as this requires a high speed of advance and high-coverage rate. Route surveying thus needs to be carried out at speeds up to 15 kt with a path cover about 2,000 m wide. This requires a sonar range of about 1,600 m. In good propagation conditions a sonar with an azimuth resolution of 3° and a range resolution of 20 n miles would be sufficient to carry out such a route survey.

Classification, on the other hand, demands a much slower speed of advance with much greater resolution. Thus speeds of 5 kt are the norm, and to achieve good classification results using acoustic shadow and echo to allow evaluation of the shapes of detected objects at a range of at least 275 m (to ensure platform safety), requires a bearing resolution of 23° with 5 n miles resolution. In addition, classification is further aided by employing sector-scan techniques. For close-range identification an even higher resolution capability will be required.

As targets become smaller and more elusive the ability to detect and classify accurately will demand even higher frequencies and smaller beamwidths, while identification will be aided by optics and laser systems.

Search and sweep patterns are usually conducted in long ladders with a small overlap on the return path. During the search the MCMV is kept precisely on the programmed track using its autopilot. The autopilot derives the vessel's actual position from a shore-based hyperbolic navigation aid such as Hi-Fix, Hyper-Fix and so on. From this data the autopilot calculates any necessary corrections to the MCMV's track and applies them to the ship control system. In hostile areas navigation errors would be evaluated using a portable Trisponder (or similar) equipment or short scope buoys placed before the MCM operation began and from which an exact search pattern could be plotted. Operations are now greatly eased with the use of DGPS (differential global positioning system) using satellites.

The future

The key to the whole question of sonars, both for ASW and MCM, is technology.

One of the new emerging technologies that may overcome the problems of long-range detection and classification of mine-like objects is the low-frequency broadband sonar. This sonar exploits the full spectrum of low frequencies below 20 kHz, thus avoiding substantial attenuation at longer ranges and in the sediment, while achieving a bandwidth comparable to that of sonars operating at much higher frequency. Furthermore, the bandwidth of these signals is such that reduced reverberation and localisation can still be achieved while maintaining low frequency over the entire band. The use of multibeam multipulse imaging to detect and localise objects can thus be achieved using the most favourable incident angle.

Because of the fact that the acoustic reflection pattern of small objects is relatively broad in azimuth at low frequencies, this pattern can be unambiguously measured as a two-dimensional function of aspect angle and frequency, while still maintaining a relatively fast sweep rate. Such sonars could provide key information on both the size and three-dimensional structure of the contact. Furthermore, for objects that have flat or cylindrical surfaces, this also insures that detection of a small, smooth reflecting surface will be achieved, increasing signal strength by 10 to 20 dB over random aspect angle detection.

Since this low frequency does not depend on high-azimuth resolution for classification the physical array length requirement, although greater than that for high-frequency systems, is still practical.

An even greater problem facing the minehunting sonar is the detection and classification of buried mines. The problem of the buried mine is two-fold. Firstly there is the need for minehunting sonars to be able to penetrate beneath the immediate surface sediment layer on the seabed, and secondly for designers to understand the acoustic properties of sediments and the acoustic characteristics of buried mines and objects.

Surface scattering, volume reverberation and high absorption loss in sediment are significant factors affecting detection and classification of buried mines. Because the target is within the nearfield of a sonar antenna the signal-noise ratio must be improved through focused array processing, while the signal frequency should be sufficiently low to achieve bottom penetration. These are conflicting requirements, as to achieve the necessary low frequency to achieve bottom penetration results in a loss in resolution. There has, therefore, to be a trade-off.

Further difficulties present themselves, for at LF the sonar image contains diffraction effects and cannot be resolved using familiar 'straight ray' model analysis. Diffraction and low signal-noise ratios thus combine to produce images where shadows are absent. One way in which this problem could be overcome may lay in the use of certain features already available in existing data, which might be able to be used instead of the normal highlight/shadow information used in the classification of mines above the seabed using sidescan sonars.

Already significant importance is attached to the fact that a buried object's target strength can be deduced from surface patches normal to the incident signal wave. Signals from conventional mine shapes, the dimensions of which comprise many wavelengths, are strongly influenced by the aspect angle. Reverberation from objects such as sand ripples, small rocks and even clumps of seaweed is also affected by the aspect angle. Trials have revealed that the reverberation effect can change by as much as12 dB with different track courses.

To achieve satisfactory detection, trials have shown that the target signal should be more than 6 dB in excess of other signals. For satisfactory classification this should be considerably more if advantage is to be taken of the aspect dependency of the signal's time envelope or spectrum. To achieve such figures requires a considerable enhancement in the signal-noise ratio which may be aided by the use of synthetic aperture processing of the data.

Conventional HF minehunting sonars are generally unable to project much acoustic power into the bottom sediment, certainly at the low grazing angles required for detection. Two approaches are currently under study – the Synthetic Aperture Sonar (SAS) and the parametric sonar. The former appears to be offering greater promise at present with its potential for generating a considerable volume of high-resolution imagery for the detection of buried mines. However, the detection and classification of buried mines is not easy, and the solution, whatever that may be, will require a low-power sonar able to both detect and classify buried objects from a UUV or AUV. Thence, extrapolation of the data gathered will need to be handled in such a way that an accurate 3-D image of the sedimentary layer can be generated, from which it will be possible to certainly detect a buried object, and once the acoustic characteristics of buried objects and mines have been determined, to classify it.

This also affects classification as analysis of the target's acoustic shadow cannot be exploited. To overcome this problem lower frequency sonars are now the subject of investigation. These sonars will produce grazing angles that are above or below the critical angle of 'total reflection' from the water-sediment interface. In other words the acoustic energy can penetrate into a thin layer of sediment and be reflected off a buried mine-like object.

New and improved transducer materials are required to increase cavitation limits, synthetic aperture sonar processing would enable the range and coverage rate of sonars for MCM to be increased without degrading resolution and requiring a large underwater body. Parametric sonar techniques would enable sonars to penetrate the seabed to detect buried mines, a feature which is now of paramount importance in the face of the latest mine technology. The potential threat to MCMVs from modern sophisticated mines is such that previous generations of ROV fitted with HF sonars no longer provide the necessary safety radius for the parent vessel. The next generation of ROV must, in effect, be a self-propelled sonar – a vehicle carrying both HF and LF sonars which can swim well ahead of the parent vessel, sending back to it all the necessary data for detection, classification, and identification.

As with ASW, there is also the need for increased capabilities in the field of real-time data processing and post-processing techniques. Finally, the Man/Machine Interface (MMI) has to be improved, together with computer-aided detection and classification, which will greatly assist the operator.

Finally there is the need to address the problem of the new generation of low target strength mines likely to be encountered in the demanding littoral environment. This is being addressed by wideband FM processed sonar. This type of sonar offers a marked improvement in detection range compared to the noise-limited performance of CW sonar. There is also an improvement in range resolution which is proportional to the bandwidth, which could offer improved long-range classification.

With the increasing diversity of roles being assigned to submarines, that dealing with AUVs in the mine warfare role possibly poses the greatest challenge. For the AUV to be effective in this role requires it to be able to deploy both Synthetic Aperture Sonar (SAS) necessary for the detection of buried mines and large real aperture forward looking arrays. The size of these sonars is of critical importance when designing such systems for AUVs. A further challenge for sonar designers is to encompass the necessary degree of image processing capability within the hull of the AUV in order that the amount of data to be transmitted back to the submarine is reduced to a minimum. This is necessary in order to ensure the continuing covertness of the ISR mission.

One of the latest requirements in MCM is referred to as REA (Rapid Environment Assessment). This concept is essential for the safe deployment of forces in areas where knowledge of the local seabed environment is at best scant, or at worst completely missing.

To carry out satisfactory REA, the mine warfare community is now carrying out extensive studies into the use of AUVs in this role. Here, however, there is a limitation relating to the type of payload best suited to this operation. One possible payload with considerable potential is the bathymetric sidescan sonar, using a commercial sonar with specially developed algorithms. Such a system would be used to determine the local bathymetry and classify the seabed in terms of complexity in order to conduct effective minehunting operations. Using the interferometric sidescan sonar allows the simultaneous collection of image data close to the seabed together with bathymetric readings, thus overcoming the need for co-localisation of data such as is required by the more conventional method of fusing data from a multiple beam echo sounder and a sidescan sonar.

Trials have already shown that data from bathymetric sidescan sonar are sufficiently accurate to produce a precise digital terrain model suitable for planning amphibious and MCM operations. Further development will doubtless overcome the problems of degradation of the bathymetry experienced during early trials, particularly in the areas of sonar positioning and lack of depth sensor calibration. Among the vital data that could be gathered by a covertly operating AUV-deployed system are: level and type of seabed, seabed clutter, density of mine-like and non-mine objects and reverberation level.

Areas of development which need to be addressed were highlighted in the NATO Long Term Scientific Study MO2015 Mine Warfare Advanced Concept Study of April 2000. Among the areas which related to acoustic measures to penetrate bottom sediment for detection and subsequent classification of buried objects were: biosonars, biomimetics, acoustic properties of sediments, acoustic classification characteristics of buried objects and mines, multi-aspect imaging and 3-D visualisation of imagery acquired from sonars engaged in detecting buried mines.

UPDATED

Table XXIII[1]

Operational sonar equipments as at August 2004

System	Manufacturer	Country	Installed on	Navy	Units[2]
AN/UQS-1		USA	MSC 268	South Korea	4
AN/UQS-1		USA	MSC 268	Spain	1
AN/UQS-1		USA	Bluebird	Thailand	2
AN/UQS-1D		USA	MSC 294	Greece	8
		USA	Adjutant	Greece	1
		USA	Adjutant/MSC 268/MSC 294	Turkey	9
AN/SQQ-14	Lockheed Martin	USA	MSC 322	Saudi Arabia	4
	Lockheed Martin	USA	Adjutant	Greece	2
	Lockheed Martin	USA	Aggressive	Taiwan	4
SQQ-14IT	WASS	Italy	Gaeta	Italy	8
	WASS	Italy	Lerici	Italy	4
AN/SQQ-32	Raytheon	USA	Yaeyama	Japan	3
	Raytheon	USA	Segura	Spain	4
	Raytheon	USA	Avenger	USA	14
	Raytheon	USA	Osprey	USA	12
CMAS 36/39	C-Tech	Canada	Leeuwin	Australia	2
	C-Tech	Canada	Sagar	Bangladesh	1
DSQS-11	ATLAS Elektronik	Germany	Lindau	South Africa	2
	ATLAS Elektronik	Germany	Lindau	Estonia	2
DSQS-11H	ATLAS Elektronik	Germany	Bang Rachan	Thailand	2
DSQS-11M	ATLAS Elektronik	Germany	Frankenthal	Germany	12
	ATLAS Elektronik	Germany	Kulmbach	Germany	5
	ATLAS Elektronik	Germany	Lat Ya	Thailand	2
DUBM 20B	Thales Underwater Systems	France	Circe	Turkey	5
DUBM 21A	Thales Underwater Systems	France	Tripartite	Netherlands	10
DUBM 21B	Thales Underwater Systems	France	Tripartite	Belgium	7
DUBM 21B/D	Thales Underwater Systems	France	Tripartite	France	3
	Thales Underwater Systems	France	Tripartite	Pakistan	3
DUBM 41B	Thales Underwater Systems	France	Antares	France	3
DUBM 42	Thales Underwater Systems	France	Laperouse & Thetis	France	4
MG 7		RFAS	Yevgenya	Bulgaria	4
		RFAS	Yevgenya	Cuba	3
		RFAS	Yevgenya	India	3
		RFAS	Yevgenya	Syria	3
		RFAS	Yevgenya	Ukraine	1
		RFAS	Yevgenya	Vietnam	2
		RFAS	Yevgenya	Yemen	5
MG 69/79		RFAS	Natya I	India	12
		RFAS	Natya I	Yemen	1
		RFAS	Sonya	Bulgaria	4
		RFAS	Sonya	Cuba	2
		RFAS	Sonya	RFAS	21
		RFAS	Sonya	Syria	1
		RFAS	Sonya	Ukraine	2
		RFAS	Sonya	Vietnam	4
		RFAS	Vanya	Bulgaria	4
MG 79/89		RFAS	Notec I	Poland	13
		RFAS	Natya I	RFAS	8
		RFAS	Natya I	Ukraine	2
SA 950	Kongsberg Simrad AS	Norway	Alta	Norway	4
	Kongsberg Simrad AS	Norway	Stockholm	Sweden	2
	Kongsberg Simrad AS	Norway	Adjutant/MSC 268	Taiwan	4
	Kongsberg Simrad AS	Norway	Goteborg	Sweden	4
	Kongsberg Simrad AS	Norway	Kaparen	Sweden	6
SHL 100/200		Poland	Mamry	Poland	4
Stag Ear		RFAS	T 43	Albania	2
		RFAS	T 43	Egypt	3
		RFAS	T 43	Indonesia	1
		RFAS	Yurka	Egypt	4
		RFAS	Yurka	Vietnam	2
Tamir II		RFAS	T 43	China	40
TSM 2022	Thales Underwater Systems	France	MHC	Egypt	3
	Thales Underwater Systems	France	Tripartite	France	10
	Thales Underwater Systems	France	Tripartite	Indonesia	2
	Thales Underwater Systems	France	Landsort	Singapore	4
	Thales Underwater Systems	France	Lerici	Malaysia	4
	Thales Underwater Systems	France	Lerici	Nigeria	2
	Thales Underwater Systems	France	MSC 289	South Korea	4
	Thales Underwater Systems	France	Landsort	Sweden	7
	Thales Underwater Systems	France	MWV 50	Taiwan	4
	Thales Underwater Systems	France	Vukov Klanac	Serbia & Montenegro	2
TSM 2023N	Thales Underwater Systems	France	Oksoy	Norway	4
TSM 2054	Thales Underwater Systems	France	SAV	Denmark	6
	Thales Underwater Systems	France	Munsif	Pakistan	3
Type 162M	Kelvin Hughes	UK	Type 42	Argentina	1
	Kelvin Hughes	UK	Prat	Chile	2
	Kelvin Hughes	UK	Leander	Chile	3
	Kelvin Hughes	UK	Leander	Ecuador	2
	Kelvin Hughes	UK	Godavari	India	3

System	Manufacturer	Country	Installed on	Navy	Units[2]
	Kelvin Hughes	UK	Type 21	Pakistan	6
	Kelvin Hughes	UK	Leander	Pakistan	1
	Kelvin Hughes	UK	Leander	New Zealand	1
Type 193M	Plessey	UK	Hunt	Greece	2
	Plessey	UK	Lindau	Latvia	1
	Plessey	UK	Lindau	Lithuania	2
	Plessey	UK	Swallow	South Korea	6
	Plessey	UK	Hunt	UK	11
Type 2093	Thales Underwater Systems	UK	Aydin	Turkey	2
	Thales Underwater Systems	UK	Huon	Australia	6
	Thales Underwater Systems	UK	Sandown	Saudi Arabia	3
	Thales Underwater Systems	UK	Sandown	UK	11
	Thales Underwater Systems	UK	Sugashima	Japan	8
	Thales Underwater Systems	UK	Yang Yang	South Korea	1
ZQS 2B	NEC/Hitachi	Japan	Hatsushima	Japan	7
ZQS 3	NEC/Hitachi	Japan	Uwajima	Japan	9

[1] Only systems carried by mine countermeasures vessels are noted in this table
[2] Building or on order

UPDATED

Canada

CMAS-36/39

Type
Mine detection and avoidance sonar.

Description
Derived from the CTS-36/39 multipurpose sonar, the CMAS-36/39 provides all of the CTS 36/39 features as well as an enhanced small target detection feature (it can locate tethered, bottom, near surface mines and divers). Like the CTS-36/39, this sonar is a high-speed scanning, multibeam, hull-mounted sonar using narrow receiving beams and digital processing techniques to provide instantaneous detection and tracking of targets. Video and audio processing provides for target classification assistance.

High-resolution Mine CounterMeasures (MCM) mode operation provides a 180° sector which may be positioned through the 360° azimuth area. A high-resolution (0.25 m) 250 m window may be set through the full operator-selectable range scale.

Operational status
The CMAS sonar is in service with the navies of Australia (Leeuwin class AGS), Bangladesh (Sagar class MSO), Canada, and Denmark (Flyvefisken and Thetis class).

Specifications
Operating frequency: dual-frequency 36 kHz/39 kHz, operator selectable in CW or FM mode
Beamwidth: receive – (horizontal and vertical) 6°; transmit – horizontal omni or selectable sector; vertical 6°
Transmitter: 270 channels; power output/channel 50 W, 13.5 kW omni total
Source level: 223 dB (at 1 μPa/1 m)
Source power: 10 kW

Contractor
C-Tech Ltd, Cornwall, Ontario.

UPDATED

Denmark

SeaBat 6012

Type
ROV scanning sonar.

Description
The SeaBat 6012 is a high-definition, real-time, electronically scanning, forward-looking sonar designed to be deployed on ROVs or small surface vessels (including inflatable boats). With 60 455 kHz beams in a forward-looking configuration, the SeaBat 6012 is used to locate objects such as mines and swimmers at distances up to 200 m.

The system includes a lightweight, low-magnetic sonar head; a surface processor; a trackball; and a high-resolution colour display. It is controlled by user-friendly 'point and click' on-screen menus, so that the operator never need avert his/her eyes from the sonar image. Commands include receive and transmit settings, five different colour ranges, grid on/off, distance measurement, zoom and freeze frame.



Elements of the SeaBat 6012 ROV sonar

The display features 256 colours and can be recorded in PAL or NTSC VHS video format. An optional disk drive allows images to be imported into word processors for documentation.

The sonar scans a forward sector of 90 × 15° at 455 kHz using 60 individual 1.5° narrow sonar beams which update simultaneously up to 30 times per second. The result is high resolution with minimal noise and clutter. Seven range settings from 2.5 to 200 m are available, offering an actual increase in sonar display resolution. Undistorted images are produced in real time, even at speeds of up to 12 kt in water.

Operational status
Operational with the Coastal Systems Station of the Dahlgren Division, Naval Surface Warfare Center, USN; Carderock Division of NSWC where it is used in carrying out hull maintenance; on the Double Eagle Mk II ROV of the Finnish Kuha class and Danish Flyvefisken class navies.

Specifications
Operating frequency: 455 kHz
Sector: 90°
Bandwidth: 20 kHz
Range settings: 2.5, 5, 10, 25, 50, 100, 200 m
Range resolution: 5 cm
Number of beams: 60
Horizontal beamwidth: 1.5° (receive, each beam); 165° (transmit)
Vertical beamwidth: 15° (receive); 15° (transmit)
Source level: 210 dB (nominal)
Operating depth: 350 m (600 m available)

Contractors
RESON Systems A/S, Slangerup, Denmark.
RESON Inc, Goleta, California, USA.
RESON Offshore Ltd, UK.

UPDATED

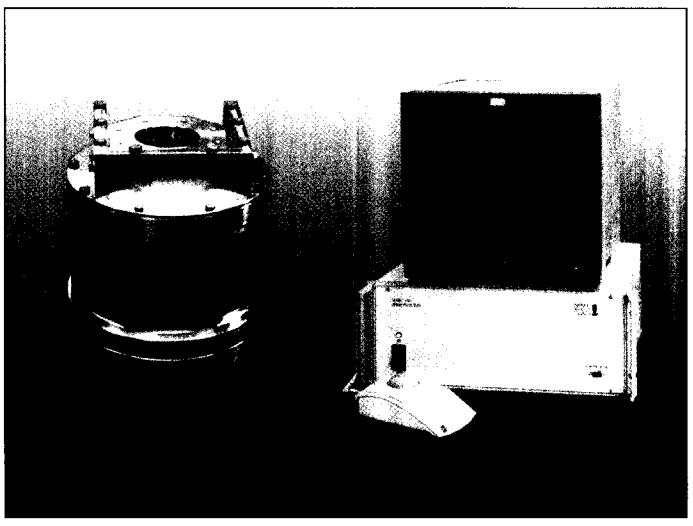
SeaBat 8100

Type
Obstacle avoidance sonar.

Description
The new-generation SeaBat 8100 is a volume scanning, beam-steered forward-looking multibeam sonar operating at 240 kHz. Optimised for use in shallow-water, high-reverberation environments, the SeaBat 8100 provides high-resolution, real-time displays out to 400 m, with a field of view that is configurable up to 360°. The transmitter is electronically compensated for pitch and roll. Updating up to 40 times per second and featuring a low magnetic signature, the SeaBat 8100 is ideal for fast MCM operations. Other applications include obstacle avoidance, static surveillance (against divers, chariots, ROVs and mini-submarines), marine mammal studies, and protection of offshore structures and vessels.

The SeaBat 8100 uses RESON's advanced 81-P Series processor architecture. This system combines advanced operating features (such as automatic beam steering, target location output, user-definable custom settings, and the ability to download new firmware through a communications port or Ethernet connection) with straight forward operation (including a point-and-click user interface, automatic calibration, and onboard self-diagnosis).

Operational status
The Seabat 8100 is mounted on the four Swedish Styrsö class as a mine avoidance system.



Sonar head and control unit and display of SeaBat 8100 (RESON Inc) 0007419

Specifications
Operating frequency: 240 kHz
Resolution: 5 cm
Number of beams: 100-240
Horizontal beamwidth:
transmit-170-360°
receive-1.5°
Vertical beamwidth:
transmit-1.5/3°
receive-20°
Range settings: 2.5, 5, 10, 25, 50, 100, 200, 400 m

Contractor
RESON Inc, Goleta, California.
RESON A/S, Slangerup, Denmark.
RESON Offshore Ltd, UK.

UPDATED

France

DUBM 21B/TSM 2021

Type
Minehunting sonar system.

Description
The TSM 2021B (service designation, DUBM 21B) is a modern minehunting sonar, the design of which applies experience with the DUBM 20A, also developed by Thales Underwater Systems. The hull-mounted sonar is intended for use in conjunction with precision navigation equipment, and a MCM destructor system such as the PAP 104. A former version is the 2021A with different array housings and minor display variations. TSM 2021 functions are:

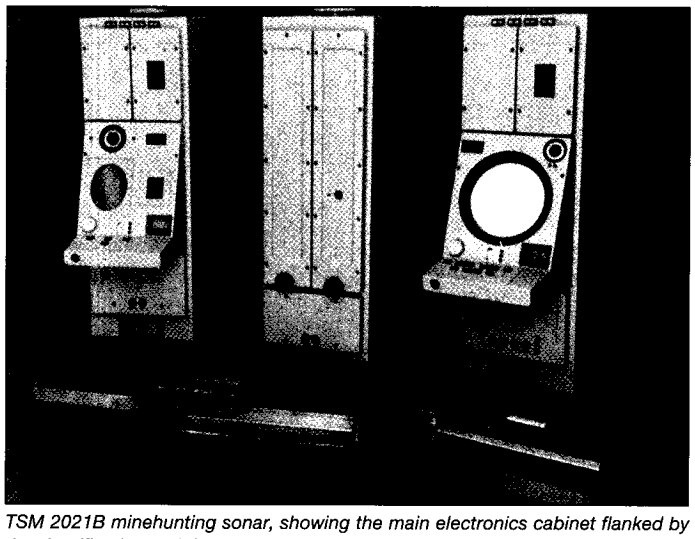
- the detection of mines at distances up to 600 m
- the classification of such targets by the study of the shape of their echo and acoustic shadow, at distances up to 250 m.

Each detection and classification sonar chain consists of an acoustic transmitter/receiver transducer, the associated transmission and reception electronics, and a display console. A subassembly performs the stabilisation, steering, and retraction of the detector and classifier arrays. Stabilisation is provided against 15° of roll and 5° of pitch. The sonar provides simultaneous detection and classification using preformed beams. The 32-stave detection sonar produces 20 preformed beams and the 64-stave classification sonar 80 preformed beams. Detection is carried out over a ±175° sector in sectors of 30, 60 and 90°. Classification is performed over 3, 5 and 10° sectors. The sonar operates at a frequency of 100 kHz.

The Electro-Acoustic subAssembly (EAA) includes:

- the classification sonar transmitter/receiver chain cabinet
- a display console which controls the transmission and reception functions and has Cathode Ray Tube (CRT) presentation of mine detection (PPI display) and location by the detector sonar chain
- a display console with CRT displays for presentation of mine locations within the classification chain
- bridge repeater display, showing range and bearing of designated targets.

The TSM 2021D (French Navy designation DUBM 21) is an upgraded, fully digitial version of the TSM 2021B fitted with hybrid circuitry. The sonar is fully integrated with the tactical system. It comprises two 19 in high-resolution colour sonar consoles, an electronics cabinet and two acoustic antennas. The mechanical subassembly of TSM-2021D is the same as for TSM 2021B. This subsystem is produced by ECAN Ruelle.



TSM 2021B minehunting sonar, showing the main electronics cabinet flanked by the classification and detection display console (left and right), with the transducer arrays in the foreground

Operational status
The DUBM 21B is in service with the Belgian, French and Pakistan Tripartite MCMVs. Altogether some 60 systems have been ordered. The sonars on the French Tripartite vessels is being replaced by the TSM 2022 Mk III.

The DUBM 21D is in service on the French Navy MCMV, *Sagittaire*, and the Pakistan vessels *Muhafiz* and *Mujahid*.

Specifications
Coverage: ±175° in sectors of 30, 60 and 90° for the detector chain; 3, 5 or 10° for the classification chain
Elevation: variable, between –5 and –40°
Stabilisation: ±15° (roll); ±5° (pitch)

Detection sonar
Frequency: 100 kHz (modulated ±10 kHz)
Sound level: 120 dB
Pulse duration: 0.2 or 0.5 ms
Range scales: 400, 600 or 900 m
Max sound level: 120 dB
Channels: 20
Beam aperture: 1.5°

Display: PPI
Classification sonar
Frequency: 420 kHz (modulated ±15 kHz)
Sound level: 122 dB
Range scales: 200 or 300 m
Max sound level: 122 dB
Channels: 80
Beam aperture: 0.17°
Display: CRT and storage magnifier tube

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

DUBM 41B (IBIS 41)/TSM 2050

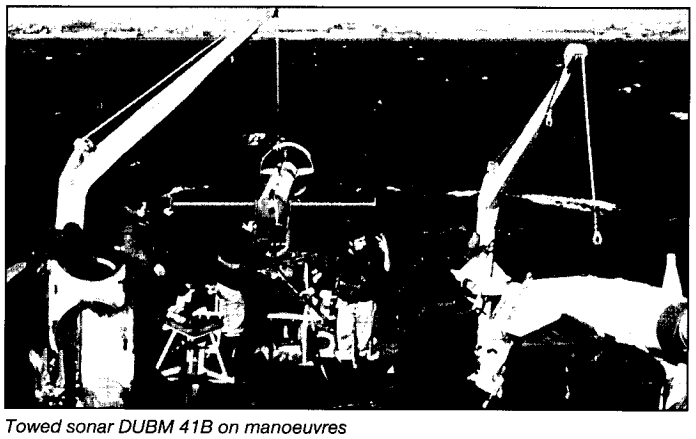
Type
Side scan minehunting sonar system.

Development
Development of the DUBM 41B was conducted in collaboration between the French Navy Mine Warfare DCN (GESMA) and Thomson Marconi Sonar SAS.

Thales Underwater Systems was contracted by GESMA to carry out a feasibility study of an experimental panoramic sonar for the detection of buried mines, as part of an international research programme involving France, Netherlands and the UK. The contract was concluded in 1992 following trials of a derivative of the DUBM 41 aboard the Netherlands Navy hydrographic vessel *Tydeman*.

Description
The sonar and a navigation system are derived from the DUBM 41B towed sonar, and the new towed unit houses non-linear acoustic arrays and part of the processing system. Thales Underwater Systems is responsible for the towed arrays and transmission circuits, as well as the interface and display systems, and BAE Systems for the receiver section.

The TSM 2050 (service designation DUBM 41B) system is a high-resolution side scan sonar system designed for the location and classification of targets lying on the seabed. The system consists of three towed sonar vehicles, two consoles, the necessary cables, shipboard hoists and handling gear. In normal operation two of



Towed sonar DUBM 41B on manoeuvres

the three sonar bodies are used, with the third kept as a ready spare. A permanent record of the sonar data gathered is made on a facsimile type recorder and a tape recorder. The information is also presented simultaneously on two CRT storage tubes, these console-mounted displays providing an image of the seabed. The system is designed for use by low-tonnage vessels and in waters of 100 m or deeper. The towed sonars operate at about 5.5 to 7.5 m above the seabed at speeds of 2 to 6 kt covering a 400 m swath. The towcables are provided with deflector vanes which ensure that the bodies are towed at a distance to left and right of the ship's track, and marker floats are provided to indicate the line of travel for each sonar.

The sonar body is a streamlined vehicle fitted with the side scan sonars, plus additional sonar transducers for determining height above seabed and for obstacle detection. Servo-controlled fins are provided for depth control and roll stabilisation is incorporated by means of a separate set of four fins. Dimensions of each sonar vehicle are: length 3.725 m, diameter 36 cm and in-air weight 340 kg. An acoustic pinger is installed as an aid to recovery should the sonar body break its tow. Manual controls are provided at the operating console to permit manual piloting, either to override automatic control or as a standby mode.

Each of the two sonar bodies operates on its own frequency (735 and 785 Hz), the two being separated by 50 kHz, with the area of seabed between them being scanned by both sonars. A typical scanned area covered by the two bodies amounts to a total width of about 200 m, with maximum sonar range selected. There are two other range settings, 50 and 25 m, and the latter setting resolution is stated to be better than 5 × 10 cm in the lateral (scan) direction and in the line of travel.

Operational status
In service. The DUBM 41B is deployed from the French Navy Antares class route survey vessels.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

DUBM 42 (IBIS 42)

Type
Side scan mine detection sonar system.

Development
Development of the DUBM 42 was carried out jointly by the French Navy (DCN Research Establishment specialised in mine warfare – GESMA) and Thomson Marconi Sonar SAS in association with Société ECA. The sonar was originally developed for the French BAMO type MCMV, a project that was subsequently cancelled.

Description
The DUBM 42 is a 500 kHz side scan sonar able to detect and classify mines at ranges up to 200 m, with an area coverage of 2,000 m^2/s. The system is designed for use at an operational speed of 10 kt and a height above the seabed of 30 m.

The basic system consists of one vehicle with three sonars (two lateral DUBM 41 multibeam and one front-head DUBM 60 forward looking) on the sonar body, one Colibri sonar display, one Colibri tactical display and one high-density magnetic recorder. The data collected by the three sonars are recorded for analysis in a land-based processing centre. In addition, a visual display of the seabed is provided on the operator's console. A magnifier provides a more accurate classification. All navigation functions such as piloting and automatic control are integrated on the same console.

The two lateral and single front-head sonars operate on their own individual frequency, the swept channel being 400 m wide.

Operational status
IBIS 42 is the export nomenclature. In service aboard French Navy Survey vessels of the Laperouse class, and the *Thetis*.



IBIS 42 sonar

Contractor
ECA, Boulogne-Billancourt.
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

IBIS 43

Type
Mine surveillance system.

Description
IBIS 43 consists of the TSM 2054 multibeam side scan sonar and the TSM 2061 tactical system. Baseline configuration data collected is analysed offline in a shore centre. In Mk III the configuration data is analysed in real time on board. To carry this out, the IBIS 43 Mk III comprises:

- TSM 2054 multibeam side scan sonar
- TSM 2061 tactical system
- detection and classification sonar console
- database
- CAD and CAC sonar processing.

This system differs from the former DUBM 42 in that the towfish is shorter (3 m long) and uses dedicated software applicable to operations around the coast of Denmark. The tow speed is up to 15 kt.

Operational status
In service with the five MCM modules of the Danish Flyvefisken class.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Sea Keeper

Type
Stand-off MCM system.

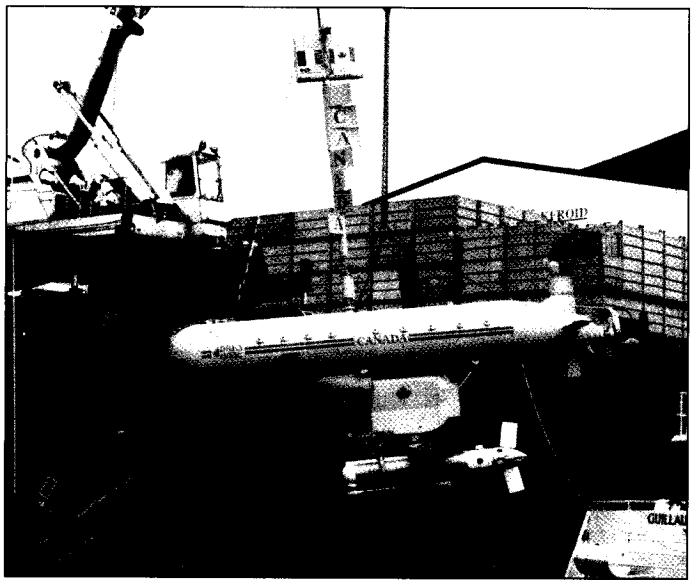
Description
The Sea Keeper (formerly FDS3 [Forward Deployed Side Scan Sonar]) MCM system has been developed by DCN to provide ships with an immediate capability to engage in MCM without the need to call up dedicated minehunters.

The system is based around the Canadian ISE Dorado or Dolphin™ unmanned semi-submersible towing a side scan sonar system at depths between 6 and 200 m at speeds up to 15 kt. The system (referred to in the French/Canadian variant as Dorado) performs detection, classification and identification simultaneously in two distinct areas: detection and classification carried out by the Dolphin vehicle with identification of targets performed aboard the parent vessel which operates from the safety of a previously swept channel.

Raw sonar imagery from the Sea Keeper is passed to the MCMV in real time via a command link that has a range of up to 10 km. The tactical system on board the parent vessel requires between three and five multifunction consoles which are used to control the Dolphin™ vehicle, sonar processing, and the standoff MCM system (side scan sonar). For the trials for the French Navy a Klein 5500 multibeam side scan sonar is being used with a Triton Elics ISIS sonar processor.



Artist's impression of Sea Keeper towing side scan sonar (DCN/ECPA) 0079554



A Dolphin vehicle being launched for trials in Douarnenez Bay, France. Note the small Aurora vehicle underneath Dolphin (DCN) 0103963

The system can be deployed in the area of operations very quickly by aircraft and then rapidly integrated on most types of ship in a task force.

The highly flexible system is able to perform its tasks at an average cover rate of 8.5 n miles²/hour. In this way, the system can achieve a fast and efficient channel sweep, which can be further improved when two vehicles are used in tandem or echelon. For operational tasks, the area to be swept is divided into channels, which are themselves divided into sections, each about 3 n miles long. Placing the MCMV in an adjacent swept channel, the vehicle is deployed forward to a new section to commence its task of detection and classification. Objects detected and classified by the Sea Keeper are identified on board the MCMV and the mine disposal system deployed to inspect and neutralise any 'possible mine' objects. Once a section has been cleared, the units move forward to the next section.

Sea Keeper can also be launched from the coast using a container as a command and control shelter to form part of a coastal defence system. The container can also be mounted on a COOP.

Operational status

Dolphin™ has been evaluated by the French Navy since 1999 and has proven its efficiency up to 200 m deep. Further trials with the French Navy and others were conducted just before the UDT in June 2003.

Specifications

Dolphin vehicle
Length: 8.3 m
Height: 11 m (including antennas)
Height of keel: 1.15 m (without towfish)
Beam: 2.5 m
Displacement: 6,700 kg (with fuel)
Speed (max transit): 16 kt
Range: >400 n miles @ 12 kt
Endurance: 16-74 h (depending on towfish depth and speed)
Sonar
Swept path: 2 × 150 m
Operating depth: 200 m
Operating speed: 12 kt

Contractor

DCN, Paris, France.

VERIFIED

TSM 2022 Mk I/II

Type

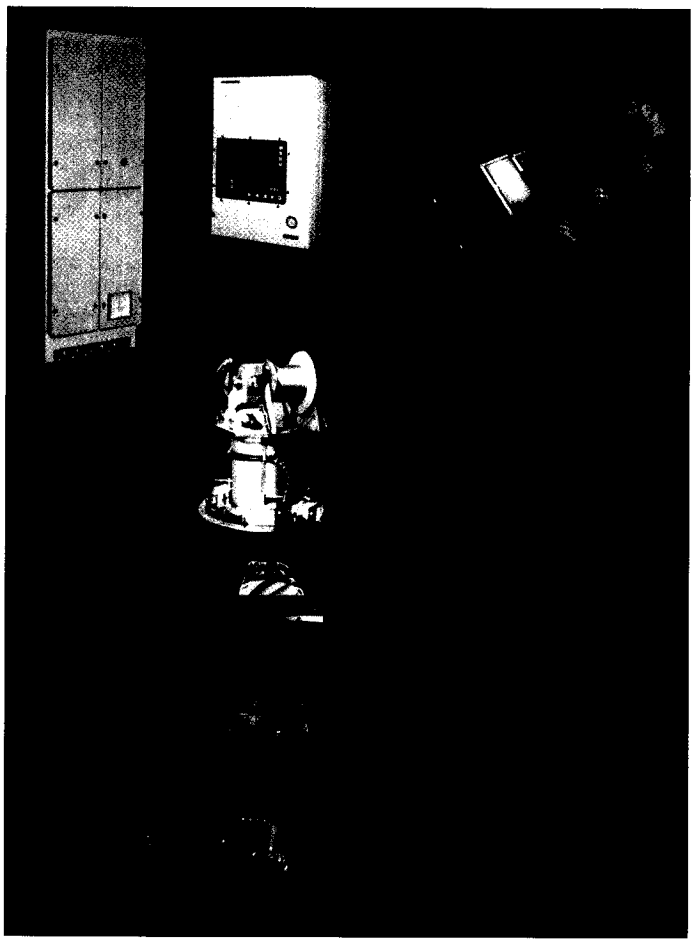
Hull-mounted minehunting sonar system.

Description

The TSM 2022 is a lightweight minehunting sonar designed specifically for small- and medium-sized mine countermeasures vessels. The sonar can also be used for mine avoidance on minesweepers, or in civil applications such as bottom profiling and side scan surveys.

The TSM 2022 is based largely on experience gained with the DUBM 21B in the field of high-resolution beam-forming techniques. It is a hull-mounted equipment intended also for use in conjunction with precision display and navigation equipment and a mine countermeasures system.

The main feature of the TSM 2022 is its small-size retractable single-array assembly, used for both detection and classification, which enables easy



Elements of the TSM 2022 Mk II minehunting sonar system, with acoustic array

installation and maintenance. The high-resolution features of the DUBM 21 are maintained and improvements are mainly in the field of digital processing technology.

The main functions of the sonar are: detection (165 Hz frequency) and classification (400 kHz frequency) of moored and bottom mines, detection at distances up to 600 m, and classification of targets by analysis of the shape of their echo or shadow at distances up to 250 m in water 10 to 90 m deep. In the classification mode, horizontal beamwidth is 7°; in detection mode either 14° or 28° beamwidth can be selected. In both modes the vertical beamwidth is 15°.

The main assemblies are:

- the hoisting and stabilisation system together with the retractable array which is installed in the sonar trunk (0.75 m diameter). The total weight is only 900 kg
- electronics cabinet
- operator's console.

The operator console provides display of sonar images in the various modes, memory and display of former sonar contacts, and includes interfaces with current mine disposal and navigation equipments.

In the Mk II configuration the TSM 2022 is equipped with a 19 in high-resolution Colibri colour console and specific sonar processing such as Computer-Aided Detection (CAD), Computer-Aided Classification (CAC) and Performance Indicator (PI).

Operational status

Some 31 equipments have been ordered by seven navies. The Swedish Navy has seven TSM 2022s in operation, Egypt three, Indonesia two, Malaysia four, Nigeria two, Singapore four, Taiwan four and Serbia and Montenegro one.

Contractor

Thales Underwater Systems, Sophia Antipolis.

VERIFIED

TSM 2022 Mk III Family

Type

Minehunting sonar system.

Description

The TSM 2022 Mk III sonar belongs to the new, wideband, multifrequency, minehunting sonar generation developed by Thales Underwater Systems. It has been developed to take into account:

- the evolution of the threat: mines have become more intelligent (multi-influence) due to progress in technology, more stealthy due to appropriate coatings,

smaller in size or amorphous in shape as well as shallow or very shallow water oriented and deep water
- the specific constraints of minehunting operations

(a) Greater security (development of PVDS concept, operating ahead of the MCMV parent vessel)
(b) Increased operational efficiency (optimised detection probability and computer aids to the operator)
(c) Reduced cost (use of standard technology, hardware and software).

The TSM 2022 Mk III is currently available in two versions:

(1) Hull mounted sonar. This version is a four-frequency, wideband sonar that performs both detection and long range classification of all types of mines in very shallow and shallow waters. Coupled with a PVDS in deep waters, it can cover the entire water volume
(2) PVDS. This system dramatically increases the ship's safety and the coverage rate. By getting close to the contacts, it provides excellent classification close to visual identification, hence reducing the number of divers or ROV interventions for identification.

The arrays of the hull-mounted version are automatically stabilised for roll, pitch and yaw compensation. This version uses four operating frequencies giving six modes of operation:
- LF detection
- HF detection (for adverse conditions)
- HF mine avoidance sonar offering automatic detection and automatic moored mine classification
- HF echo classification of seabed mines and moored mine classification
- VHF shadow classification
- VHF interferometric very high resolution shadow classification

The sonar features a multitransducer design in which the integrated front end conditioning circuits form a compact design. With its flexible transmit/receive FM wideband operation the sonar offers a high probability of detection and probability of correct classification with a low probability of false alarm.

In the PVDS version the arrays are automatically stabilised for pitch and yaw compensation. This feature, combined with a very high sonar transmission rate, allows for continuous presentation of data on the ship's display, even when the ship or ROV is making rapid course changes and quick turns during the classification phase of the operation. Mechanical stabilisation is still essential in order to achieve the highest performance in detection and classification. The PVDS version uses the same operating frequencies as the hull-mounted version except for LF detection, which is not required as the ROV is operating about 500 m ahead of the parent vessel. The PVDS version is ideal for operations in shallow water, but to overcome any deep water thermal layers which it may encounter it is equipped with a TV camera that is used to carry out identification of any mine like object after classification by the sonar.

Both versions use a number of advanced signal processing algorithms and operator aids including:
- Coherent processing
- Digital beamforming
- Interferometry
- CAD (Computer Aided Detection)
- CAC (Computer Aided Classification)
- Performance indication

The last feature is important as it uses the sonar's operating parameters, combined with measured environmental parameters, to provide the operator with real-time performance predictions for all operating modes. The mine warfare officer is therefore able to use the sonar's operating parameters in real-time to achieve the best results.

Operational status
Both the hull mounted and PVDS versions of the TSM 2022 Mk III have been selected by the French, Dutch and Belgian navies for Tripartite MCMV update. The Dutch version will be mounted in the nose of five Double Eagle Mk II ROVs which are being acquired. The first of the French upgraded 'Tripartite' vessels equipped with the TSM 2022 Mk III, the *Andromede*, was accepted back into the French Navy during February 2003. Thales is also to supply a TSM 2022 Mk III array to Centrum Techniki Morskiej (CTM) of Poland for use in the development of the SHL-101/T hull-mounted minehunting sonar for the new Kormoran class minehunters of the Polish Navy.

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED

TSM 2023N

Type
Hull-mounted minehunting sonar.

Description
The TSM 2023N has been developed by Thales Underwater Systems in collaboration with Simrad Subsea, with Thales as the main contractor and Simrad Subsea as subcontractor being responsible for the detection sonar.

The multiple frequency (35 kHz detection and three frequencies between 250 and 525 kHz for classification) TSM 2023N performs mine detection and classification simultaneously, and comprises:
- a detection sonar which covers a bearing sector of 90° electronically steerable through 360°
- a classification sonar which can perform shadow analysis at three different frequencies. The three different frequencies allow the beam resolution and bearing sector to be adjusted according to the size of the detected object
- two Colibri sonar consoles, one for detection, one for classification, equipped with Computer-Aided Detection (CAD) and Computer-Aided Classification (CAC) processing and a performance indicator.

Operational status
The TSM 2023N was ordered by the Norwegian Navy in 1990 and four systems are in service aboard the Oksoy class minehunters.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

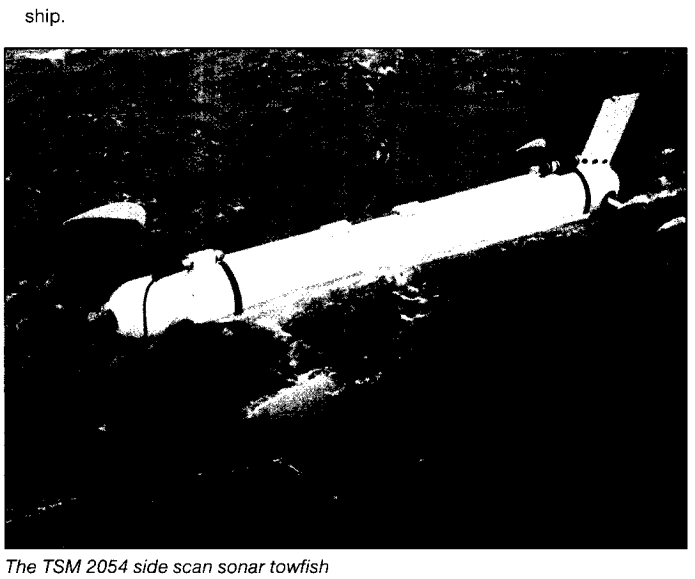
TSM 2054

Type
Side scan multibeam minehunting sonar.

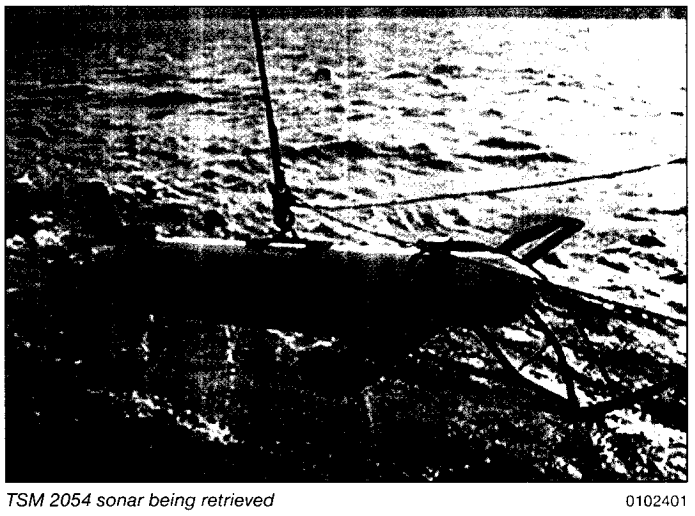
Description
The TSM 2054C (IBIS 43) is a high-resolution multibeam side scan sonar derived from the DUBM 42. The detection and classification of mine-like objects is performed at a maximum speed of 15 kt and the swept channel width is 200 m.

The towfish sonar vehicle is 3 m long and its weight is less than 300 kg. The fish operates at depths down to 200 m and carries an obstacle avoidance sonar that allows it to 'overfly' 10 m high obstacles at its maximum towing speed. The 'fish' can be programmed to transit at a fixed height above the seabed, for which it uses its onboard echo sounder. It is also equipped with a Doppler sonar for accurate speed measurement. Automatic correction of speed, yaw and pitch, and the precise location of the towed body, is computed aboard the ship to an accuracy of 9 m and less than 1 m in altitude.

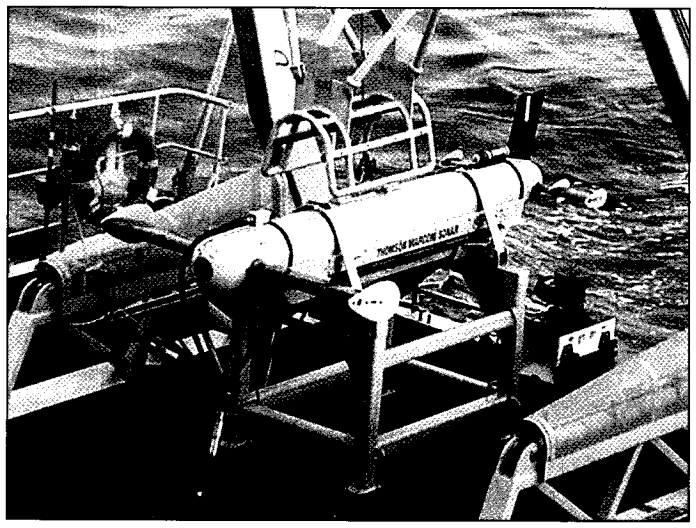
Two operating concepts are available:
- data collected by the sonar are recorded for analysis in a land-based processing centre
- detection and classification of new mine-like contacts is carried out on board ship.



The TSM 2054 side scan sonar towfish



TSM 2054 sonar being retrieved 0102401



TSM 2054 on cradle under the A-frame of Danish MCMV MSF 1 (A.J.Watts)
NEW/0589554

The system is based on two multifunction Colibri display consoles and is used for tactical detection and classification operations as the IBIS 43.

Operational status
The Royal Danish Navy has ordered a number of systems. A contract for a third batch of systems was placed in October 1996. The award covers two systems: four 2054 sonars and two real-time processing units. The sonar is streamed from the six SAV class drones of the Danish Navy. Also operational in the Swedish Navy aboard the MSF drone purchased from Denmark. The system may also be purchased by Pakistan for the Munsif (Eridan) class minehunters.

Specifications
Manual or automatic towfish navigation at constant depth or altitude
Water depth: 6 to more than 200 m
Altitude in relation to the seabed: 3-15 m, programmable from the sonar console keyboard.
Automatic, high-precision terrain-following of irregular seabeds with gradients of more than 15%
Obstacle avoidance capability: obstacles up to 10 m high at maximum speed
Speed in relation to water: 4-15 kt
Sonar range: 2 × 50 m; 2 × 100 m
Resolution: 2 × 10 cm or 2 × 20 cm, according to sonar range
Coverage: up to 5.4 km²/h

Contractor
Thales Underwater Systems, Sophia Antipolis.

UPDATED

Germany

AIS 11

Type
Active identification sonar for minehunting.

Description
The AIS 11 (German Navy designation DDSX-11) is an active identification sonar intended for use with submersibles. Although the equipment can be used for a variety of underwater tasks, its prime role is that of mine countermeasures, for which purpose it is normally fitted to the PAP 104 or Penguin B3 mine disposal units (see PAP 104 and Penguin B3 entries).

The underwater parts of the AIS 11 consist of an electronics unit and a transducer unit, the latter being fitted in the hull of the submersible. The parent surface ship is equipped with an evaluation unit, a control panel and a display. Weight of the overall system is 160 kg, that of the underwater part being about 20 kg. Data transfer between the underwater part and the surface takes place along a cable.

During operation, a 60° conical beam is transmitted ahead of the vehicle and the acoustic signals reflected by an object are received by a linear antenna. These signals are then processed in real time, by both analogue and digital methods, and transmitted to the surface vessel where the information is shown on a PPI display in a sector-shaped format with correct angular representation. Fast real-time signal processing enables the underwater scene to be displayed at the frame repetition rate of a normal cine film. The unit features a variable range setting for the search phase and classification/identification phase.

Operational status
No longer in production. In operational service with the German and Taiwanese navies on Pinguin ROV.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

DSQS-11M

Type
Hull-mounted minehunting sonar.

Description
The DSQS-11M minehunting sonar is a high-definition, dual-triple-frequency sonar which forms an integral part of the ATLAS Minehunting Weapon System MWS 80, MWS 90 and MCM 2000.

The sonar performs:
- simultaneous detection, classification and target tracking of all types of seabed, short tethered and moored mines, and partly buried mines
- high-clearance performance by simultaneous detection and classification within a 90° sector trainable over the entire azimuth
- simultaneous three-dimensional (bearing, range and depth) precision target localisation
- Computer-Aided Detection (CAD) and Classification (CAC)
- automatic tracking of stationary and moving targets
- integrated sonar performance prediction function
- integrated route survey mode (side scan function)
- video and data recording and playback
- comprehensive Built-In Test Equipment (BITE) to ensure system availability.
- Mine avoidance function

The sonar provides: LF long-range detection; LF long-range classification (echo mode); HF high-resolution detection (in a high-clutter environment); HF classification (in echo and shadow mode); and depth classification. Classification of underwater targets is carried out using geometrical shape, length and aspect angle. The hydrophone arrays are fully stabilised. The system incorporates a performance prediction function and advanced signal processing including pulse compression techniques. With its large (2 m) mechanical and electronic precision stabilised antenna the sonar offers a reliable performance at depths down to 150 m. Operational frequencies provide coverage from 40 kHz up to 450 kHz.

The system comprises an operator console, an electronics cabinet, the hoisting unit (with transducer arrays, signal processing units and stabilisation unit) and the hydraulics unit.

The DSQS-11 M multifunction console includes two high-resolution flat screen displays and keypads for direct system operation. Additionally, the operation is supported by easily accessible menu guidance on both graphic displays.

The version for the Thai minehunter incorporates a lower frequency capability for very long-range detection and for detecting buried mines.

Operational status
The DSQS-11M is in operational service in the German Navy's 12 Type 332 and five Type 333 MCMVs. The DSQS-11M has also been installed in the Thai Navy's Lat Ya class MCMVs as part of the MWS 80-6 minehunting system. The earlier DSQS-11H system is operational in the Thai Navy's Bang Rachan class MCMVs.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

MAS

Type
Mine and obstacle avoidance sonar.

Description
The MAS mine and obstacle avoidance sonar is based on the DSQS-11M sonar and performs 3-D processing and display in real time. The sonar can be adjusted to suit the specific environmental conditions prevailing in the area of operations.

The flexibility and modular construction enable installation either in a stand-alone configuration or as part of an integrated sonar suite for combat ships or submarines. It is also suitable for high value surface vessels such as hydrographic and specialised merchant ships.

The antenna of the MAS can either be installed in a fixed hull system orientated in a forward direction providing up to 90° horizontal search sector, or in an optional hoisting unit enabling 360° coverage.

To ensure optimised operational results even in adverse environmental conditions, the MAS may be configured with respect to frequency, pulse length and source levels, together with the suitable antenna geometry according to customer requirements.

The sonar features high resolution in both vertical and horizontal axes, providing high performance against all types of object from the seabed to the surface, with optimised performance against objects sited near the surface.

To detect and avoid moored mines or obstacles, a 3-D presentation of raw data of the whole insonified volume is given in real time, with a colour coding of target depths. Acoustic warnings via the audio channel and a display warning are generated. Simultaneously the avoidance function recommends a new course for a vessel.

A data recording function is used to store and recall track data and related information on disk memory. A snap shot of the complete display can also be stored on disk for recall, enabling the operator to analyse and compare mine and obstacle images and areas during and after operations.

In the integrated version, the MAS can be connected via the Ethernet bus to the main combat system's data recording function.

MAS also features a capability for onboard training of basic skills in display control, operating mode selection and menu operation techniques. For this purpose a limited number of sonar contacts are simulated either via the MAS in the stand-alone version or via Ethernet link from the main combat system in the case of an integrated system.

Depending on the application, different operator consoles are available for the stand-alone version. These are single operation, single display workstation-based consoles.

For the system executive and the MMI, standard tools like OSF/Motif and X-Windows are used.

On the sound propagation and ray trace display, the prediction of maximum sonar range in different environments and against different targets is presented.

Sector coverage is achieved with a single ping period with echo classification processing providing classification of moored mines. Simultaneous bearing range and depth of all contacts is provided and automatic tracking facilities are incorporated.

Typical detection ranges in LF mode are:

- Moored mines - 1,100 m
- Obstacles - 1,400 m
- Small submarines – 1,600 m

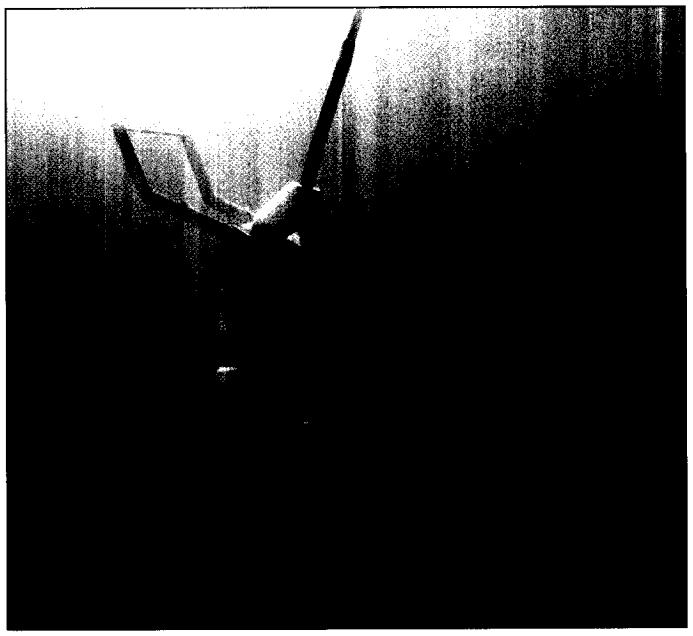
In very LF mode:

- Small obstacles – 1,500 m
- Large obstacles – 2,300 m
- Very large obstacles – 2,900 m.

Operational status
In service with the HL 352 advanced Troika vessels of the German Navy.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED



Simulation of the AN/SQQ-32 minehunting sonar system under way

International

AN/SQQ-32

Type
Advanced minehunting search and classification sonar system.

Development
Technical and operational evaluation of the advanced minehunting sonar system (AN/SQQ-32), produced for the US Navy by Raytheon teamed with Thomson Sintra in France, has been completed. The system is installed in the US Navy's MCM ('Avenger') and MHC ('Osprey') class MCMVs.

Description
The system consists of two separate sonars: a search sonar for initial detection; and a high-frequency, high-resolution sonar for classification of the targets. The two sonars are partially housed in a hydrodynamically shaped vehicle and towed at various speeds by the minehunting ship. The latest technologies in beam-forming, signal processing, modular packaging and displays are used throughout the system.

The detection sonar, designed and manufactured by Raytheon, detects mines over a wide range of distances and bottom conditions. This system incorporates a computer-aided detection facility which is designed to help the sonar operator to discard non-mine objects detected by the sonar. Raytheon also provides the computer facilities and display consoles and is responsible for overall system integration.

The classification sonar, designed and manufactured by Thales Underwater Systems, is based on its experience with the DUBM 21 and TSM 2022 minehunting sonars. The classification sonar provides high-resolution transmission and reception of underwater signals to enable targets to be identified with near-picture quality.

The wet end, consists of a hydrodynamically shaped vehicle and a deployment/retrieval system, designed by Charles Stark Draper Laboratory of Cambridge, Massachusetts. The towed body is housed in a vertical trunk extending from keel to deck, just forward of the bridge. The body is roughly egg shaped, with a pair of boomerang shaped vane arms pivoted on either side. When stowed in the trunk, these lie alongside the body itself, once clear of the ship's keel they swing aft to stabilise the body as it is towed along in the direction normal to its axis. The body is slung from pivots on either side to a fork assembly that is connected to the towing cable, so that its axis remains vertical. Within it are the search sonar staves arranged as a 360° ring array belted around the body, together with immediate sonar electronics and associated equipment. Detection is performed in the 35 kHz frequency using a 60° horizontal by 3.1° vertical beam. Below the body is the rotating scanner for the classification sonar which can operate at three frequencies between 445 and 650 kHz using a 14° horizontal by 0.13° vertical beam.

Detection is accomplished using multi-ping processing, which detects mine-like objects against a high reverberation background. Longer detection ranges are achieved in both deep and shallow water through the use of lower operating frequencies. Computer aided detection enhances the search by marking any mine-like contact with an indicator.

The system provides high resolution views of the ocean bottom and contact evaluation information of mine-like objects on or near the bottom or tethered in the water column. Data is presented in B-scan format from two azimuth search sectors on the left hand side of the screen. At select times, the display shows terrain features, mine-like objects and computer generated symbols for identification of potential targets, and other data of interest.

Classification is achieved using very narrow acoustic beams, which produce high-resolution imagery for both echo and shadow mode displays. Image storage and contact measurement techniques permit operators to accurately determine the nature and dimensions of detected objects.

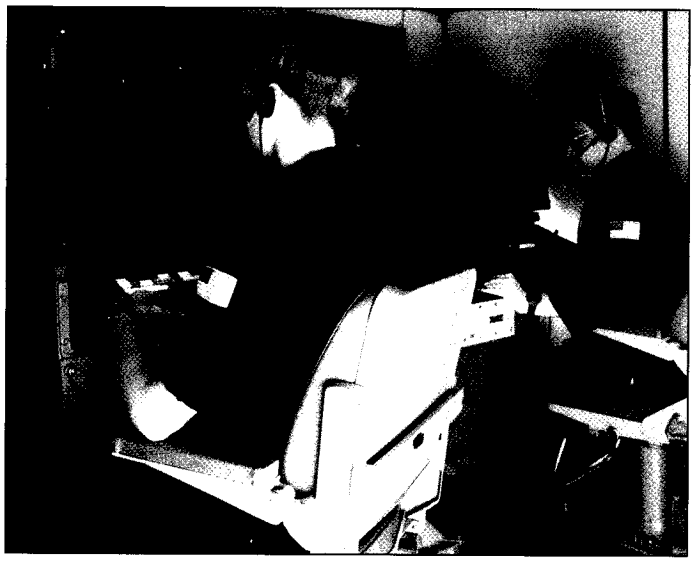
The AN/SQQ-32 features of two identical operator consoles with high-resolution displays. Search and classification data can be displayed simultaneously or independently using direct and shadow mode. A search display presents video patterns for the detection operator to examine, and computer-aided detection indicates objects likely to be mines. Search data is presented on six screen displays allowing the operator to determine if a mine-like object is a real target or a natural bottom feature. The system proceeds to long-range classification, with the second operator, by measuring the detected object's height above the seabed in order to assess the probability of it being a moored mine. The classification operator then uses the high-resolution classification sonar, which has very narrow beams with dynamic focusing, to examine objects detected on the bottom.

Automated detection and control functions are performed by two AN/UYK-44 computers.

The AN/SQQ-32 (V) 3 introduced into the US Navy in 1999 features new colour displays and an open system architecture with COTS processors. The architecture also supports wideband processing.

The AN/SQQ-32(V)3 configuration features enhanced below deck electronics with new colour displays and open system architecture with COTS processors. The system architecture also supports wide band processing.

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AN/SQQ-32 operators' consoles

Operational status

In February 1989, Raytheon received a US$46 million contract to build two production systems and to refurbish two of the three full-scale development systems. In January 1990, Raytheon received a contract worth US$125 million for 11 systems (eight for the US Navy and three for Japan where it equips the Yaeyama class).

In February 1992, Raytheon received a contract worth US$73 million for six systems, plus a set of shipboard electronic units to support shore-based training. In 1994-95 Raytheon was awarded the competitive follow-on production contract worth US$66 million for the balance of the systems required by the US Navy. AN/SQQ-32 production systems are installed on 14 Avenger class MCMVs. The AN/SQQ-32 is also installed on the Osprey class MHC vessels, the Japanese Yaeyama class minehunters and is equipping the new Spanish Segura class.

The AN/SQQ-32(V)3 configuration was introduced into US fleet service in 1999.

Contractors

Thales Underwater Systems, Sophia Antipolis.

Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

UPDATED

UPDATED

Italy

MIN Mk 2

Type

ROV sonar.

Description

This high-resolution, high-frequency sonar has been designed for the MIN Mk 2 ROV. The unit comprises a control and display unit which is integrated into the main shipboard console, and the underwater sonar head and electronic assembly mounted on the ROV.

The main features of the sonar are its high resolution in bearing and range and its ability to identify underwater objects using echo and shadow techniques. Displays are presented in either PPI or B-scan format. The sonar is mechanically sectorally scanned in the horizontal plane using a bidirectional motor. Vertical scan is achieved by tilting the head of the ROV.

The transducer consists of a horizontal transmit array, and horizontal and vertical receive arrays. The three arrays are mounted in the same plane, a configuration which provides for future implementation of sonar signal processing in order to give an acoustic image in pseudo three-dimensional form.

Operational status

In service with the MIN Mk 2 ROV in the Italian Navy.

Specifications

Range scales: 3/6/12/25/50 m
Scan rate: 15°/s (min), 120°/s (max)
Scan period: 0.6 s (min), 19 s (max) (depending on selected scan rate and range scale)
Pulse transmission modes: FM and CW
Max transmission bandwidth: 40 kHz with 0.5 ms pulse length (FM coherent processing)
Min pulse length: 0.5 ms (CW coherent processing)
Transmit beam: 1° horizontal, 40° vertical
Receive beam: horizontal array - 1.25° horizontal × 40° vertical; vertical array - 16° (horizontal) × 5° vertical
Source level: >=210 dB/µPa/1 m
Range resolution: between 2-8 cm (depending on selected full-scale range)
Max range: >25 m (bottom contact), >50 m (moored contact)
Angular resolution: better than 1.25°
Horizontal coverage: ±35° (with reference to longitudinal axis of ROV)
Mechanical vertical tilt: +60 to –90° (with reference to longitudinal axis of ROV)
Spatial sampling: 0.25/0.5/1°

Contractor

Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

SQQ-14IT

Type

Minehunting sonar.

Description

The aim of the SQQ-14IT programme has been to redesign the AN/SQQ-14 minehunting sonar, and completely new electronics have been developed for both the dry and wet ends. Only the mechanical parts of the old hoist system remain.

In line with the next-generation sonars, new functions such as real-time performance monitor, speed scan, memory display and remote display have been included, as well as Built-In Test Equipment (BITE) functions which provide self-diagnosis and the location of malfunctions down to the printed circuit cards. The sonar operates at 80 kHz frequency for search scanning across an 82° sector and 350 kHz frequency for classification using a 0.3° beam.

The transfer of the transmitter unit into the towed body has provided an increase in the system's operational performance, as well as a redundancy of the principal functions, that is, console interchangeability and the possibility of operating with reduced efficiency in the case of malfunction in one or more of the transmitter sections. The adoption of the latest consoles for search and classification operations has greatly improved the man/machine interface, and simplified the use of the system and the training of operators. Recording and mission playback facilities are available, as well as training and simulation programmes.

Separate search, classification and memory display consoles are provided.

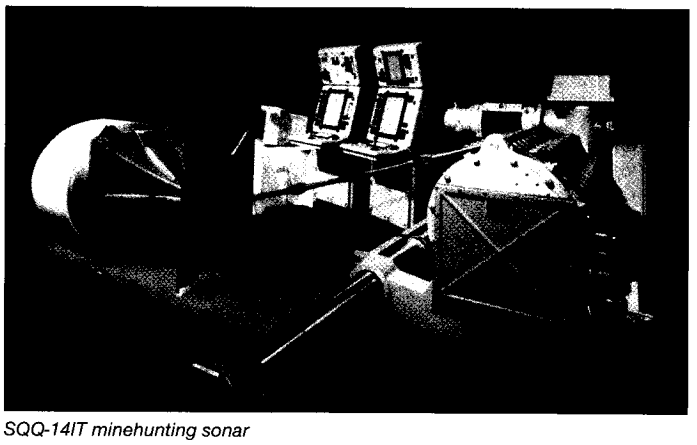
Operational status

The system is no longer in production. There are 12 SQQ-14IT minehunting sonars in service with the Italian Navy.

Contractor

Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED



SQQ-14IT minehunting sonar

Norway

SA 950

Type

Mine detection and avoidance sonar system.

Description

The Simrad SA 950 is an active, high-resolution, multibeam sector scanning sonar designed for fast and accurate detection of moored and bottom mines. The design of the sonar ensures simple and accurate operation, a high degree of maintainability, and low size and weight.

The system consists of a hull unit (with transducer array), transceiver unit, servo unit, and an operator/display unit. Detection is achieved using 95 kHz frequency combined with high-source level and CW or FM signal processing. Transmission is sectoral, covering a sector of 45 or 60° with 32 beams of 1.7 or 1.9° each with a vertical beamwidth of 10°. The sector is mechanically trainable and tiltable covering ±190° in the horizontal plane and from +10 to −90° in the vertical plane. The centre beam is stabilised against pitch and roll.

The signal processing is performed in a fast digital system using the full-dynamic range of the echo information. The receiver has time variable gain and automatic gain control on the preamplifiers, background normalisation after the beam-forming, and ping-to-ping correlation.

The echoes are presented in mono or 64 colour high resolution on a 20 in monitor. There is sector presentation and time/range (echogram) presentation. In addition, PPI, relative or true motion is selectable and target or position can be tracked. The system is controlled by a single operator using designated hardware switches, joysticks and trackerball on the operator unit front panel and interactive with a menu on the display.

The SA 950 Mk 2 can be used as a stand-alone system or form part of the MICOS integrated combat information system. It can also be used in combination with Simrad towed array sonars.

The sonar interfaces to Doppler log, gyro, radio position system, VRU, CTD sensor and tactical system.

Operational status
In January 1989 Simrad received an order from the Turkish MoD for SA 950 systems to be fitted to six ex-German Navy minesweepers.

The five Alta class minesweepers of the Norwegian Navy are fitted with the SA 950 as part of their MICOS system. The SA 950 also equips the Kaparen class. The Stockholm and Goteborg class corvettes of the Swedish Navy are also fitted with the sonar. Other operators include Finland and Taiwan.

Contractor
Kongsberg Maritime, Horten. ***UPDATED***

SS 9500

Type
Mine detection and avoidance sonar.

Description
The SS 9500 is a hull mounted active mine detection and avoidance sonar, capable of detecting bottom, moored and floating mines, as well as other objects. The operating frequency is 95 kHz, with a stabilised multibeam array controllable by tilt and train. The sonar is prepared for mounting on both monohull and surface effect ships. Hemispherical coverage is achieved by tilt and train and array stabilisation is provided to compensate for roll, pitch and yaw.

The modular architecture of the WINSON®/WINCON® operator unit features object-oriented software, and is based on commercially available components (COTS), which allows easy integration of the sonar into the vessel's weapon system. All control and command functions are performed on the operator unit, which includes a control panel with dedicated buttons for frequently used operations. Other functions are available in pointer-operated menus. While implemented in a Windows environment, focus is on sonar operation. The operator unit provides a wide selection of screen worksheets, designed to reflect the actual operational situation. These consist of single or multiple views, such as sector, B-scan, tactical, ray-trace or echogram. Post-processing features ping-to-ping filter, normalisation, and automatic tracking. The sonar data can be presented in a geographical or vessel reference system. The rotation and tilt features of the sonar can be used for automatic target tracking as well as position tracking. External connections available include Ethernet and/or serial lines.

Specifications
Operating frequency: 95 kHz
Source level: 220 dB (re. 1 µPa at 1 m)
Sector scan: 45° or 60°, centred on training direction
Horizontal beamwidth: 1.7° or 1.9°
Vertical beamwidth: 10°
Pulses: CW, stepped FM

Contractor
Kongsberg Maritime, Horten. ***UPDATED***

WINSON

Type
Sonar Operator Unit for ASW and MCM.

Description
The WINSON®/WINCON® operator unit is designed for operation of various sonar equipments, including ASW and MCM sonars. WINSON® – the Windows Sonar Display Software, runs on WINCON® – the WINSON® Console. The operator unit is based on commercially available components (COTS) that simplifies maintenance and allows easy integration into the vessel's command and control system.

WINSON® is a component-based software, with a flexible and modular design, that allows tailoring to specific sonars, with the possibility of additional functionality. Operation is carried out using a control panel and/or menus. Data is presented in single or multiple views in sector, tactical, true motion, B-scan, echogram and ray-trace displays. Screen images can be stored for later retrieval. The operator can chose from a number of selectable palettes, including grayscale. Automatic target tracking and position tracking is available with geographical or vessel reference system applied to the data. External connections use Ethernet and/or serial lines.

WINCON® consists of a robust aluminium console, which can be freestanding, wall or rack mounted, and which contains one or two computers, one or two flat-screen LCD colour displays, as well as the splash-proof foil type control panel. The foldable control panel features a PC keyboard, dedicated buttons, a joystick for tilt/train, and a roller ball.

Contractor
Kongsberg Maritime, Horten. ***UPDATED***

United Kingdom

AS360

Type
Scanning sonar for ROV purposes.

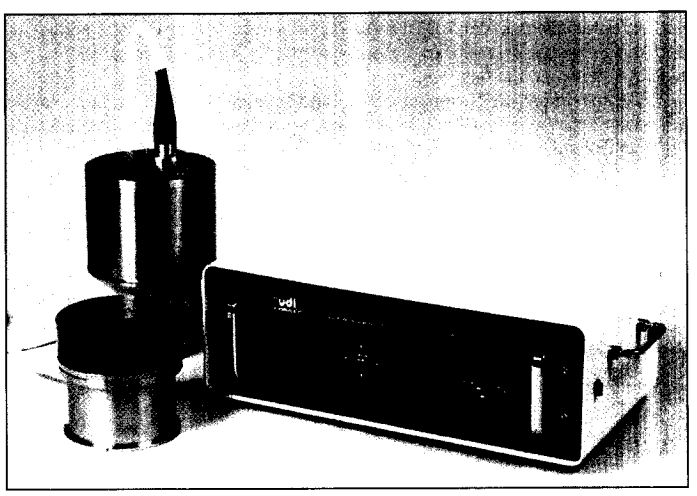
Description
The AS360 is a series of mechanically scanned sonars of high-resolution capability designed specifically for installation on remotely operated vehicles. TV refreshed techniques offer a visual presentation in both monochrome and colour.

The AS360M and AS360 MS5 are derivatives of the basic AS360 equipment. The AS360M has a range of 100 m and employs a colour TV display. It is designed for use on large manned or unmanned submersibles, and can be used in a number of other applications.

Operational status
The Type AS360 MS1/1 has been selected for installation on the ECA PAP Mk 5 ROV to be used by the Royal Navy's Sandown class minehunters.

Specifications
Frequency: 500 kHz (AS360M and MS1A)
Beamwidth: 1.4° × 27° (AS360M and MS1A)
Depth rating: 300 m (AS360M); 1,500 m (AS360 MS1A)

Contractor
Stenmar SonaVision Ltd, Aberdeen. ***VERIFIED***



AS360 MS5 ROV sonar equipment

Sea Scout

Type
Shallow water minehunting/avoidance sonar.

Description
Sea Scout is a lightweight, portable, rapidly deployed mine avoidance sonar which can also be used for detection and classification of seabed ordnance in shallow

water conditions. It is designed to operate from small COOP offering rapid response in high-threat areas.

The sonar is based on Thales Underwater Systems' family of high-frequency mirror sonars, and carries out a continuous search of the seabed, detecting and classifying objects in the water column or on the seabed. Contact range and bearing are relayed to any command system fitted on the parent platform to geographically position contacts for further investigation.

The mirror array offers optimum in-water beam-forming with a minimal number of components. It also allows the system to be used at greater speeds than conventional MCM systems. The mirror provides a fixed-azimuthal field of view of 20° within which a narrow (0.6°) azimuthal beam is electronically scanned over the full field of view to provide an azimuthal resolution of nominally 0.6°. Sea Scout is capable of being mechanically scanned ±30° to provide an overall azimuthal field of view of at least 80°. The system has a fixed-vertical field of view of ±5° selectable within the total vertical range of +10° up to −45°, this being set as a function of the operational mode. When not in use the array is simply and rapidly removed from the bow and stowed on board.

The system is controlled using a simple MMI. In mine avoidance mode the operator sets the centre of the vertical field of view nominally around the sea surface to a specific depth in the water column, for the detection and classification of contact mines. In seabed search mode, the operator simply sets the depression of the sonar system to provide optimum cover of the seabed as a function of the water depth. The array can also be turned through 90° in order to provide a height-finding capability. In all operational modes, target data can be transferred automatically to the command system by the operator positioning a cursor over the detected target and pressing the 'mark' button.

Operational status
In service with US Explosive Ordnance Disposal teams.

Specifications
Frequency: 250 kHz
Azimuthal coverage: 20° fixed, 80° scanned
Azimuthal resolution: nominal 0.6°
Range: >300 m
Weight: 26 kg (in water) 47 kg (in air)

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Type 162M

Type
Side-looking target detection sonar.

Description
Sonar Type 162M, detects and classifies both mid-water and seabed targets. It displays port and starboard recordings simultaneously on a single straight-line recorder, which has a maximum range scale of 1,200 yd. Operation is simplified by entirely automatic gain control. Reliability is enhanced with solid-state technology and maintenance is facilitated by ease of access and comprehensive built-in testing and monitoring features.

The three transducers are all similar and employ 49.8 kHz barium titanate elements. Their beam pattern is fan shaped, about 3° wide and 40° vertical angle; the side-looking elements have their axes 25° below the horizontal.

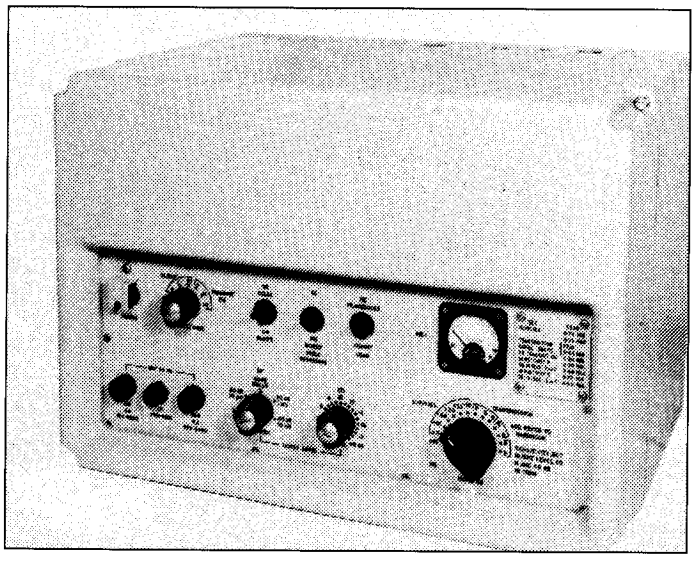
The recorder design uses a double helix (left and right hand) so that there are two points of contact with the moist electro-sensitive paper. As the helix rotates, the two points of contact move outwards from the centre. Port and starboard signals are fed respectively to the left- and right-hand points of contact so that they are recorded simultaneously. There are two zero lines near the middle of the paper, and the 18 mm gap between them is used for time marks every 5 minutes. The paper width is 286 mm, and each trace occupies 133 mm.

An electronic oscillator provides a controlled frequency supply for the driving motor and interval marks. Motor speed changes, for the three range scales, are made by frequency division so as to avoid the use of change speed gearbox, and a stroboscopic arrangement is included so that the helix speed may be easily checked.

A loudspeaker and a socket for headphones enable signals to be monitored aurally if required.

The three range scales are 0 to 300, 0 to 600 and 0 to 1,200 yds, and accuracy is better than 2 per cent assuming a sound velocity of 4,920 ft/s. The paper speed changes automatically when the range scale is selected, and the speeds are 6, 3 and 1.5 in/min (152, 76 and 38 mm/min) respectively. At a ship speed of 10.8 kt the display scales are the same across the paper and vertically. A take-up spool is fitted but its use is optional. A fix marker draws a line across the width of the paper when a button is pressed, and it can be operated in conjunction with a Type 778 echo-sounder or other equipment.

A new transducer array has been developed as a direct replacement unit. The new array incorporates redesigned elements and techniques using a low-voltage device which virtually eliminates insulation problems. Tuning boxes for the three transducers are no longer required since the transducer tuning coils are incorporated into the individual housing gland.



Type 162M sonar transmitter/receiver unit

Operational status
No longer maintained or spares supplied since late 1980s. In service in a number of ex-Royal Navy ships in the Chilean Navy.

Contractor
Kelvin Hughes Ltd, Hainault.

VERIFIED

Type 193M/193M Mod 1

Type
Sector scanning minehunting sonar.

Development
Development of the Type 193M was undertaken by Plessey (subsequently GEC-Marconi Naval Systems and now Thales Underwater Systems) in 1968. Since then a continuous programme of development and operational trials in conjunction with the UK MoD has resulted in further system improvements defined as the Type 193M Mod 1.

The system offers greatly improved performance in detection and classification by the use of digitally processed video and display systems, together with computer-aided target classification.

The sonar is being given a wideband upgrade for the Royal Navy Hunt class being redesignated Type 2193 (see Type 2193 entry).

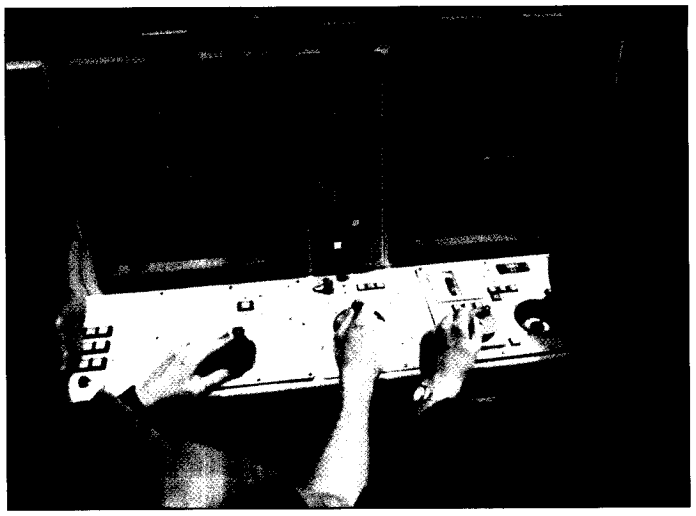
Description
The 193M is a short-range, high-definition sector scanning sonar, providing detection and classification of both moored and ground mines. It has been developed from the Type 193 minehunting sonar; the adoption of solid-state electronics and other advances in technology has resulted in a reduction in installed weight to about 860 kg, which compares with a figure of some 2,100 kg for the older Type 193. Among the operational improvements are extensive use of digital displays and facilities for interfacing with computer systems.

The basic concept is to employ high-definition sonar to locate and classify mines which are then destroyed by explosive charges.

The sonar provides both bearing and range data; the fine range and bearing resolution enables the operator to assess accurately the shape of a target and hence its nature. Since the resolution depends both on operating frequency and pulse length, two selectable frequencies are provided, with a choice of pulse lengths in the classification mode. An optional Mills Cross array enhancement provides improved detection, location and classification of small contracts at long range.

Range and bearing data appear on two displays: in the search mode one display presents the target range up to 550 m and bearing data for the total range scale selected; in the classification mode, a 27 m section of the search display is expanded to fill the second display screen and permit close examination of the target.

Two frequencies are employed by the 193M sonar: 100 kHz for long-range search and 300 kHz for short-range search and classification. The transducers for these signals are carried beneath the ship on a stabilised, steerable mounting, the whole assembly contained within a dome. A choice of either inflated fabric or GRP material is provided for the dome. The receiver uses a modulation scanning technique with 15 beams, 1° wide in LF and 0.33° wide at HF, giving azimuth coverage of 15 and 6° respectively. The searching of wider areas of the sea bottom is achieved by means of an automatic search sequence selected in accordance with the type of sea bottom. The returned echoes are presented to the operators on separate CRTs at the control console. One of these displays range and bearing of targets within the sector being scanned by the search transducer, while the other is



Type 193M Mod 1 sonar operator's console

used for expanded range presentation in search mode and also the presentation of the classification channel data. The controls for adjusting the transducer position, signal parameters such as frequency and pulse length and for co-ordinating with the rest of the minehunting and destruction systems, are also provided at the console. Type 193M data can also be fed into other ship systems.

Once a contact has been detected, a symbol (a question mark) is automatically placed by the target on the tactical display and a danger area of about 180 m in diameter circled around the target. This provides the minehunter with a safety zone around which it can circle the target to carry out further analysis. Once the target is identified as a mine then the ROV can be launched to carry out mine destruction.

Range and bearing data outputs are provided in synchro and digital forms, allowing the sonar to be interfaced with various plotting tables, action information systems and remote indicators. The system is also fully compatible with the NAUTIS-M command system as chosen for the Royal Navy single-role minehunter.

Operational status

In service with the UK and many other navies.

Type 193M is fitted in the Royal Navy's Hunt class MCMVs. In total, 12 navies purchased some 50 equipments, including both the 193M and the earlier version, 193. The system remains in service with the Argentine Navy (2 Ton class), Greek Navy (2 Hunt class MCMV), South Korean Navy (6 Swallow class MCMV) and the United Kingdom (11 Hunt class – to be replaced by Type 2193).

The Type 193M Mod 1 enhancements have been retrofitted as a modification to RN ships fitted with 193M, while complete Type 193M Mod 1 sets have been exported.

Additions to the system are a surface and near-surface mine detection mode, which also provides a mine avoidance capability while minesweeping.

Contractor

Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Type 2093

Type

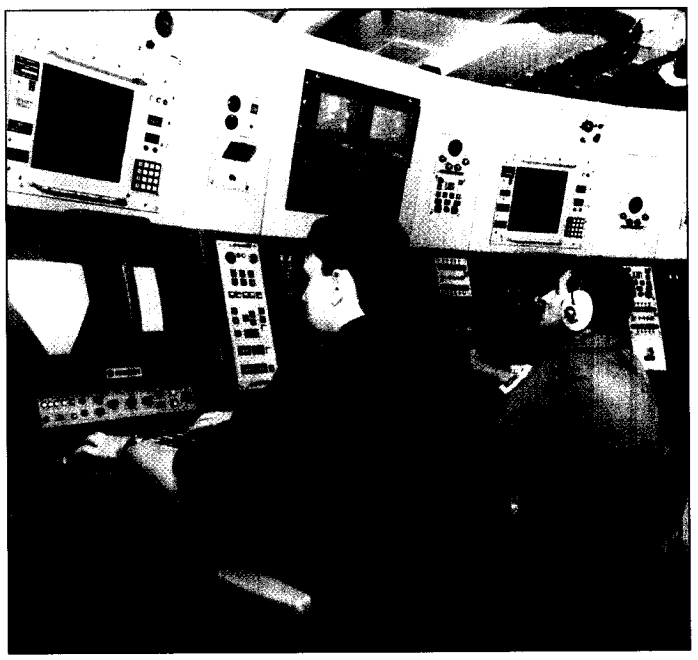
Multimode minehunting sonar.

Description

Designed by Thales Underwater Systems, Sonar 2093 is fitted in the Sandown class single-role minehunter ships of the Royal Navy. The system is designed to operate in either hull-mount or variable depth mode, deployed through the ship's centre well, and will detect, localise and classify all current and future mine threats.

As the culmination of a six year development programme, the system is designed to carry out its mission at high speeds without compromising the ship's safety. A variable depth, dual-frequency (30 to 100 kHz) search and tri-frequency (300 to 500 kHz) classification capability enables the sonar to operate under all bottom and sea conditions at a range claimed to be twice that of hull-mounted sonar and with an increase of three times detection depth. The 13,000 kg Type 2093 is integrated with the ship's command system to allow simultaneous operation in combinations of search, detection, classification and route survey modes. The area coverage rate capability will allow a significant improvement on current route survey operations. The towed body is deployed from 300 m of armoured cable which allows the body to be operated at 20 m water depth.

The towed body of the 2093 is cylindrical with hemispherical ends. Stabilising vanes consist of fixed strips mounted a few centimetres away from the shell, largely parallel to its surface and curved so as to be concentric with its axis, and with the centres of the hemispherical ends over an arc of 45°. The sonar arrays within the body consist of two 360° rings for LF and VLF operation, hydrophones for HF and VHF reception, and separate HF and VHF projectors. Below is a cylindrical VLF projector and finally a VLF depth sounder. LF and VLF are used for search, survey and moored mine classification; HF and VHF for classification and survey.

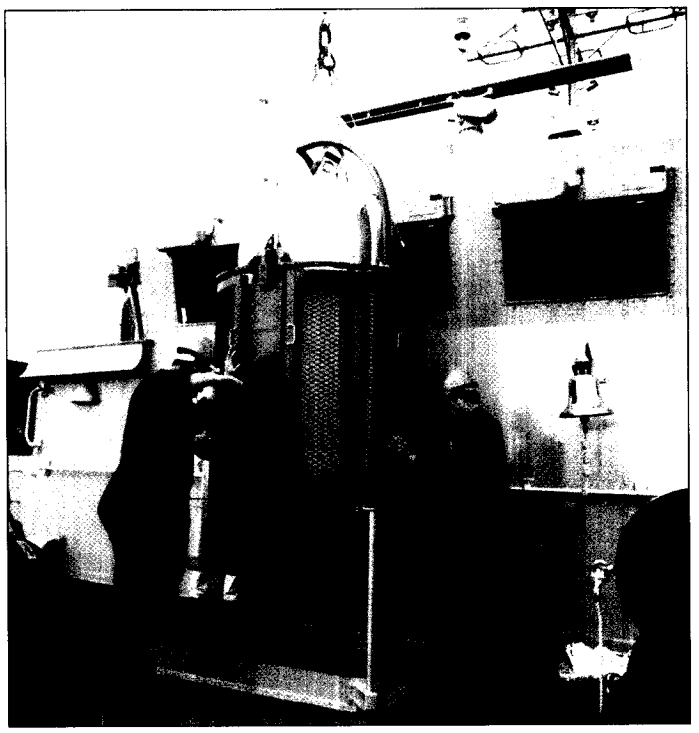


Sonar Type 2093 consoles fitted in HMS Sandown

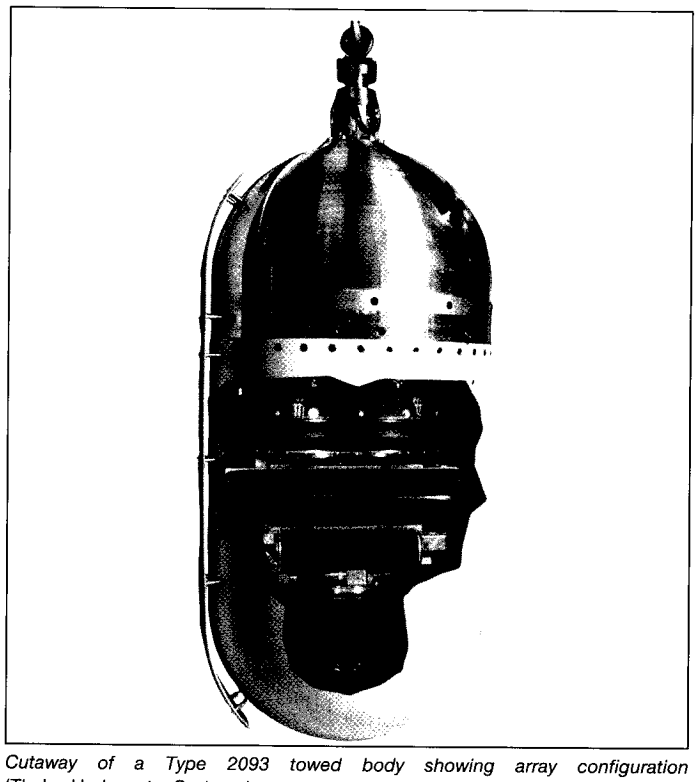
Integral with the sonar is a tracking system which allows the position of the towed body to be accurately resolved when the system operates in the towed VDS configuration. It also concurrently tracks the mine disposal vehicle.

Sonar 2093 employs the unique approach of multiple operating modes, which offer the MCM commander the choice of a number of operational configurations to match the prevailing threat and environment. These multiple operating modes comprise: VLF and LF search and moored mine classification, VLF and/or LF dual search, search at either VLF or LF for ground mine classification, also search either VLF and/or LF for route survey. Sonar 2093 can combine these modes to enable concurrent operation. There are two search frequencies covering a 90° sector to a range of 1,200 m. The classification element uses three frequencies (HF and VHF) covering a 20° sector to a range of 300 m.

The systems supplied to Australia for the Huon class MCMVs have been substantially re-engineered to improve their performance in the warm waters around Australia. This involved a redesign of the classification arrays to optimise directivity; the implementation of newly designed transducer materials developed in Australia with increased aperture to optimise in-water performance; the redesign of the curvature radius of the transducer matrix to optimise beam patterns; incorporation of a classification image database allowing comparison of current image against a stored library of images for contact correlation; a route survey database input using optical drives offering faster speed of advance and clearance rates by comparing current and historic imagery; improvements to GUI; consolidation of text displays within sonar displays; and implementation of large, full colour sonar displays.



Installing a Type 2093 towed body on a Sandown class minehunter (Thales Underwater Systems) 0143751



Cutaway of a Type 2093 towed body showing array configuration (Thales Underwater Systems) 0143752

Operational status

In production, with 15 systems having been ordered for the Royal Navy and three systems for Saudi Arabia. The Type 2093 entered service with the Royal Navy in 1992. A further six systems have been ordered by Australia for the Huon class MCMVs and serial production is underway for the navies of South Korea and Japan (licence built by Hitachi). The Turkish Navy has ordered six Type 2093 VDS systems for installation on the new minehunters to be built by Lürssen Werft.

Contractor

Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Type 2193

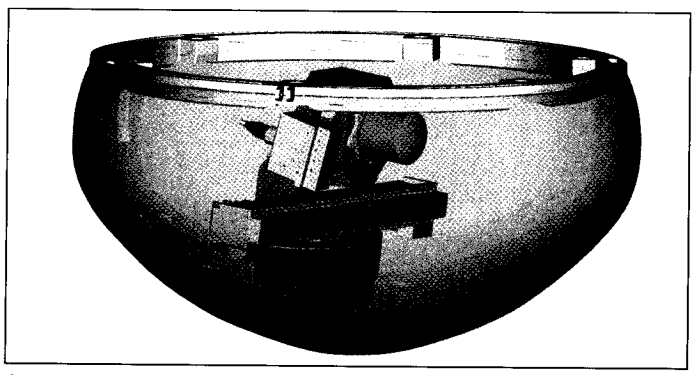
Type

Hull-mounted sonar.

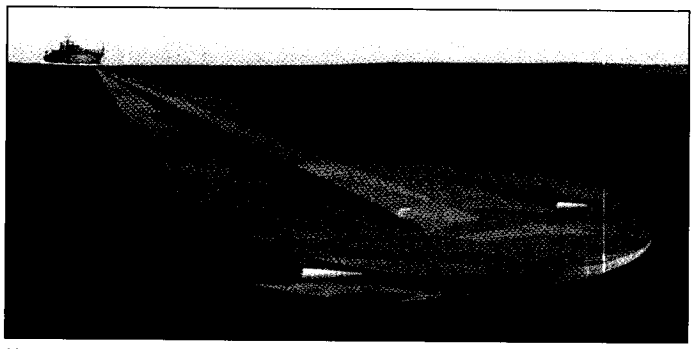
Development

The Type 2193 hull-mounted minehunting sonar was planned to meet the requirement for the Royal Navy Hunt class mid-life upgrade. The sonar was intended to replace the existing Type 193M Mod 1 sonar fitted to the Royal Navy Hunt class minehunters. Two teams, one led by Thales Underwater Systems and a second led by Lockheed Martin Ocean Radar and Sensors systems were awarded a 10-month Project Definition (PD) contract early in 1998 to develop Type 2193 including a demonstration hardware system for trials, which were conducted in October 1998.

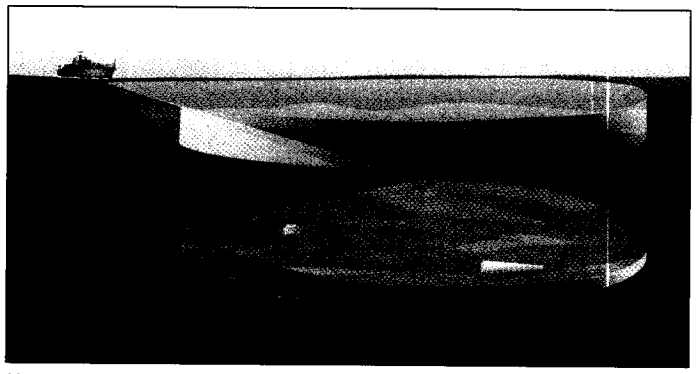
Originally shipsets were required for all 13 Hunt class vessels, together with three shore-based systems. This was reduced to 11 units following the UK MoD Strategic Defence Review of 1998, under which two of the Hunt class are to be retired. Tenders for full development and production were submitted in late 1998.



Array dome of Type 2193 (Thales Underwater Systems) 0143753



Normal search pattern for ground mine classification (Thales Underwater Systems) 0143754



Normal search pattern for near surface mine avoidance (Thales Underwater Systems) 0143755

Description

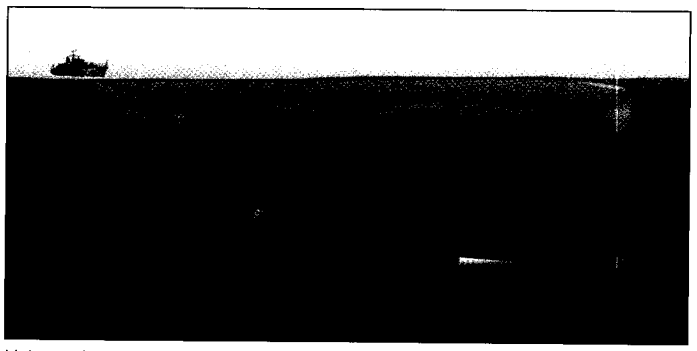
The Type 2193 is a hull-mounted high-frequency, wideband FM minehunting sonar system which uses advanced wideband technology based on applied research carried out by the former DERA (Defence Evaluation and Research Agency, now QinetiQ). The technology has proved to offer better performance in environmentally adverse and noise limited conditions. It also exhibits a reduction in echo fading achieved by averaging of the long, wide bandwidth pulses in both time and frequency. In addition echo information is increased so that the echo structure itself can be used to aid classification over extended ranges. This provides for the detection of seabed mines with low signatures down to depths of 80 m at ranges out to 1,000 m.

Among the features to be incorporated in Type 2193 are:

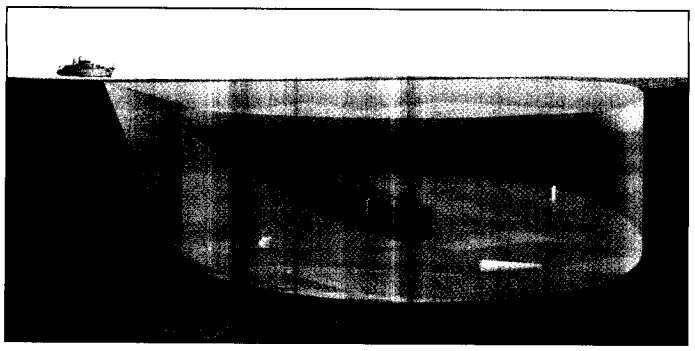
- wideband transducer array
- computer aided detection
- multiping integration to improve both search and classification display image quality
- non-linear image compression to give a clear tactical picture in a multiple contact environment
- interferometric classification for high resolution imaging at greater ranges than conventional classifiers
- long range classification
- forward-look route survey
- fully integrated performance prediction and sonar setting recommendation (RTPM2)

Operational status

In February 1999 the two contenders were asked to re-submit tenders for the upgrade, which was then reduced to a requirement for only eight shipsets (four more of the 'Hunts' being modified for patrol duties and removed from the upgrade programme). Shortly after, budgetary pressures forced the Royal Navy to shelve the major upgrade, which was then considerably reduced in scope. It was announced, in late March 1999, that the Type 2193 programme had been deferred for two years. In March 2001 Thales Underwater Systems was awarded the contract to develop the Type 2193. The first equipment was installed in a trials vessel in 2001, and will enter service early in 2004.



Volumetric search pattern for mid-water tethered mine classification (Thales Underwater Systems) 0143756



Volumetric search pattern for short tethered mine classification (Thales Underwater Systems) 0143757

Contractors
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Type 3010/T (Minescan)

Type
Mine detection and route surveillance sonar.

Description
Minescan (3010/T) is a variant of the 3010 sonar and is a low-cost route surveillance and mine detection side scan which is particularly suited to Craft Of Opportunity (COOP) applications, and for use by reserve or regular forces. The 3010/T version has a greater range and includes the Ferranti Trackpoint II towfish tracking system.

Key elements of the system are:

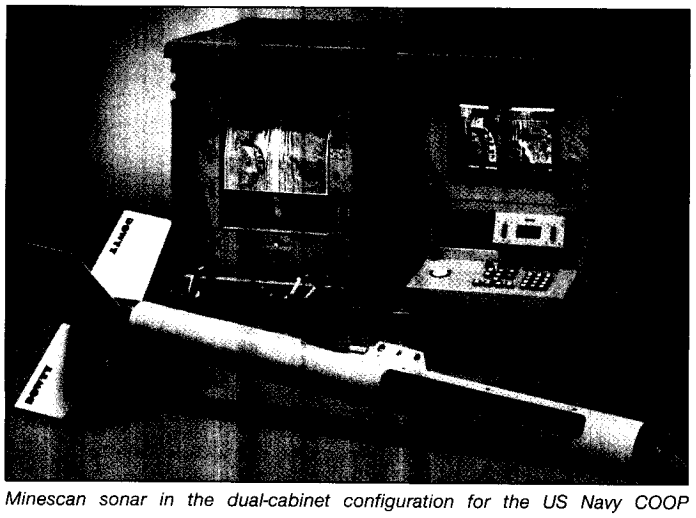
- heavy-duty, dual-frequency towfish, 100/325 kHz, operable to 300 m depth, with optional depressor
- dual-cabinet transportable system in shock-mounted, splashproof units
- single-cabinet system for permanent installation applications
- colour video display with image enhancement and target marking facilities
- range selection – 50, 100, 200 and 400 m port and starboard; total swathe width up to 800 m
- image correction – slant range and speed over ground
- high-density sonar data recorder with random access target image recall
- high-resolution thermal linescan recorder
- interfacing to integrated navigation processors.

The manufacturer states that other elements of the complete COOP mine countermeasures, such as the winch, towfish tracking system, navigation aids, ROV, and shore planning and analysis, can be supplied as a turnkey operation.

Operational status
The Type 3010/T and subsequent variants, including the Type 3020 and 3030, are in service with several navies for route survey, route surveillance and hydrographic survey. More than 50 systems are in use with the US Navy, Royal Navy, navies in Asia and the Dutch Rijkwaterstaat organisation.

Contractor
Ultra Electronics Ocean Systems, Weymouth, Dorset.

VERIFIED



Minescan sonar in the dual-cabinet configuration for the US Navy COOP programme

United States

AN/AQS-14A, AN/AQS-14(V1)

Type
Helicopter or surface towed side scan sonar.

Description
This is a helicopter or surface towed side-looking high-speed, high resolution multibeam sonar, with electronic beam-forming, all-range focusing and an adaptive processor, intended for use with the MH-53E Sea Dragon helicopters used by the US Navy for mine countermeasures. The US Navy has also operated the AN/AQS-14 from surface craft, remotely controlled drones and air cushion vehicles. The underwater vehicle is 3 m in length and has an active control system which enables it to be run at a fixed height above the seabed, or at a fixed depth beneath the water surface as chosen by the operator in the helicopter. The towcable is armoured and is non-magnetic.

The sonar can scan up or down to picture objects moored above, or lying on the seabed. Two sonars are mounted to scan to port and starboard along the axis of the body.

Controls in the helicopter (now updated to the Mod A configuration) include: a high-resolution monitor waterfall sonar display; underwater vehicle controls and status displays; system status indicators; and a magnetic tape recorder for sonar data recording. The system functions include all that is needed to locate, classify, mark, permanently record and review records of mines, mine-like objects and underwater features in the search area. Because the sonar employs multibeam techniques, a rapid search speed is possible. At lower tow speeds the towed sonar automatically reduces the number of transmitted beams. The system is adaptable to surface platforms, especially hovercraft and remotely operated drone vessels for route survey missions.

In 1993, the US Navy contracted three system enhancements. The first is a Post-Mission Analysis (PMA) system, which allows for portable side scan sonar tactical analysis. Designed primarily to support mine countermeasures missions, the PMA system incorporates computer-aided detection/classification of mines and mine-like objects, and automatic target logging. The PMA systems have been delivered. The second enhancement is a realistic AN/AQS-14 operator training system. The trainer utilises interactive simulation to train sonar operators, and evaluates each student's performance when the simulation is complete. Three AN/AQS-14 training systems have been delivered. Under the third enhancement Northrop Grumman developed, built, tested and delivered Mod A upgrades to the AN/AQS-14 system. Mod A updated all the helicopter-borne displays and vehicle control electronics (hardware and software).

The AQS-14A also incorporates a digital recorder-reproducer, high-resolution 19 in colour video monitor and a new navigation and acoustic control processor which uses COTS boards to provide the operator with accurate, real-time target position.

The AQS-14(V)1 features an improved and digitised wet end together with additional sensors (SM 2000 laser linescan). The AQS-14(V)1 offers twice the sonar resolution of the AN/AQS-14A at long range and four times the resolution at short range and can operate at twice the depth. The laser provides positive identification of the target. A new volume mine location facility provides the geographic position of moored mines.

A quadrature amplitude modulation telemetry system allows a coaxial tow cable to carry more than 40 MHz of signal bandwidth over lengths of 600 m or more.

Also, Ocean Systems has performed a feasibility demonstration of a mobile operations command and datalink from the MH-53C helicopter to a ground station. The US Navy has data linked to the sonar for operation for remotely operated vehicles.

Operational status
Introduced in 1984 where it was used in sweeping operations in the Red Sea. Operation Desert Storm in 1991 also saw the AQS-14 used operationally. Upgrades in production for the US Navy MH-53E ASW helicopters with over 32 systems delivered. Eight AN/AQS-14A systems were delivered to the US Navy in 1995 and additional systems have been delivered. The AN/AQS-14(V)1 is now in production and officially entered service with the US Navy with helicopter MCM Squadron HM-14.

Contractor
Northrop Grumman Corporation, Electronic Sensors and Systems Sector, Oceanic and Naval Systems, Annapolis, Maryland.

VERIFIED

AN/AQS-20

Type
Towed side scan sonar.

Description
The minehunting variable depth towed side scan AN/AQS-20 sonar is designed to detect, classify, localise and identify seabed, near bottom moored mines, volume mines and near surface mines. The system comprises three subsystems: a mission

control display subsystem, a console subsystem in the helicopter and a towed body subsystem.

Compared to its predecessor the AN/AQS-14 the system features improved resolution and greater range. The compact, lightweight, hydrodynamically stable towfish is designed to be towed at high speed by CH-60S MCM helicopters of the US Navy. It has also been modified for deployment from the AN/WLD-1 remote minehunting system (see separate entry).

The system is designed to provide total coverage of the seabed, unlike the AQS-14 that leaves a gap immediately beneath the towfish. To cover this gap requires that the AN/AQS-14 make an additional pass along the track. The AN/AQS-20 features additional sensor systems to provide coverage of the gap beneath the towfish requiring just a single pass to check a lane for seabed and moored mines.

The towfish is equipped with five sensor systems; port and starboard side scan sonars; a gap filler sonar mounted in the bottom of the towfish to scan the seabed immediately beneath the towfish; a forward looking sonar; a volumetric sonar which provides coverage above and around the towfish in a near 360° arc. An imaging laser is also carried for mine identification. Sonar processing in the towfish includes analogue signal conditioning and analogue-to-digital conversion, beamforming and quadrature demodulation. Onboard software processes sensor data to determine the actual heading roll, pitch, yaw rate, roll rate and pitch rate of the towfish. The processing algorithms determine the required fin deflections to maintain the desired attitude.

In operation the AN/AQS-20 towfish is linked by a fibre optic cable to the processing suite located in the towing helicopter. As the surveillance data is transmitted back to the aircraft it is processed using automatic computer aided detection and classification algorithms and presented on a display screen and monitored by customised software to identify mine-like objects. Sonar contacts can be recorded and played back during mission analysis.

A near term upgrade currently under development will integrate a modular Electro Optic Identification (EOID) sensor in the towed body. This will provide real-time identification of seabed mines.

Operational status
The US Navy has increased from six to 10 the number of sets ordered to equip the MH-53E Sea Dragon helicopters pending delivery of the new SH-60S Knight Hawk helicopter and the upgraded AN/AQS-20/X system.

Specifications
Towfish
Length: 3.2 m
Span: 1.5 m
Weight: 16 kg (in water), 410 kg (in air)

Contractor
Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

AN/AQS-20/X

Type
Towed side scan sonar.

Development
The lightweight AN/AQS-20/X has completed engineering and development and is ready for production. The system has been designed as a replacement for the AN/AQS-14.

Description
The minehunting variable depth towed side scan AN/AQS-20/X is designed to provide carrier battle groups and amphibious readiness groups with the ability to detect, classify, localise and identify seabed and moored mines in shallow and deep water.

The AN/AQS-20X system features five subsystems: the towed body, fibre optic tow cable, airborne console, interfaces and mission command and display subsystem.

The hydrodynamically stable towed body houses five sonar arrays and various other sensors. The towfish (approximately 5 m long) is equipped with port and starboard side scan sonars; a gap filler sonar mounted in the bottom of the towfish to scan the seabed immediately beneath the towfish; a forward looking sonar; a EOID (electro-optical identification) system to rapidly identify real mines as against false contacts (this replaces the volumetric sonar in the AN/AQS-20). Using its sensors the AN/AQS-20X can provide total coverage of the seabed, including coverage of the gap beneath the towed body.

Hydrodynamic control of the towed body is achieved using software that processes sensor data to determine the actual heading, roll, pitch, yaw rate roll rate and pitch rate of the body. From this processed data the software calculates the required fin deflections to maintain the desired attitude and depth.

The EOID system has been developed by Areté Associates from their STIL (Streak Tube Imaging LIDAR) technology. In this, a pulsed laser transmitter and a time-resolved streak tube receiver provide high resolution (1.25 cm) images in three dimensions enabling mines to be automatically detected and classified in turbid conditions at high search rates. The laser beam is diverged in one dimension using a cylindrical lens to form a fan beam. The back scattered light is imaged by a conventional lens onto a slit in front of the streak tube photocathode and is time (range) resolved by electrostatic sweep within the streak tube, generating a 2-D range-azimuth image on each laser pulse. By orienting the fan beam perpendicularly to the vehicle track, the in-track dimension is sampled by adjusting the PRF of the laser to the forward speed of the vehicle. This results in a 30-D ocean volume sweep operated in a 'push-broom' fashion.

Within the towed body the sonar array processing includes analogue signal conditioning and analogue-to-digital conversion, beam forming and quadrature demodulation. The base banded beam outputs and their associated environmental and navigation data are output to the airborne console via the fibre optic tow cable. As the surveillance data is transmitted back to the aircraft it is processed using automatic detection algorithms and presented on a display screen and monitored by customised software to identify mine-like objects. Sonar contacts can be recorded and played back during mission analysis.

Compared to its predecessor, the AN/AQS-20/X offers improved resolution and greater range. The sonar is designed to be towed at high speed by the MH-60S MCM helicopters of the US Navy.

Operational status
Two engineering development models are being supplied to the US Navy and have undergone tests. Production is scheduled for FY03.

Contractor
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

UPDATED

AN/SQQ-14

Type
Variable depth towed mine detection sonar.

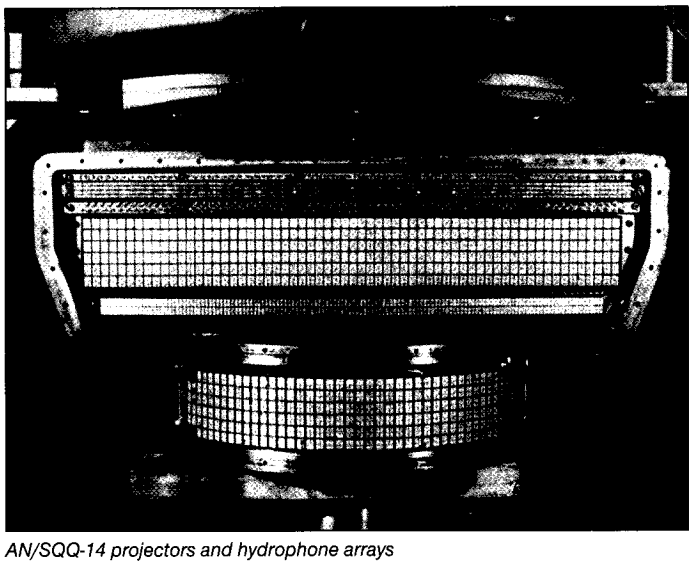
Description
The AN/SQQ-14 system is essentially a variable depth, dual-frequency sonar for detecting and classifying bottom mines in shallow water. It utilises a towed body in the shape of an elongated sphere towed through a centre well on a US Navy minesweeper.

The AN/SQQ-14 can operate down to 45 m. It transmits at 80 and 350 kHz respectively for search and classification, scanning over azimuths of 100 and 18°, and through an elevation of 10° in each case. Azimuth and range resolutions are 1.5° and 1 m for search, and 0.3° and 8 cm for classification.

A unique aspect of the AN/SQQ-14 design is the 120 m towing cable. This consists of discrete, 18 in (457 mm) sections of articulated struts with universal joints at each section, permitting the cable to flex in any vertical plane, but restraining it from torsional motion. This configuration imparts a constant heading to the towed body, thereby eliminating the need for a gyroscopic heading reference system.

A rubber-jacketed electric cable containing 35 shielded, coaxial and individual conductors passes through the centre of the strut sections. The cable terminates in a slipring in the towed body and in a winch with compound winding drum in lieu of a slipring installed on the 01 deck of a mine countermeasures ship.

The articulated strut type of towcable posed unique problems related to winching, storage on the winch drum, and ship's tow point construction. Struts, of which there are 117 per system, are stored in a single layer on a cylindrical drum equipped with specially designed pads serving as contact points for the articulated strut knuckles. Since a conventional level wind mechanism could not be used with the struts, the winch drum itself is designed to traverse axially by means of an Acme lead screw and rotating nut, thereby accomplishing the level wind function and maintaining a fixed fleeting point. All equipment for this application must be non-



AN/SQQ-14 projectors and hydrophone arrays

magnetic. Struts, bearings and knuckles are fabricated of high-strength Inconel alloy. The winch drum is cast aluminium; the supporting structure is aluminium and stainless steel.

Operational status
No longer in production. In operational service with the Greek, Saudi Arabian and Taiwanese navies.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems - Undersea Systems, Manassas, Virginia.

VERIFIED

ASLS

Type
Side scan bottom imaging sonar.

Description
The ASLS (Advanced Side Looking Sonar) is a high-resolution multibeam side scanning sonar for rapidly mapping and photographing large ocean areas primarily for the detection of seabed, close tethered and moored mines. It operates in three range modes up to 200 m on each side with resolutions of 12.5 cm both along and across track. The towfish uses a mid-point tow, active dynamic AMU controlled stabilisation, an acoustic bottom Doppler sensor and complete instrumentation. The sonar has three operational modes:

- Detection - 200 m sweep each side, 12.5 × 37.5 cm
- Detection/classification - 150 m sweep each side, 12.5 × 25 cm
- Classification - 75 m sweep each side, 12.5 × 12.5 cm

The sonar uses several motion compensation systems in addition to a processing system that forms motion compensated multiple beams focused at all ranges, to create the effect of a telephoto lens on a tripod. These features enable the sonar to produce photo quality, real time images with unparalleled sharpness, at high tow speeds up to 10 kt and depths to 200 m, and in high sea state conditions. A high background-to-shadow contrast ratio (>15 dB) enhances bottom features and target definition. The sonar is capable of detecting 0.5 diameter × 1 m target on a sandy bottom with a probability of detection greater than 0.9. It features a high search rate (1.9 n miles^2/h) with a terrain following operational mode.

The towfish operates in either constant depth or terrain-following modes. It is accompanied with a motion-compensated towfish-handling device that deploys and retrieves the towfish and dynamically decouples it from the ship's motion. The system is packaged in an ISO container for transportation and can be installed in less than four hours.

Operational status
In service with Canadian forces aboard Kingston class MCDV. The first unit was delivered in late 1998.

Specifications
Length: 3.0 m
Diameter: 0.3 m
Span: 1.5 m
Weight: 590 kg (in air)
Operation modes: Classification - range 75 m (each side)
Detection/Classification - range 150 m (each side)
Detection - range 200 m (each side)
Resolution (across track): 12.5 cm
Resolution (along track): Classification - 12.5 cm
Detection/Classification - 25 cm
Detection - 37.5 cm
Coverage: Classification - 0.7 n miles^2/h
Detection/Classification - 1.4 n miles^2/h
Detection - 1.9 n miles^2/h
Background-to-Shadow contrast ratio: Classification - >15 dB
Detection/Classification - >10 dB
Tow speed: 12 kt (max in sea state 4)
Operating depth: 10-200 m

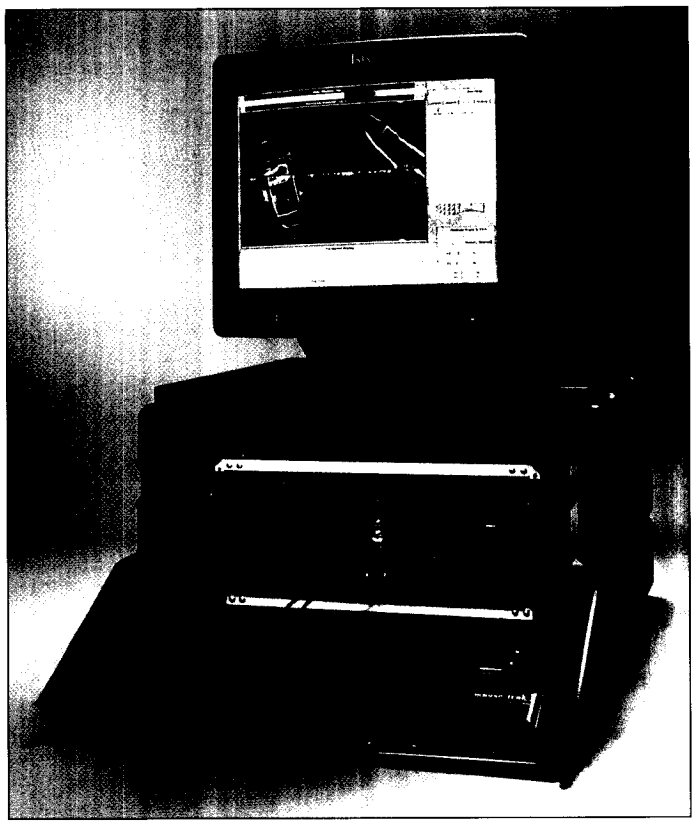
Contractor
L-3 Communications, Sylmar, California.

UPDATED

ISIS

Type
Modular sonar image processing system.

Description
ISIS sonar digitises, stores and processes side scan sonar signals and combines the sonar imagery with navigation inputs to geocode the data in real time. The system interfaces with most conventional analogue and digital side scan sonars and runs under the Windows operating system. ISIS sonar includes many image processing capabilities such as beam and grazing angle corrections, edge detection through spatial filters and target mensuration.



ISIS sonar terminal and display

Post processing modules for ISIS sonar include Triton Elics International Delph Map, a geoprocessing and mapping package that builds a georeferenced visual database of images, vectorised sonar feature extractions and other spatial data. An operator can process side scan sonar images acquired by ISIS sonar into geocoded sonar mosaics and combine them with swath bathymetry data in a single software environment.

ISIS sonar applications include MCM and Q-route surveillance, research, harbour and ship security and hydrographic survey.

Operational status
ISIS has been selected by the US Navy (Deep Submergence Unit, NAVOCEANO, SUPSALV, EOD) and by other navies for route surveillance and MCM operations. For hydrographic applications, ISIS is in use with the Australian, Brazilian and US navies and with the Hydrographic departments of Denmark, Germany and Portugal.

Contractor
Triton Elics International, Watsonville, California.

VERIFIED

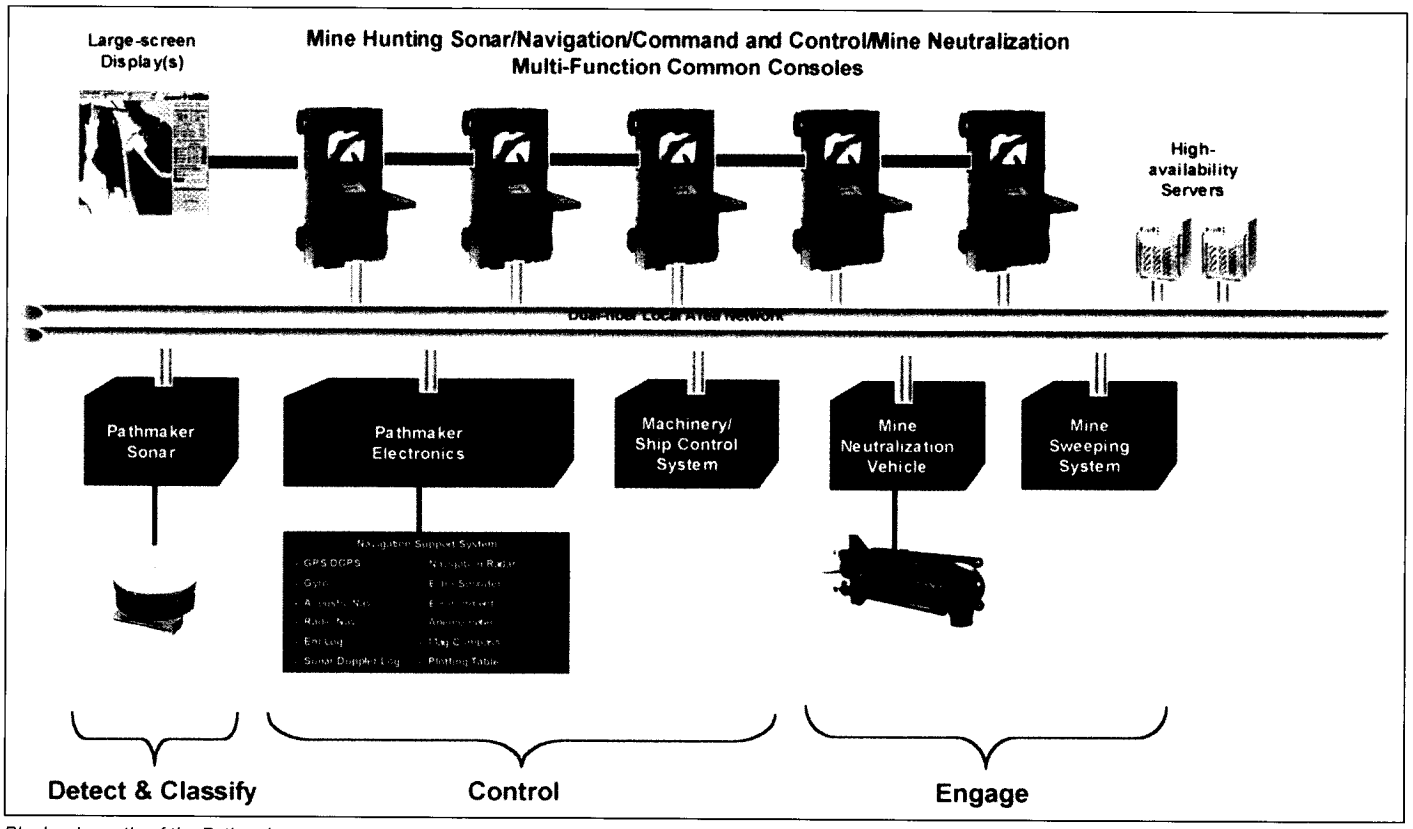
Pathmaker

Type
Integrated mine warfare system.

Description
The Pathmaker mine warfare system from the Ocean Radar and Sensors Systems Division of Lockheed Martin has been developed to provide enhanced MCM capability in regions where high levels of reverberation are experienced. Operating functions include route survey and mapping, surveillance and mine clearance (detection, classification, identification and neutralisation).

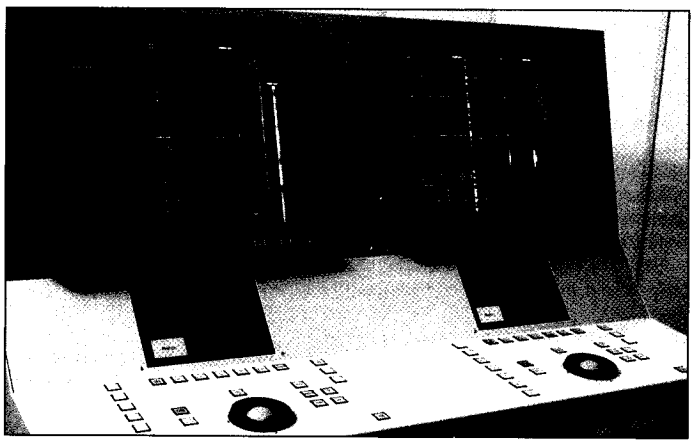
The system uses technology from the British Type 2193 sonar advanced wideband sonar initiated for the Hunt class mid-life update programme. The broadband multirole sonar is integrated with a new combat system based on the US Navy's Integrated Weapon Control System (ICWS).

The sonar whose array can be fitted in the hull or in a variable depth configuration, uses very wideband techniques in transmission, receiving and signal processing. With its advanced signal processing techniques, the Pathmaker system is able to specifically target mines with anechoic coating, and irregular shapes. Using Super Nyquist sampling for high quality target imaging, pulse compression to enhance signal-to-noise ratio, frequency domain beam forming, and speed of sound and frequency equalisation to sustain high bandwidth time functions, the sonar can detect objects with a target strength 10 to 15 dB lower than normal.

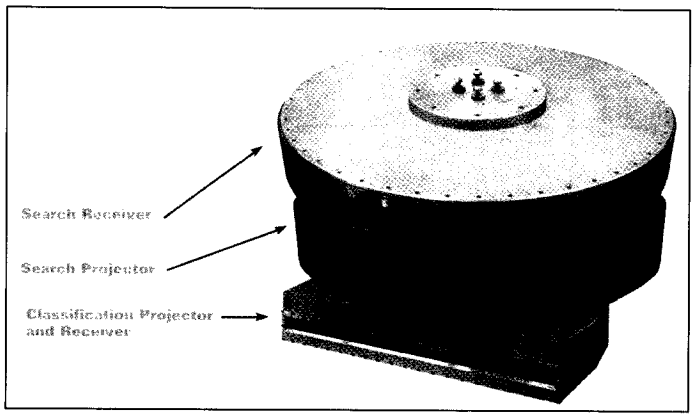


Block schematic of the Pathmaker system

0099762



Flat panel displays on the Pathmaker console (Lockheed Martin) 0099929

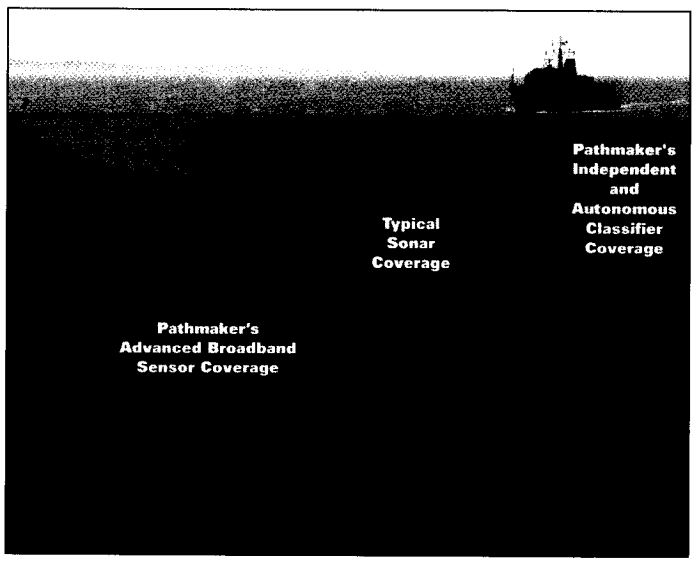


The array system used in the Pathmaker system (Lockheed Martin) 0099928

A mine avoidance mode uses independent and autonomous beams to track mines allowing the vehicle to manoeuvre with safety through unsearched water.

The sonar also incorporates a height finding capability enabling it to determine the direction of the signal. Other features include full 360° coverage in azimuth which increases coverage by 15 to 20 per cent with the possibility of this being further increased by up to 50 per cent depending on environmental conditions. It offers autonomous search and classification in dual frequency mode together with autonomous and independent mine avoidance tracking beams for continuous target tracking during evasive manoeuvres.

Detection ranges have been considerably extended and in the hull mounted configuration offer 1,000 m in azimuth and 80 to 100 m in depth with the VDS configuration extending the depth range down to 300 m.



Sonar coverage of the Pathmaker system (Lockheed Martin) 0099930

Data is displayed on a multifunction console with two 20 in liquid crystal flat panel screens presenting the operator with broadband, HF data with about 50 per cent more dynamic range with what Lockheed claims to be 'near acoustic image quality'. This allows the operator to detect and classify mines by image or shadow. ROVs can also be controlled from the console.

The modular combat system is based on a dual redundant fibre optic LAN using COTS technology with open architecture.

Operational status

Hardware for the original Type 2193 sonar has undergone seawater trials. The Pathmaker system was unveiled at the 1999 UDT in France.

Contractor

Lockheed Martin, Ocean Radar & Sensor Systems, Syracuse, New York.

VERIFIED

SAS

Type

Synthetic aperture sonar

Development

The US Naval Sea Systems Command awarded a US$4 million contract in 2001 for a technology demonstration model of a slow-speed aperture sonar to provide

clandestine minefield and area reconnaissance in support of submarine, battle group and amphibious operations. Such a system, if proven successful, would be suitable for integration in the AN/BLQ-11 LMRS platform as well as other mine warfare and undersea platforms for special operations.

Description

The concept of the synthetic aperture sonar (SAS) is similar to that of the synthetic aperture radar (SAR) but operating in a different environment presents quite different challenges. For a start, the speed of sound in water is much less than that of electromagnetic signals in air, and the potential for path variations in water is far greater than in air. Hence much greater processing power is required to handle SAS signals compared to SAR signals simply to correct these path variations. This can be achieved in the same way as in SAR using an inertial measurement unit, but much more advanced algorithms are required for motion compensation and auto focussing.

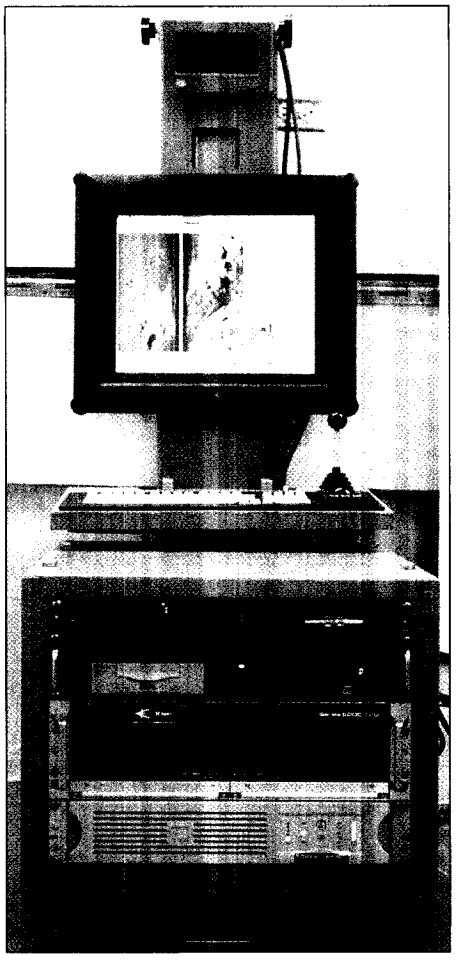
The slow-speed SAS is required to provide long-range, high-resolution imagery in sorties that would last for up to 62 hours at a speed of 4 kt. In this time, the sonar would be expected to detect up to 32 non-mine targets and 200 other sonar targets in each square nautical mile.

It is required that the slow-speed SAS shall be capable of classifying bottom and close-tethered mine-like objects using the frequency band 90 to 250 kHz. It must be capable of providing well-focussed, shadow-graphic (high contrast) imagery of mine-like targets and bottom topology in both along-track and cross-track directions at speeds between 3 and 7 kt to provide simultaneous port and starboard coverage. Resolution in both directions should be 2.5 cm or better at these speeds. Operational range of the system should be as close as possible to the theoretical maximum, that is, 457 m at 3 kt and 195 m at 7 kt in deep water The hydrophone array will be up to 1.95 m long and be capable of operating at depths down to 122 m. The maximum range is required to be four times the water depth with a maximum of 48 m and minimum of 4.5 m.

Operational status

Under development.

VERIFIED



Display and control unit for Series 5000 sonar (Klein Associates)
0129628

Series 5000

Type

Multibeam side scan sonar for MCM/route survey operations.

Description

The Series 5000 high speed, high resolution side scan sonars use digital technology to form multiple, dynamically focused and collimated sonar beams on each side of the sonar. The Model 5500 (five beam) sonar systems produce beams that have a 20 cm along-track resolution (normal) and 10 cm along-track resolution (high-resolution mode).

The design of the Series 5000 sonar systems permits contiguous placement of the collimated sonar beam allowing gap-free, 100 per cent bottom coverage at speeds up to the maximum of the specific sonar model. The Model 5500 having a maximum speed of 10 kt at 150 m ranges. This capability is achieved while maintaining the specified along-track resolution. As a consequence of the use of multiple sonar beams, the Series 5000 sonars can produce up to five times the data of an unfocused, single-beam, side scan sonar at significantly higher area coverage rates.

At slower speeds, the sonar beams are controlled to maintain equally spaced, contiguous beam placement, so that the sonar maintains 100 per cent bottom coverage. The use of multi-beam side scan sonar increases the image quality and enhances the detection of small targets, while increasing area coverage rates over that available through the use of single-beam side scan sonars.



Series 5000 system viewer details (Klein Associates) 0058808

The transmitters are multiple channel, synthesised waveforms with independent phase modulation. The receivers are high-gain, ultra low noise units with digitally controlled TVG ±0.5°. Data is transmitted up the tow cable via a high-speed digital telemetry link, requiring only a single coaxial or fibre optic cable.

The Series 5000 sonar systems have been designed for operation from a tow cable, permitting the towfish (transducer) to be towed in the vicinity of the sea bottom for optimum resolution and for the avoidance of environmental interference. However, for shallow water operations, Series 5000 sonars can be hull mounted and maintain operational capabilities in water depths as shallow as 2 m.

A Series 5000 high-speed, high-resolution, dynamically focused multibeam side scan sonar system consists of the following elements:

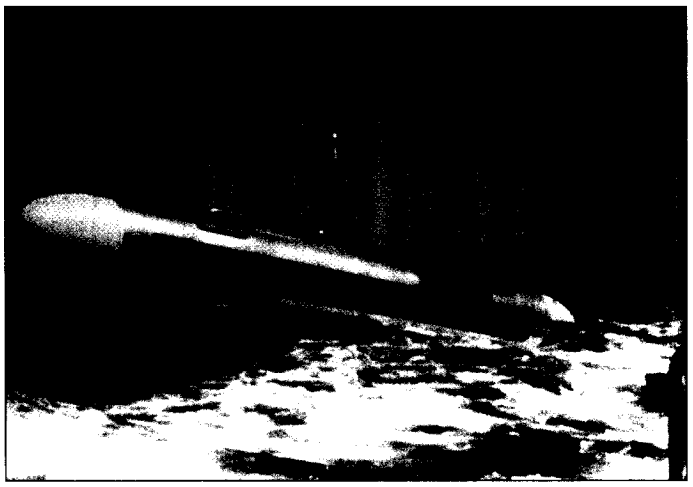
- variable depth sonar transducer (towfish)
- transceiver processor unit
- display and control unit computer

The stainless steel towfish for the Model 5500 nominally weighs 70 kg, permitting operations from small research and survey vessels without impact on vessel performance or sea worthiness. The towfish incorporates two multichannel acoustic arrays and a pressure canister, which houses the electronics and sensors necessary for sonar data acquisition, attitude sensing, system control and telemetry.

The surface units consist of:

- transceiver processor unit
- control and display computer with 17 in video monitor

These are available in a rack-mounted configuration.



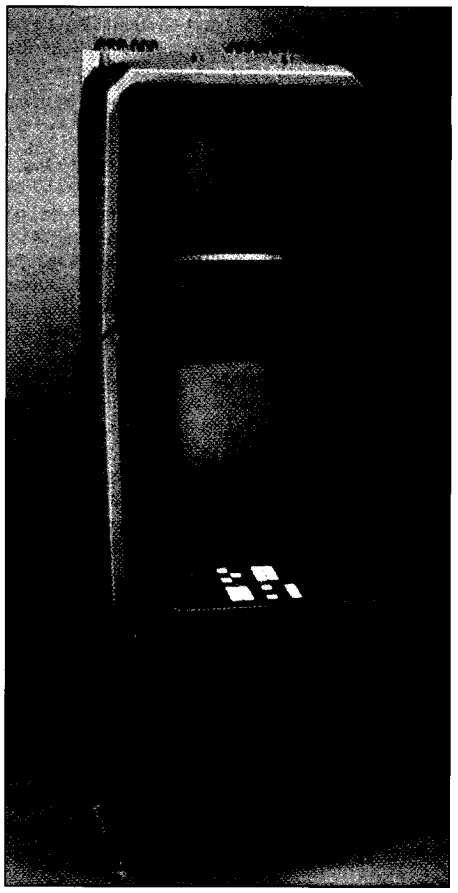
Series 5000 towfish (Klein Associates) 0011318

Operational status
The Model 5500 systems are in production and available off-the-shelf for immediate ocean operations. Series 5000 high-speed, high-resolution multibeam side scan sonar systems are currently in use in navies around the world for MCM and hydrographic applications.

Specifications
Model 5500 five-beam sonar
Length: 1.94 m
Diameter: 15.2 cm
Number of channels: 24 (12 on each side)
Number of beams: 10 (five on each side)
Operating frequency: 455 kHz
Pulse length: 50 to 200 µs, operator selectable
Range: 50-150 m (in four steps)
Resolution (along track): 20 cm to 75 m, increasing to a maximum of 6 cm to 150 m
Resolution (across track): determined by selected pulse length
Transducer tilt angle: 20° (from horizontal)

Contractor
L-3 Communications Klein Associates, Inc, Salem, New Hampshire.

UPDATED



Control/display unit of the SH 100 minehunting sonar

SH 100

Type
Mine detection and classification sonar.

Description
The SH 100 mine detection and classification sonar is an active, dual-frequency, high-resolution sonar designed for hull mounting on coastal or inshore minehunting or minesweeping vessels. The operational capability of this very compact sonar is from the amphibious landing zone out to depths of 100 m for detecting and classifying bottom mines and beyond that for detecting moored mines. The SH 100 is an extension of the single-frequency SA 950 mine avoidance sonar (see SA 950 entry).

The transducer arrays are mounted on a fully retractable hull unit which is mechanically stabilised against roll, pitch and yaw. With the stabilised array, reliable detection and classification performance is maintained even in severe conditions.

The SH 100 design uses hybrid preamplifier circuits to maximise performance and reliability while reducing the size, weight and cost of the total system. The signal processing, including beam-forming, is performed in a fast digital signal processing system using the full dynamic range of the signals.

The SH 100 operates at 95 kHz (LF detector) and 335 kHz (HF classifier) and has a sectoral transmission and multibeam reception covering an LF sector of 45°, with 32 beams of 1.4°, and an HF sector of 16° with 64 beams of 0.25°. Vertical coverage is 10°. The sectors, which are aligned along the same axis, are mechanically trainable (±200°) and tiltable (+10 to –90°).

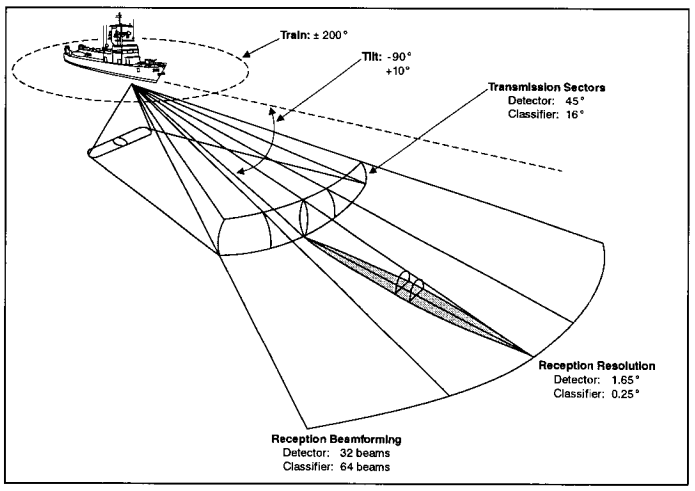
The selection of the two frequencies is optimised for the separate tasks of detection and classification. Extensive test and application results from a range of sea environments have proved this sonar's ability to consistently detect bottom and moored mines at a range of 600 m and classify at a range of 200 m. Mine detection with the SH 100 has been demonstrated at ranges greater than 1,000 m.

The sonar can operate on both the LF detection and HF classification frequencies simultaneously. Signal enhancement and display techniques, such as shadow mode normalisation, FM pulse compression, ping-to-ping filtering, echogram detection and zoom, can be applied separately to each frequency. This allows the sonar operator to optimise system performance for the specific mission task. The following operational modes are available:

- wide sector search and target acquisition using only the LF mode
- high-resolution classification and precise localisation using only the HF mode
- combination of LF and HF on alternate transmissions
- vertical positioning of the transducer for moored mine classification and depth measurement.

The SH 100 sonar consists of a hull unit, preamplifier, transceiver, servo control unit, servo transformer unit, and a control and display unit. The basic configuration includes software and hardware interfaces to Doppler speed log, gyrocompass, roll and pitch sensor, and surface navigation systems. Simrad can deliver the SH 100 as a stand-alone system which includes these additional sensors and power units if required. Interfaces to buyer-supplied combat systems for transferring target data or the full sonar image data can be readily adapted.

The control and display console includes two high-resolution 20 in RGB monitors mounted one above the other. The lower monitor displays the sonar echo image while the upper one displays tactical information. The echo display presents the sonar image in B-scan and/or echogram modes. The tactical display presents a map-like image of the sonar situation including the ship symbol and past track, target positions and classifications, LF and HF sector coverage, and tilt and train graphics. Additional tactical data displayed include the ship data such as position, course and speed, and target positions (both relative and geographical). The simple MMI provides access to all the primary controls with the buttons and joysticks on a control panel. Secondary commands are accessed through an on-screen menu.



SH 100 mine detection and classification sonar

Enhancements to the basic configuration are available providing data distribution to multiple locations on the vessel, recording of target database, sonar image printing, and more powerful tactical and navigational functions. The sonar can also integrate with other Simrad systems such as: vessel control system; Electronic Chart Display and Information Systems (ECDIS).

Operational status
Five systems in service.

Contractor
Kongsberg Maritime Inc, Lynnwood, Washington.

UPDATED

MINE WARFARE LASER SYSTEMS

International

Hawk Eye

Type
Light Detection And Ranging (LIDAR) mine detection system.

Development
Hawk Eye is a laser-based scanning LIDAR that is primarily used by the Swedish Navy for ASW applications in shallow waters and bathymetry. Consequent on this is a developing interest in the application of the technology for mine hunting operations.

Under a collaborative venture, Germany and Sweden carried out joint sea trials in September 1999 with the aim of detecting small objects using the Hawk Eye system. Sweden managed the LIDAR experimental set up and helicopter flights, while Germany performed the ship-based experiments and environmental measurements, which included acoustic seabed mapping, turbidity measurements and the characterisation of the sea state, using a drifting air-sea interaction buoy.

Description
The Swedish Hawk Eye scanning laser system used for the trials was an Nd:YAG laser that was frequency doubled, and emitted radiation at 532 (green) and 1,064 nm (IR) wavelengths. The pulse length was 7 ns at a repetition frequency of 200 Hz.

While the IR beam in the LIDAR system is reflected by the sea surface, most of the green light penetrates the surface, the depth of penetration depending on the sea surface condition and the water attenuation coefficient. The two optical beams are transmitted simultaneously and coaxially with the beams being swept by a scanning mirror in a semi-arc pattern with a nearly constant angle of about 20° relative to the vertical.

Reflection of the IR pulse from the water surface is detected by an optical receiver located at the laser source and is used for land/water discrimination and to measure the distance from the sensor to the water surface. The green pulse is partially transmitted through the water, the receiver detecting its reflection from the bottom later. The detection of the green light is divided between a sensitive photo-multiplier tube and an avalanche photo diode. The field of view can be varied between 15 and 50 mrad. The depth of an object is determined by measuring the elapsed time between receiving the IR and green return signals. This depth value is subsequently corrected for geometric and environmental effects. The optical receiver features a telescope, beam splitters, filters, field stops, and detectors.

Real time processing permits the presentation of depth sounding data during flight, the time interval between surface and bottom echo being used as an estimation of depth. For the present, however, the detection of small objects requires land-based post processing.

For the trials, a beam diameter of about 1 m at the sea surface was used, with 1 m distance between each sounding and a swath width of 50 m. Using these figures a search rate of around 0.5 km^2 was achieved. Depth penetration and echo reflection is strongly dependent on the water quality – suspended sediment in the water results in backscattering, and floating organic matter such as algae absorbs the green light. In the trials in the Baltic, this limited sounding depths to about 12 to 15 m. From these results, it was found that a 1 m^3 cube on the seabed could be detected down to around 10 m in the Baltic, with a probability of detection of about 95 per cent.

Depths, or underwater objects, are detected in real time and displayed to the system operator, together with navigation information. The operator display also includes a real time display of already surveyed areas, depicted as swaths of colour-coded depths.

Operational status
Trials were conducted in the Baltic in September 1999 and proved that Hawk Eye is capable of detecting anchored mines depending on the environmental conditions. The detection of seabed mines, however, is restricted by the limited pulse repetition frequency and depth resolution. Classification and identification is not effective, but could be improved by more advanced detection algorithms, shorter laser pulses and faster imaging detectors.

Nevertheless, the system could provide an important element in Rapid Environmental Assessment (REA) because of its flexibility in operation.

Contractor
Optech Inc, Toronto, Ontario, Canada.

UPDATED

United States

AN/AES-1 (ALMDS)

Type
Airborne Laser Mine Detecting System (ALMDS).

Development
Currently in engineering and manufacturing development under a contract awarded in April 2000 and due for completion in January 2005. The technology is aimed at providing self-protection for a battle group when transiting choke points and confined straits, as well as providing rapid reconnaissance in support of amphibious operations.

Description
The ALMDS AN/AES-1 is designed to be carried in a pod mounted under the fuselage of a CH-60S Knight Hawk helicopter for the detection and localisation of drifting/floating and shallow water (down to about 15 m) tethered mines. The system is designed to gather data during a single high-speed pass covering a wide swath.

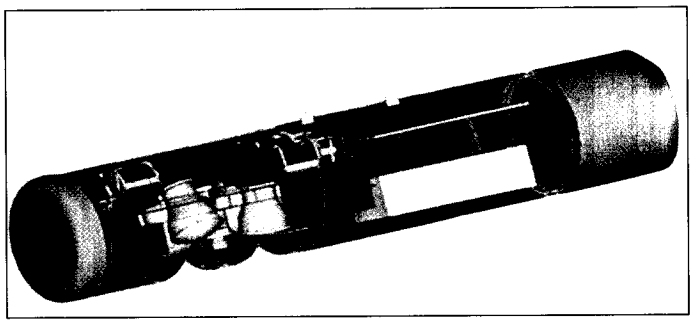
The AN/AES-1 incorporates a LIght Detection And Ranging (LIDAR) sensor using a scanning laser of the blue-green type, operating on a wavelength of 532 nm, pulse duration of 9 ns and pulse rate of 100 Hz. The technology for this has been developed by Areté Associates and is based on their STIL (Streak Tube Imaging LIDAR) technology. In this, a pulsed laser transmitter and a time-resolved streak tube receiver provide high resolution (1.25 cm) images in three dimensions enabling mines to be automatically detected and classified in turbid conditions at high search rates.

The laser will generate a topographical map of the seabed together with computer-enhanced imagery of detected mines. The image will show the shape, size and location of any detected mines.

Operational status
Under development. The initial technical and operational evaluation system is scheduled for delivery in July 2003 with production due to commence in 2004.

Contractor
Northrop Grumman Corporation, Integrated Systems and Aerostructure, Dallas, Texas.

VERIFIED



Schematic of AN/AES-1 (Northrop Grumman) 0095681

ATD-111 LIDAR

Type
Airborne light detection and ranging (LIDAR) system.

Description
The ATD-111 airborne LIDAR system is under development for the US Navy to detect and classify underwater threats, primarily submarines and mines. The system is a stabilised scanning laser unit mounted aboard a SH-60 Seahawk helicopter.

The ATD-111 uses a self-contained solid-state laser mounted in a pod. The operator control unit provides detection information, images and maps in GPS co-ordinates on a flat panel colour display.

Operational status
In development. The ATD-111 is currently undergoing upgrades for future testing to explore the potential of active laser-based technology to achieve superior mission capability in shallow water.

Contractor
BAE Systems North America, Information and Electronic Warfare Systems, Nashua, New Hampshire.

VERIFIED

LS-4096

Type
Active laser line scan underwater imaging sensor.

Description
The LS-4096 is a synchronous optical scanning system for two-dimensional reflectance maps of seabeds and submerged objects. A visual image of scanned objects, which can have a resolution as high as 4096 points across a 70° field of view, is obtained by displaying reflectance data on a high-resolution CRT monitor.

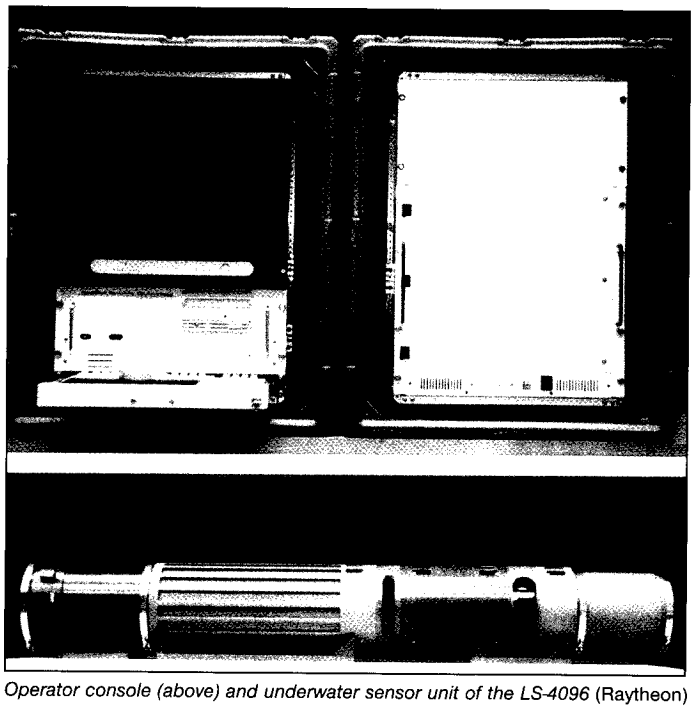
The system uses a diode-pumped solid-state frequency doubled Nd:YAG laser as a light source. The laser produces approximately 200 MW of light at a wavelength of 532 nm (green). Optical reflectance data are digitised in the sensor with 14-bit dynamic range and transmitted to the surface control console via a digital fibre optic link.

The surface console comprises two modules: a real-time processor and a display processor. The real-time processor compresses the dynamic range of the raw video signal while performing other signal processing functions and then transmits data to the display processor. The display processor presents processed reflectance data in a visual format and provides the operator interface as a graphic overlay. Unprocessed digital data can be stored on a conventional magnetic hard disk, a removable magneto-optical disk, or a high-capacity digital tape.

Operational status
In service with the US Navy's Coastal Systems Station, Panama City, Florida, for subsea mine reconnaissance applications. Commercial versions in service with offshore survey companies in association with SubSea Survey of Aberdeen, UK.

Contractor
Raytheon Company, Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

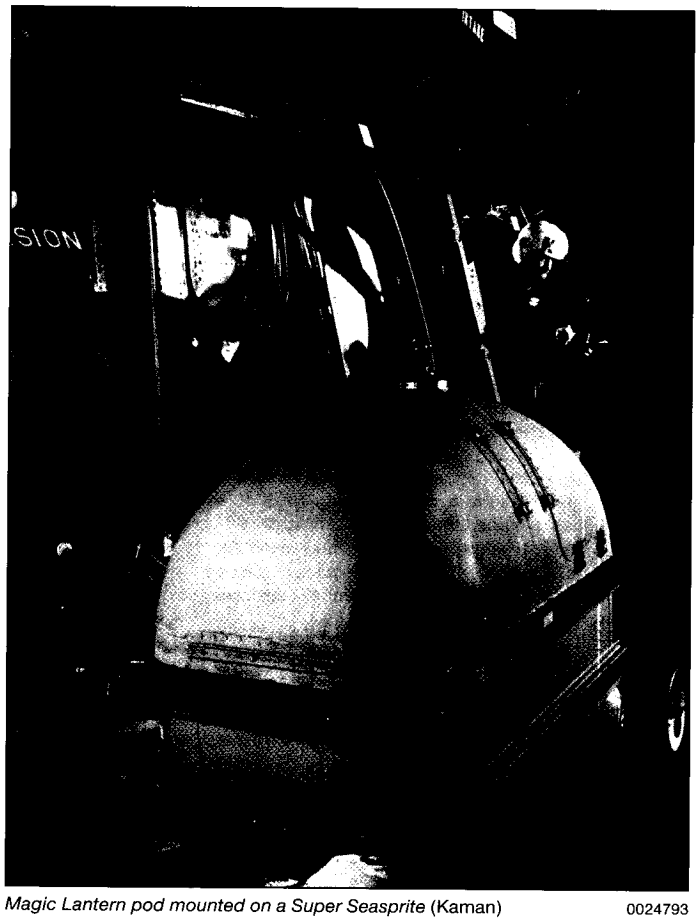
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Operator console (above) and underwater sensor unit of the LS-4096 (Raytheon) 0089217

Magic Lantern

Type
Laser-based minehunting system.



Magic Lantern pod mounted on a Super Seasprite (Kaman) 0024793

Development
The laser-based Magic Lantern mine detection system underwent initial evaluation trials in 1988, where it was used to find, classify, and locate sea mines under real conditions. Subsequent to successful trials, an advanced version of the system was deployed aboard US Navy helicopters and used during the Desert Storm Operation. Three systems have been built and are known as the Magic Lantern Deployment Contingency ML(DC). Incorporating a GPS system, ML(DC) can detect and precisely locate sea mines. The system includes an automatic target recognition capability and multiple receivers to focus on many depth levels simultaneously. The systems are undergoing a conversion to be compatible with the MH-53E helicopter as part of the Navy's Airborne Mine Countermeasures Supporting Force concept.

Description
Magic Lantern uses a neodymium-YAG blue-green laser linked to six intensified charge-coupled device cameras to detect mines at different depths. The system pulses the laser into the sea and pulse-timing generators electronically open the shutters of the cameras to allow them to receive a return of laser energy from preselected depths. Objects that break the laser beam at those depths appear as reflections. Energy reflected from the mine is detected by any of six highly sensitive electronic image-intensified cameras and a scanner. The scanner provides increased area coverage by moving the beam across continuous swaths of water perpendicular to the aircraft's flight path. The unique feature of the cameras is that they are able to distinguish reflected energy returned from below an object, such as a moored mine, and to produce a shadow image of that object. The received image is automatically catalogued, analysed and stored in the system's memory. It is also available for real-time analysis by an operator.

The system is mounted in a 4 ft long pod mounted on the helicopter's fuselage.

An adaptation of Magic Lantern has been demonstrated as part of a US Navy programme for mine detection from the high water mark on the beach out to 12 m water depth in advance of amphibious operations.

Operational status
The system is no longer in production or maintained or supported by the manufacturer. The systems are assigned to the Commander, Mine Warfare Command in Corpus Christi, Texas as contingency assets. Integration and flight demonstrating of the system on an MH-53E helicopter commenced in late January 2002. Three systems have been reconfigured for use on MH-53E helicopters and have been delivered to the US Naval Sea System's Coastal Systems Station. Eight SH-2G Seasprite helicopters of the US Navy Reserve Squadron HSL-94 have been modified to carry Magic Lantern.

Contractor
Kaman Aerospace Corporation, Electro-Optics Development Center, Tucson, Arizona.

UPDATED

SM 2000

Type
Laser line scan underwater imaging sensor.

Description
The SM 2000 laser line scan system (which can be used in a stand-alone configuration or integrated into the AN/AQS-14A(V)1 minehunting sonar) utilises the latest high-power solid-state laser technology to provide high-resolution optical imaging while consuming less than 100 W continuous operating power. The system comprises an underwater unit and a command and control console mounted in the surface platform. The sensor unit consists of a bottle containing the Argon ion laser illuminator, scanning optics and photo multiplier tube sensor assembly. It provides an optical image of objects on the seabed, through water, with ranges up to 38 m, travelling at speeds of up to 10 kt. The laser scans the bottom with a narrow pencil beam as it moves forward, while a narrow instantaneous field of view receiver is synchronously scanned to detect light reflected from the spot and to provide a waterfall display on a high-resolution monitor. It can resolve objects as small as 0.3 cm at a distance of 7.5 m through turbid waters. The 532 nm wavelength of the laser is near the maximum bandpass for seawater and hence signal attenuation is low. For daytime operation nearly all the ambient light is filtered out while still allowing the laser light to reach the detector. The digital images can be pieced together with computer software to provide a comprehensive picture of a large ocean floor area. The system can be linked to a GPS to provide precise navigation and relocation of objects on the seabed. For daytime operations, virtually all ambient light is filtered out and rejected whilst still allowing the laser light to reach the detector.

The SM 2000 can be used for various commercial survey, environment, research or military applications such as minehunting and mine identification. Mine identification, determining which underwater objects detected by sonar are mines or other objects, can save considerable time during an MCM mission.

In the Summer of 1996, the SM 2000 was used by the US Navy to identify sections of the aircraft flight TWA 800 that crashed in the Atlantic Ocean off Long Island, New York. The SM 2000 laser line scan system was deployed from a surface craft in about 30 m water depths. The laser was prepared and provided by the navy in only two days after Northrop Grumman was asked to assist in the search and salvage effort.

Northrop Grumman has integrated the SM 2000 into its AN/AQS-14A to provide positive target identification.

Operational status
In production as commercial or military undersea sensor. Forms part of the AN/AQS-14 sonar system.

Specifications
Dimensions (commercial)
Length: 1,752 mm
Diameter: 279 mm
Weight: 163 kg (dry)

Operating parameters
Operating depth: 1,525 m
Survey swath width: 3-61 m with 15-70° swath width (user adjustable)
Operating range: 2.5-38 m (depending on water turbidity)
Resolution: 0.3 cm @ 7.5 m, 1.2 cm @ 30 m
Laser wavelength: 200-400 mW, Nd:Yag @ 532 nm (green)
Power consumption: 100 W steady state (250 W max)
Speed of operation: 0.5-6 kt

Contractor
Northrop Grumman Corporation, Electronics Sensors and Systems Sector, Oceanic and Naval Systems, Annapolis, Maryland.

VERIFIED

UNDERWATER VEHICLES

Introduction

The task of Mine CounterMeasures (MCM) is becoming ever more difficult as mines become more sophisticated. It is now recognised that Mine CounterMeasures Vessels (MCMVs) must remain well outside the danger zone of any potential mines. Dealing with the modern influence mine is an extremely complicated affair requiring a very careful approach. Once an object has been detected and classified as a mine by a minehunting system it has to be neutralised. In the past this highly dangerous task was accomplished either by the MCMV itself — an operation of considerable danger to the ship — or by clearance divers operating from inflatables carried by the MCMV.

Ever since the Second World War, shallow water minehunting has been carried out using hull-mounted minehunting sonars on the MCMV. These sonars were designed to scan ahead of the vessel searching for, detecting and classifying objects at what was then considered to be a safe distance ahead of the ship. However, because of the position of the sonar in relation to the seabed (the angle of incidence of insonification) and the problems of acoustic propagation near to the surface where thermal layers can create barriers to the sound propagation, these sonars were really only effective in depths down to about 100 m.

To overcome some of the problems associated with hull-mounted sonars, and in particular for operation in deeper water where mines began to be laid, the Variable Depth Sonar (VDS) was developed. This allowed the sonar to penetrate the inhibiting thermal layers, and to be placed much closer to the level of the potential target. However, the VDS is limited by the fact that being a towed body it necessarily trails in the water, a characteristic which increases with the vessel's speed and the depth of immersion of the body. The towed body could therefore finish up quite some distance behind the towing platform, placing the latter in a vulnerable position in relation to the danger zone of any mine. To overcome this limitation necessitated the sensors having improved detection and classification ranges. These characteristics could only be achieved by using a lower frequency, which in turn resulted in loss of resolution and contrast, features essential in minehunting.

Using technology originally developed for the offshore industry, a range of underwater Remotely Operated Vehicles (ROVs) has been developed to undertake mine neutralisation tasks. The advent of the ROV has given MCMVs used on MCM tasks a much greater flexibility of operation. Using the ROV, MCM operations can now be carried out under much more adverse conditions than would have been the case if only mine clearance divers from the MCMV were available. Moreover, the operation itself is completed more quickly and there is greater certainty of success without the risk of loss of life, or damage to the ship.

As the safety and efficiency of minehunting platforms is now regarded as a high priority, so the sensor used to detect mines must realise greatly improved performance characteristics. One of the technologies now being examined by a number of navies to overcome the limitations of both the hull-mounted and Variable Depth Sonar (VDS) and the limitation of current ROVs in the face of modern mines, involves deploying an ROV fitted with a highly sensitive minehunting sonar some considerable distance ahead of the parent MCMV platform. This is often referred to as the 'dog-on-lead' principle.

To carry out its role effectively the underwater vehicle must be capable of fulfilling a number of functions, the most important of which are: the ability to approach an object classified by the MCMV sonar as a possible mine target without the possibility of triggering the target and so endangering itself and the MCMV; to carry onboard sensors and relay data back to the MCMV for further evaluation of the target; on positive identification it must carry out a neutralisation attack under remote control (to lay a mine destruction charge near the mine).

In addition to these requirements, the vehicle must be capable of operating in a wide variety of environments ranging from shallow to deep water, sandy to rocky bottoms, clear water to very muddy water, and low or high sea states, in all areas of the world.

To develop an underwater vehicle to carry out the tasks outlined above in such a hostile environment requires the highest degree of technological development covering a wide range of disciplines such as mechanical and electrical engineering, metallurgy, computer technology, hydrodynamics and so on. It is not surprising, therefore, to find that firstly there are very few companies in the world involved in developing underwater vehicles for mine warfare and secondly that they and the equipment carried by the vehicles are at the forefront of technology.

An idea of the magnitude of the problems facing designers of underwater vehicles can be gauged from some of the following features which must be attainable in any such designs. Namely: they must be easy to handle, deploy and recover from the water, even in adverse weather conditions; the operator in the MCMV must be able to guide the vehicle to the target in the shortest time possible; the vehicle must be capable of allowing the operator in the MCMV to carry out positive identification of the target; to carry out its role effectively the vehicle must not generate any form of signature (magnetic, acoustic or pressure) which might trigger a mine; the vehicle must be extremely manoeuvrable, particularly at virtually zero speed in all planes, in order that the operator can carry out detailed inspection of the target.

To meet these criteria, underwater vehicles all exhibit similar characteristics but differ in specific details. Thus, all are constructed of non-magnetic materials with a hydrodynamic shape and are capable of carrying some form of countermining charge. Propulsion systems do differ but are usually either electric motor or hydraulic drive. Some form of sensor must be carried. In the past this has often been only a TV camera, but in the presence of limited visibility and for positive identification it is now recognised that to be fully effective the vehicle should also mount a small, high-resolution sonar.

Until recently the vehicle has been connected to the MCMV by some form of umbilical link through which the operator can control the vehicle's movements, and via which the data gathered can be sent back to the MCMV. This requires that on the MCMV the operator's console should possess a TV monitor, PPI presentation of the vehicle's movements, some means with which to control the movement of the vehicle (usually a joystick), and presentation of the vehicle's sonar data. Alphanumeric tote display for data from the vehicle is also advantageous.

Generally, operation of underwater vehicles entails the operator guiding it down the beam of the MCMVs sonar to the vicinity of the target. When a satisfactory range is reached the operator switches on the vehicle's own TV camera and sonar and guides it onto the target. Once in close proximity to the target, the operator manoeuvres the vehicle around the target at very slow speed and close range. Having carried out a detailed examination of the target the operator manoeuvres the vehicle to a suitable position near the target and sends a coded signal to release the countermining charge. The vehicle is then recovered and the charge detonated by coded signal or time delay fuze.

Usually, underwater vehicles can only carry out one mission, as most are unable to carry more than one countermining charge. Furthermore, they usually only have sufficient onboard power for one mission.

Mine development continues to advance and new technologies are now being incorporated into future generations of underwater vehicles making them far more autonomous, enabling the parent vessel to stand off at much greater distances from danger areas, allowing the vehicle to carry out search, location and identification, tasks previously carried out by the MCMV relaying data back to the parent vessel via RF link instead of through an umbilical.

Unmanned Underwater Vehicles (UUVs) will continue to be developed for mine detection and classification. UUVs, according to the NATO MO2015 study (a long-term mine warfare study), will be 'pivotal' to the future of MCM. The ultimate objective for the underwater vehicle must be to develop a system that can carry out the primary functions of detection, classification and possibly localisation, all within the body of the vehicle, which will mean that just the result will need to be relayed back to the mother ship.

The limited bandwidth connectivity between UUVs and the mother ship demand that such a capability be developed, if the concept of using underwater vehicles to scout ahead of carrier battle groups and amphibious forces to seek or create mine free passages, is to be at all effective.

Such a concept also demands a low-cost, fire-and-forget, mine destructor vehicle capable of navigating itself to the localised position of the mine whether it is buried, tethered or lying on the seabed, and then effectively self detonate in order to render the mine ineffective.

This creates a paradox, for while the expendable mine destructor has to be low-cost, it must incorporate within its body adequate intelligence and autonomy for it to successfully complete its task, which requires sophisticated, expensive technology.

Apart from MCM the other major role that will be assigned to UUVs in the future will be ISR (Intelligence, Surveillance and Reconnaissance) missions, particularly in advance of amphibious operations. Inherent in this role will be the need to encompass a wide range of disciplines requiring highly sophisticated and compact technology. Thus, concepts such as rapid environmental assessment, ocean modelling, coastal dynamics, inshore topography, oceanography and climatology related to the shallow water zone and their effect on this region, and so on will be embodied in UUVs with the requisite sensors, for example to collect data on depth, temperature, salinity and currents. Unlike previous vehicles, this new breed of UUVs will operate in a completely autonomous fashion as AUVs; there will be no umbilical to link between the vehicle and the parent platform, and they will be programmed to carry out their specific task before launching. However, when satisfactory underwater communications links have been developed, the operators on the parent platform will be able to communicate with the AUV allowing it to be reassigned to a new task or area of operation.

Various vehicles capable of meeting some of the requirements outlined above are now under study and development, and some will shortly begin to enter service.

Other important tasks which Autonomous Underwater Vehicles (AUVs) will be used for include rapid route survey and to provide organic MCM for high-value surface platforms and submarines, to warn the platform if it is heading into dangerous mined waters. This is now becoming an increasingly important area for development. These AUVs will also be used to deploy and control small one-shot mine destructor vehicles. The use of such concepts will considerably speed up operations and overcome the problem of sending vulnerable MCMVs into hostile areas to ensure mine-free routes for high value platforms. Included in these MCM roles are that of pathfinder missions in which the UUV will be used to inspect and identify mine free routes for shipping.

While much of the current development effort is concentrated on MCM and ISR, a further important role for the AUV will be the carriage and deployment of weapons. Ultimately such a role may be carried out fully autonomously, but for this to be successfully achieved the AUV will have to demonstrate that it is completely reliable under sustained operational conditions. It would be a disaster if an AUV was deployed on a mission carrying mines, torpedoes or any other military payload and for it to get lost, or stranded.

Another developing role for underwater vehicle operation comprises the use and maintenance of fixed seabed installations such as deep ocean surveillance systems designed to detect and track deep-diving submarines. Underwater

vehicles are increasingly being used in this area. They also offer an enhanced capability in operating fixed seabed ranges for determining a ship's acoustic and magnetic signatures, degaussing and in underwater weapon trials and so on. Here too, the underwater vehicle can be an extremely valuable tool for weapon recovery. Finally, it will become an invaluable tool for the hydrographer assisting in seabed surveys, and recovering seabed samples for analysis.

These AUVs all require a highly capable communications system if they are to be effective in their role. Tactical data gathered by AUVs will be critical to future battle group operations, data that can be shared by all platforms. This requires systems to be capable of high data rate with a low error rate within each stream of data being transmitted. This can be achieved in two ways:

- by reducing the amount of data to be transmitted which will require an increased amount of preprocessing aboard the AUV and then for the preprocessed data to be compressed and
- by increasing the transmission data rate from around the current 1 kbps at 1 km to around 30 kbps at 5 km.

These requirements pose some technological problems, which are currently being addressed using coherent processing and adaptive equalisation techniques.

It is not only communication problems that have to be solved. For the AUV to be successful in its mission, be it MCM, ISR, weapon delivery or whatever, it must be able to accurately navigate itself within the underwater battlespace. Inertial navigation systems will not provide the accuracy required by future AUVs. The AUV will have to have some form of external reference, and at present this is the global positioning system, which in time of hostilities will most probably be denied to the AUV. Without recourse to such external references, covert AUV operations will be vulnerable to time and distance errors. This problem is currently being addressed using non-traditional approaches such as the integration of different motion sensing systems with feature recognition and terrain comparison techniques, such as are used in land attack missiles. Other technologies under consideration include systems that do not require pre-existing underwater maps or feature data.

UPDATED

Table XXIV

ROV inventory

ROV	Manufacturer	Role	Optional equipment	Status/In service
AN/SLQ-48	Raytheon Company	MH/mine destruction	Sonar, TV camera, cutter, MDC	Japan, US
Archerfish	GEC-Marconi	Mine destruction	Sonar, TV camera, shaped charge	In development
Dolphin AUV	ISE	Survey/research/MH	Sonar	Canadian Hydrographic Service, France US, ISE,
Double Eagle	Bofors Underwater Systems AB	MH/mine destruction	Sonar, TV camera, MDC	Australia, Denmark, France, Sweden.
ERATO	DCN International	Weapon recovery	TV camera, manipulator	France
Hyball	Hydrovision	Inspection	TV camera, SIT camera, lights	Germany, Philippines, UK
MIN Mk2	SMIN Consortium	MH/mine destruction	Sonar, TV camera, MDC	Italy
Minesniper	Simrad	Mine destruction	TV camera, shaped charge	Norway
MUST Lab	Lockheed Martin	Research	Various	
PAP	ECA	MH/mine destruction		Croatia, Estonia, France, Greece, Indonesia, Japan, Latvia, Lithuania, Malaysia, Netherlands, Pakistan, Saudi Arabia, Singapore, South Africa, Turkey, UK, Serbia and Montenegro
Phantom	Deep Ocean Engineering	MH/mine destruction	Sonar, TV camera, manipulator, MDC	Australia, Brazil, New Zealand, Portugal, Sweden, Singapore, UK, USA
Pinguin	STN ATLAS Elektronik	MH/mine destruction	Sonar, camera, MDC	Germany, Taiwan
Pluto, Pluto Plus, Pluto Gigas	Gaymarine	MH/mine destruction	Sonar, TV camera, manipulator, MDC	Egypt, Finland, Italy, South Korea, Nigeria, Norway, Spain, Taiwan, Thailand
Seafox	STN ATLAS Elektronik	Mine destruction		Germany, Sweden
Super SeaROVER	Benthos	MH/mine destruction	Sonar, TV camera, manipulator	US
Theseus	ISE			Canada

Note: MDC – Mine Disposal Charge

UPDATED

Australia

Wayamba

Type
MCM AUV.

Development
The Australian Defence Science and Technology Organisation (DSTO) is developing Wayamba in partnership with the Royal Australian Navy's (RAN's) Acoustic Mine Imaging (AMI) project and industry partner Thales Underwater Systems Pty Ltd. It is being developed to act as a testbed for various MCM technologies.

Description
The Wayamba (the aboriginal word for turtle) is of 'flat-fish' hydrodynamic form, with six thrusters and two planes for 6° of freedom manoeuvring control. In its initial form, it is configured as an ROV with electric power being fed down the cable, but will ultimately function autonomously. The 2.9 m long vehicle is powered by six thrusters, two rear-mounted main units, three vertical and one lateral, providing a maximum speed of 5 kt. As an ROV Wayamba is currently supporting research into power, control and navigation issues. In its planned AUV configuration, the vehicle will be used to test covert underwater navigation and communication technologies, autonomous docking with submarine platforms, delivery and recovery of adjunct vehicles, and co-operative operations.

An advanced power supply is currently being demonstrated and provides power up to 15 kW at the wet end via a 7.8 mm in diameter umbilical cable, which also contains four optical fibres. A self-docking system is currently undergoing model testing. During normal operation, it functions as a conventional two-part tow system, with a separate depressor unit and sonar towfish. The depressor contains a docking station that can receive the towfish, however, allowing the system to be deployed and recovered as a single entity. It is intended to be deployed behind an autonomous drone, using active surfaces for terrain-following, in applications such as mine surveillance, hydrographic survey and support of amphibious operations.

Its design depth limit is 600 m, but its operating radius (dictated by tether length) is presently restricted to 1 km. Control is exercised from a Pentium II PC via a fibre-optic link. The on-board navigation/sensor system consists of three-axis tilt meters, a magnetic flux gate compass, six-axis piezoelectric accelerometers, a laser-ring inertial motion unit, gimballed pencil-beam sonar and a low-light video camera. Experimental instrumentation includes a high-resolution phased array sonar, a gravity gradiometer, magnetic anomaly instruments and an acoustic communications transceiver.

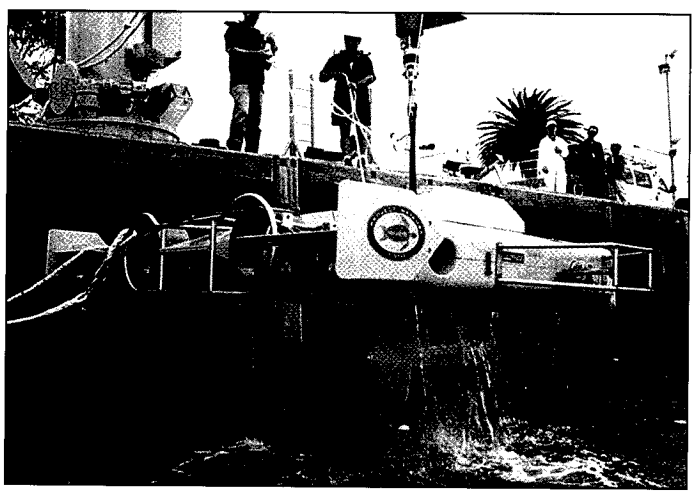
The DSTO has been using Wayamba as the platform for trialing an engineering prototype of AMI, a specialised high-definition sonar designed to provide a means of identification and high-resolution imaging of underwater mines that is unaffected by highly turbid waters. AMI exploits medical ultrasound technology, combined with a sparce aperture of miniature hydrophones and processing that permits instantaneous focusing at any point in the near field.

Operational status
Currently under development.

Specifications
Weight: 900 kg
Length: 2.9 m
Speed: 5 kt
Operating depth: 600 m

Contractor
Australian Defence Science and Technology Organisation (DSTO), Canberra.
Thales Underwater Systems Pty Ltd, Rydalmere.

UPDATED



The Wayamba research vehicle at HMAS Cerberus *conducting trials with the Fansweep 30* (DSTO, Australia) ***NEW***/0572597

Canada

Aurora

Type
Towfish.

Description
Development of the AURORA actively stabilised towfish commenced in February 1997. The vehicle design is modular, allowing the hull to accommodate a variety of wet and dry payloads of varying sizes. The vehicle consists of four pressure hull sections and a wet payload/sensor bay. Payload capacity comprises one 0.05 m^3 hull section for dry payload and a 0.025 m^3 flooded bay provides for wet payload. Rails on the bottom of the pressure hull provide additional wet payload capacity, 55 kg of combined wet and dry payload weight depending on the vehicle trim. Payload capacity is configurable with the addition of modular hull sections. Typical sensor payloads comprise: a Watson AHRS 303 gyro and heading reference system; Parascientific quartz depth sensor; EDO 3050 Doppler log for altitude and speed; and a Honeywell MAPS INU for velocity-aided inertial positioning.

AURORA has been designed with a large, actively controlled main wing to reduce cable length and scope. The large downforce created by the wing reduces the cable scope and layback, particularly with unfaired cables, enhancing the positional accuracy of the towfish. Active tail planes control towfish attitude and stability. The wings are easily removed for on-deck maintenance and storage.

Power for the various payloads is provided by 380 V DC or 460 V AC single-phase supplied from the surface PDU down the tow cable. Supervisory control of the vehicle is exercised from a surface console incorporating a PC running ISER's standard AUV user interface software. Communications link is through a 422 data stream down the tow cable. The towfish is fitted with a Motorola 68030 processor on a Gespac board/rack system running a real-time proprietary control system.

The AURORA towfish is designed to operate a speeds of up to 12 kt.

Specifications
Length: 3.3 m
Diameter: 39.6 cm
Overall height: 71.3 cm
Wing span: 2.53 m
Displacement: 465 kg (nominal)
Speed: 10-12 kt (under tow)
Operational depth: 460 m

Contractor
International Submarine Engineering Ltd (ISE), Port Coquitlam, British Columbia.

NEW ENTRY

Canadian minehunting system

Type
Remote minehunting system.

Development
Macdonald Dettwiler & Associates of Canada is developing the next-generation remote minehunting system which will have applications to all minehunting sonar sensors, as well as to shore-based facilities.

Canada has built 12 multirole Maritime Coastal Defence Vessels (MCDVs), one of whose key roles will be to provide the infrastructure for a remote minehunting system. Macdonald Dettwiler & Associates has developed the route survey module as part of the MCDV programme, having been awarded the contract for system integration. The concept involves the use of a sonar imagery map database of areas of the seabed which are susceptible to mining, showing the position of all known objects. Using this database as a reference, the MCDV can carry out a rapid survey of a selected area, comparing a new sonar image against one previously recorded, and from which any new object can be quickly detected and where necessary investigated. Such a concept will result in a significant reduction in the time required to monitor a route and neutralise any new mine-like objects which are detected.

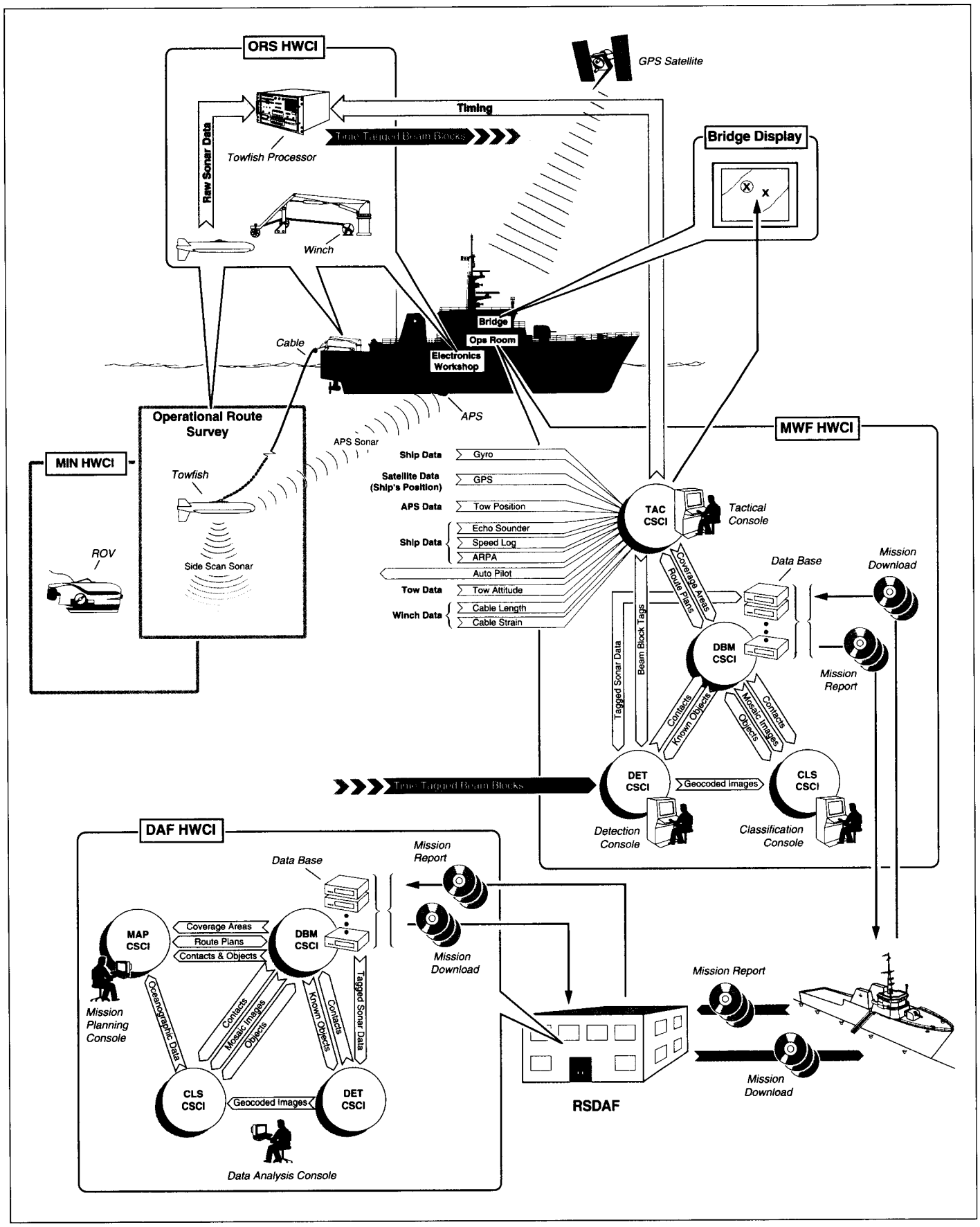
Using this system the MCDV can accurately position objects in a continuous sonar map database, geocoding and mosaicing the data. The use of this geocoded sonar imagery enables the MCM tasks of route survey, minehunting and neutralisation to be carried out independently, yet at the same time integrated by a single geographic database.

Description
The system elements comprise the MCDV, a shipboard mine warfare control system, the route survey sonar payload, the Remotely Operated Vehicle (ROV) and a mine warfare data centre.

For route surveying the MCDV will deploy a towed side scan sonar which will provide the necessary data to build up and maintain a sonar image of the seabed. During minehunting, a remotely controlled vehicle will tow the sonar and radio the sonar imagery to the ship's command and control centre. Mine neutralisation may be carried out by an ROV or expendable mine destructor.

The master databases are located in two mine warfare data centres, one on the east and one on the west coast of Canada. Each centre supports a squadron of MCDVs, providing post-mission data analysis, mission planning and maintenance of the database for route survey and all mine warfare related data for that coast.

Both the data centres and the MCDVs are equipped with common hardware and software. Operator consoles in each facility provide for mission planning, sonar data analysis and system/database management. The system also incorporates a large format plotter (for printing route plans and electronic charts) and online and



MCM sonar processing for the Canadian minehunting system

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

offline optical disc storage for the route survey database. Each MCDV features a permanently installed mine warfare control system comprising tactical MCM sensor positioning, data analysis and DataBase Management Subsystems (DBMS).

The tactical subsystem integrates all navigation sensor inputs and generates a local operations plot, based on electronic charts. These display own ship's position, sonar towfish position, radar contacts and mine warfare contacts. The data analysis subsystem includes Digital Equipment of Canada multifunction detection and classification consoles for the display and analysis of real-time and historic sonar imagery. The DBMS retrieves all sonar imagery and contacts from previous missions for display by the data analysis subsystem. As new objects are detected and classified they are stored by the DBMS.

The primary requirement for the sonar was that it should be capable of detecting buried ground mines, mines with anechoic coatings and irregularly shaped mines in conditions of high background clutter. The sonar operates at depths down to 200 m, close to the seabed to provide good object shadowing for accurate classification and avoiding thermal and salinity layers.

To meet these requirements, a multibeam side scan sonar has been selected. The array is housed in a hydrodynamically stable towfish body, incorporating active control surfaces for bottom following, and comprehensive position monitoring instrumentation. In the route survey mode the sonar towfish is stored in a standard 6 m ISO container module incorporating its own deployment crane and winch. During both launch and recovery the crane maintains positive control of the towfish, release and recovery taking place below the surface. The module can be installed on the MCDV within 12 hours.

The route survey inspection payload comprises the Aurora towfish complete with launch and recovery system. The towfish is electrohydraulically powered through an umbilical which gives it unlimited endurance. Manoeuvrability in three axes is provided by four thrusters. Sensors include a side scan sonar, colour and LLTV cameras. The towfish is monitored and controlled from the ship's command centre while deployed, its maximum operating depth being 300 m at a range of 600 m.

The vehicle designed to tow the towfish sonar for minehunting and radio sonar imagery to the ship is the Dolphin which has undergone extensive field trials. The diesel-powered vehicle can operate for up to 24 hours at a speed of 12 kt. In water, both drone and probe refuelling is possible to provide for extended duration operations. The vehicle's rough water performance allows it to remain operating when most small surface drones would be forced to return to harbour. The Dolphin has been launched and recovered without any in-water manned assistance in Sea State 5. A shipboard handling system enables the vehicle to be easily transported to out-of-area operations in force projection missions.

To carry out mine neutralisation a number of options are available including clearance divers, ROVs and expendable mine destructors. However, ROVs are expensive, and the risk to divers from today's sophisticated mine is considerable. In view of these considerations, much effort is being devoted to developing effective mine destructors. These are relatively inexpensive self-propelled weapons which can be guided to their targets by sonar, detonating in close proximity to the mine with both high hard and soft kill effectiveness.

The sonar payload is designed to operate down to depths of 200 m, close to the seabed. Resolution in classification mode is 12.5 × 12.5 cm. High area coverage rates dictate a speed of advance of 10 kt with a 400 m swath width.

The multibeam side scan sonar is carried by the hydrodynamically stable towfish body which incorporates active control surfaces for bottom following and comprehensive position monitoring instrumentation.

The geocoding and mosaicing technology applied to the sonar imagery has been developed by Macdonald Dettwiler & Associates using its expertise in surveillance satellite technology. Algorithms have been developed which automatically fuse geocoded imagery from sensors of different resolution into a single image. Geocoding is sensor independent and the technology can be used to enhance the performance of sector scan sonars and to integrate side scan sonar data with that of sector scan sonars.

Geocoding allows sonar imagery to be registered precisely to a chosen map projection and absolute geographic locations assigned to targets identified in the imagery. The sonar towfish ground speed, its position relative to the towing platform and the seabed, its roll, pitch and yaw, together with differential GPS and gyro navigational data are integrated into the geocoding process to position each pixel of sonar imagery in a geographic reference grid. Geocoding permits sonar images acquired during earlier missions to be compared with those of the present mission and changes detected semi-automatically.

Work in progress indicates that geocoded sector scan images may also be mosaiced, either for the purpose of building up a continuous map of the seabed or to smooth out background noise to improve the detection and classification range of the sonar.

Mosaicing is the process of combining swaths of geocoded imagery to create a continuous sonar image map database. Mosaicing fills in gaps in the sonar map with new mission data and discards duplicate imagery. The best data can thus be used to create the mosaic. Large areas which are in shadow from one aspect can be replaced by usable imagery acquired from a different aspect. The single mosaiced database is faster to access and the preparation of mission databases simplified.

Operational status
Four route survey modules have been supplied for the MCDVs.

Contractor
Triathlon Inc, Richmond, British Columbia.

VERIFIED

Dolphin

Type
Deep ocean unmanned semi-submersible.

Description
The air-breathing, diesel-powered, semi-submersible Dolphin is a UHF radio link remote-controlled vehicle which is similar to a small snorkelling submarine. The vehicle can be pre-programmed to follow a set course with waypoints, running autonomously. When running autonomously, the control radio can monitor mission progress. The vehicle's configuration allows for easy integration of towed and hull-mounted sensor equipment, and it features low-noise signature and sea-keeping qualities. Current sizes are in the range of 8 m in length with 150 to 300 hp installed power providing speeds of 15 to 18 kt. The vehicle trialled for the Kingston class (see under entry for the Dorado) was powered by a 350 bhp Caterpillar 3116TA diesel (273 kW), driving a 12-bladed contrarotating propulsor giving an operating speed in the region of 12 kt when towing a side scan sonar at a depth of 180 m. Under these conditions the vehicle has an endurance of 16 hours.

Dolphin is a stable instrument/sensor/radiator platform. The vehicle is capable of fulfilling a variety of missions requiring stability in high sea states, long endurance and high speed. Two missions which have been demonstrated are hydrography and minehunting.

To demonstrate the hydrographic mission, a multibeam hydrographic echo-sounder was installed in 1990. With accurate positioning from differential GPS, surveys can be conducted at substantially lower costs than those requiring the use of manned launches.

The second role for such vehicles is in MCM operations. These operations involve real-time transmission of water column and sea bottom mine-like contacts to a controlling platform, and provides battle groups and other seagoing formations with an organic minehunting capability. To demonstrate this mission, a cable winch, which could handle side scan sonar towfish, was developed in 1990-91.

A variety of sonar payloads can be carried for minehunting operations including: Klein 500 single beam side scan; AN/AQS-14 side scan; and Reson 6012 Seabat.

Operational status
To date, 10 Dolphin vehicles have been built, four of which are operated by the Canadian Hydrographic Service as survey vehicles in areas where high sea states preclude operations from manned launches. One of these has been outfitted with multibeam echo-sounder and differential GPS positioning capabilities.

Two other vehicles known as ORCAs were delivered to the US Navy in 1986 for evaluation. These now reside at Naval Research Laboratory (NRL), Stennis Space Center, MS, and are used as tactical oceanographic platforms. For this purpose they have been outfitted with the Simrad EM 100 or EM 950 multibeam echo-sounders.

Two more vehicles were delivered to the USN in 1988, and have been outfitted with a variety of mine-hunting sensors for evaluation. These vehicles are operated by Naval Coastal Systems Station (NCSS), Panama City, Florida. The most recent development was the conversion of one vehicle to the Remote Minehunting Operational Prototype (RMOP) in 1994. The RMOP vehicle was outfitted with a fleet MCM towed sonar, a cable winch complete with towfish handling/docking system, a high-bandwidth RF link for real-time transmission of sensor data, a precision GPS receiver, and hull-mounted forward-looking sonar. The command and control features were integrated with navy consoles, and installed into a standard military control van. The RMOP integration was a joint government/industry collaboration undertaken by NCSS, Rockwell AESD and International Submarine Engineering (ISE). It has been tested extensively and was operated from a combatant during an MCM exercise in March 1995, with good results.

In September 1996 Lockheed Martin was awarded a contract for further development of the RMOP and has modified the Dolphin vehicle with improved radio control, GPS navigation. Further developments incorporate synthetic aperture sonar with computer-aided detection and classification for buried mine detection and electro-optical sensors to aid detection.

The final two Dolphin vehicles are kept at ISER and are used for development and charter. They have been extensively tested for sea-keeping, towing capability, launch/recovery procedures, control strategies, and reliability. Much of this work has been conducted with Esquimalt Defence Research Detachment (formerly



The Dolphin unmanned semi-submersible aboard the trials vessel Researcher

Defence Research Establishment Pacific - DREP) for development of a Canadian Remote Minehunting System (RMHS).

A Dolphin fitted with a SeaBat sonar and AQS-14 sonar operating from the Spruance class destroyer *John Young* successfully supported a US amphibious exercise in March 1995, detecting target mines in the landing area. The vehicle was acquired as an advanced sensor suite to form part of the US Joint Countermine Advanced Concept Technology Demonstration (ACTD). This tested the capability of a joint task force to conduct land/amphibious mine detection and neutralisation in littoral warfare scenarios. The vehicle was used initially to tow advanced mine detection sensors, including a toroidal volume search sonar, side scan sonar, synthetic aperture sonar and a forward looking sonar.

Further trials of the Remote Minehunting System (RMS) were conducted from the US destroyer *Cushing* in the Persian Gulf early in 1997. The trials concentrated on testing the concept of detecting and classifying mines in waters ahead of navy battle groups. A production version of such a system is due to enter service in 2003 aboard Arleigh Burke Flight IIA class destroyers. The vehicle used in these latest trials was a derivative of the Dolphin built by Boeing. Testing of a third variant being developed by Lockheed Martin and carrying the same sensor suites as earlier variants took place in 1998. The third variant is planned for fleet service aboard DD 963s in limited numbers, interfacing with the SSQ-89. Full series production of the fourth variant is due in FY03.

In October 1996 a vehicle based on the Dolphin began trials for the Kingston class.

Specifications
(Base vehicle)

Length: 7.30 m
Diameter: 0.99 m
Weight: 2,832 kg
Speed: 12 kt continuous, 16 kt max
Endurance: 26 h @ 12 kt
Sea State: capable of sustained stable operations in Sea State 5
Propulsion: Sabre 212 turbocharged, intercooled marine diesel engine (rated at 150 shp)

Contractor
International Submarine Engineering (ISE), Port Coquitlam, British Columbia.

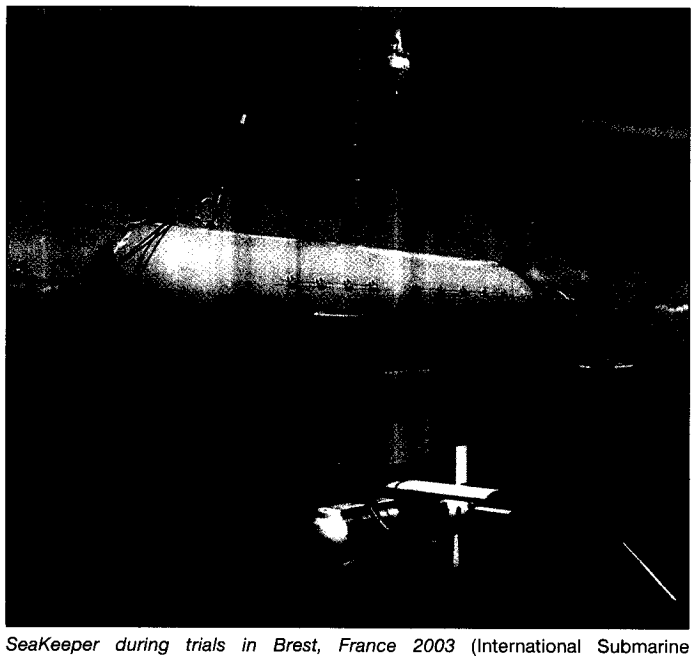
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Dorado

Type
Semi-submersible minehunting vehicle.

Description
The Dorado vehicle, owned by the Canadian Department of National Defence, was developed as a minehunting vehicle.

The Dorado is capable of towing a sonar towfish at speeds up to 12 kt and depths to 200 m. The vehicle is powered by a 315 kW Caterpillar 3126, 6-cylinder, after-cooled, turbocharged, marine diesel engine driving a contra-rotating propeller through ZF Marine 2.7:1 hydraulic reduction gear unit. Air is drawn through the mast and exhausted through the stabiliser mounted above the contra-rotating propeller. The engine also provides power for the hydraulically operated control planes and the keel-mounted winch for the sonar towfish. The hydraulically operated sonar winch is capable of spooling 475 m of 1.07 cm diameter electromechanical or electro-optical-mechanical cable.



SeaKeeper during trials in Brest, France 2003 (International Submarine Engineering) ***NEW***/1068324

Guidance and navigation is provided by a Boeing C-MIGITS IMU providing 50 Hz closed loop hydroplane control of depth, pitch, roll and heading. A Racal DGPS unit is fitted for providing position data.

Since the hull of the vehicle is deeply submerged, it has reduced drag compared to that of a surface drone and this allows it to operate at higher speeds over longer ranges than surface-based drones of similar size. As the mast is the only part of the vehicle to be affected by sea state, the vehicle is much more stable in waves than surface drones or small vessels. This stability allows high-quality side scan sonar records to be obtained in elevated sea states at high speeds.

Since the vehicle has a surface piercing mast, it is able to operate and transmit sonar data over a radio datalink, rather than a fixed umbilical or an acoustic telemetry link, permitting standoff ranges of up to 10 km from the MCMV. The mast also permits the use of DGPS for target positioning.

Command and control is exercised in one of three modes: manual, autopilot, or autonomous DGPS-based line-following between geographic waypoints. Guidance and navigation is managed using an IXEA Octans providing 50 Hz closed loop hydroplane control of depth, pitch, roll and heading.

Operational status
DCN International of France, is selling the Dorado vehicle as part of its Forward Deployed Side Scan Sonar (FDS3) system, known as SeaKeeper.

Specifications
Length: 8.23 m
Width: 2.28 m
Diameter: 1.17 m
Dry weight (fully fuelled): 5,900 kg
Fuel: 726 kg
Dry payload weight: 204 kg
Speed: 17.5 kt (12 kt surface/towing)
Endurance: 14 h @ 200 m depth with tow at 10 kt, 28 h without tow
Payload: ISE Aurora towfish, Klein 5500 sidescan sonar, 2.4 GHz data radio, Reson 8125 multibeam echo sounder

Contractor
International Submarine Engineering Ltd (ISE), Port Coquitlam, British Columbia.

UPDATED

HYSUB ATP 25

Type
Remotely Operated Vehicle (ROV).

Description
The aluminium HYSUB ATP 25 is configured as a 'call out' system which has been used for offshore oil drilling support and tunnel inspection. The vehicle has a very high thrust to weight ratio. This is made possible by using the scaling facilities available in the control system to adjust flow to the thrusters.

The vehicle is controlled using an ISE advanced telemetry control system. A 360° sector scanning colour sonar is fitted. A variety of colour or B/W cameras can be fitted according to customer specification. A 1 × 5 function rate Magnum manipulator is fitted together with five tungsten filament 250 W lights.

Specifications
Length: 2.3 m
Width: 1.1 m
Height: 1.10 m
Weight: 907.2 kg (in air)
Payload: 78.9 kg
Machinery: electrohydraulic (25 hp electric, 6 hydraulic thrusters)
Speed: 3+ kt
Operating depth: 1,524 m

Contractor
International Submarine Engineering Ltd (ISE), Port Coquitlam, British Columbia.

VERIFIED

HYSUB ATP 40

Type
Remotely Operated Vehicle (ROV).

Description
The aluminium HYSUB ATP 40 has been used primarily for drilling support. Typical tasks include visual inspection; cleaning sand and mud cuttings build-up; debris clearance; jetting and brushing operations; wall thickness measurements in flow line and valves; CP measurement; anode installation; transponder change out; guideline change out; bolt torsioning; and cable cutting.

The vehicle is controlled using an ISE advanced telemetry control system. Sensor equipment includes a 360° sector scanning colour sonar, five tungsten filament 250 W lights colour (or optional B/W) camera according to customer specifications, and a 7-function rate Magnum manipulator (a second manipulator can be fitted if required).

Operational status
A wide range of customers around the world, including the US Navy.

Specifications
Length: 2.51 m
Width: 1.42 m
Height: 1.35 m
Weight: 1,686 kg (in air)
Payload: 73 kg (nominal)
Machinery: 40 hp electrohydraulic power pack (6 hydraulic thrusters)
Operational depth: 1,850 m

Contractor
International Submarine Engineering Ltd (ISE), Port Coquitlam, British Columbia.

VERIFIED

HYSUB ATP 150

Type
Cable maintenance and repair vehicle.

Description
The Hysub ATP 150 has been developed for telephone cable maintenance and repair. These aluminium vehicles with stainless steel fixtures and anodised aluminium frame have been built with diving depths ranging from 2,000 to 2,500 m. They are fitted with jetting skid for burial and de-burial of cable. They carry cable cutters and grippers. The vehicle is capable of auto depth, auto heading, auto altitude and auto cable track.

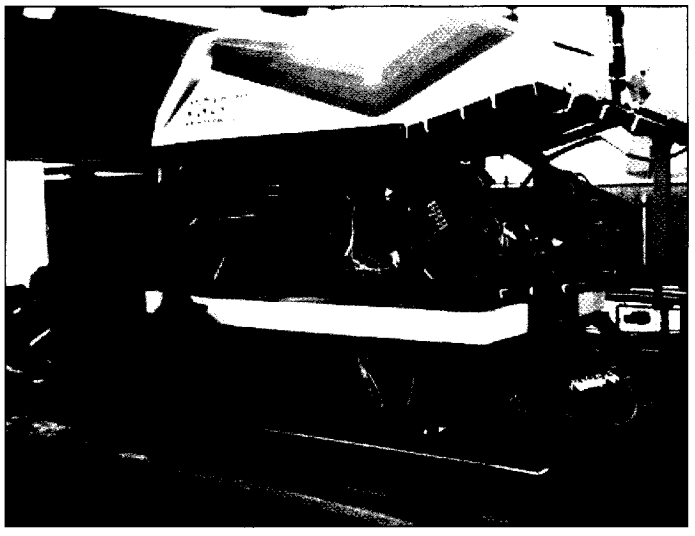
The vehicles are equipped with an ISE advanced telemetry control system and can be fitted with up to 6 cameras and 2 sonars according to customer requirements, and operate 10 × 250 W lights with 2 × 7 function Spatially Correspondent (SC) Magnum manipulators.

Operational status
Customers for these vehicles include telecommunications, consortia and the military, including the US Navy.

Specifications
Length: 3.43 m
Width: 2.08 m
Height: 1.96 m (excluding skid)
Weight: 4,355 kg (nominal, excluding skid) in air
Payload: 364 kg (nominal)
Machinery: electro-hydraulic (2 × 75 electric HP, 7 hydraulic thrusters)
Thrust: 818 kg forward
Speed: 3.5 kt
Operating depth: 2,500 m

Contractor
International Submarine Engineering Ltd (ISE), Port Coquitlam, British Columbia.

UPDATED



Hysub ATP 150 (International Submarine Engineering) ***NEW***/1068316

HYSUB ATP 250

Type
Remotely Operated Vehicle (ROV).

Description
The aluminium HYSUB ATP 250 is a progenitor for large oil patch work vehicles. Uses include deployment of pipeline repair tools; burial of flow lines; heavy salvage; deployment of large loads on the bottom; and steering large pilings. The current 600 m tether is of 100 tons breaking strain, although larger load-bearing cables can be designed to meet customers' needs. A small 10 hp vehicle can be deployed from the HYSUB 250 on a 50 m tether. This vehicle weighs 250 kg and typically has a four-function manipulator.

The vehicle is controlled using an ISE advanced telemetry control system with gyrocompass, depth sensor and imaging sonar fitted as normal. Two 7-function Spatially Correspondent (SC) Magnum manipulators are fitted.

Specifications
Length: 4.90 m
Width: 2.50 m
Height: 2.50 m
Payload: 3,000 kg variable (air ballast)
Machinery: 2 × 125 hp electrohydraulic power packs (12 hydraulic thrusters)
Operating depth: 1,000 m

Contractor
International Submarine Engineering Ltd (ISE), Port Coquitlam, British Columbia.

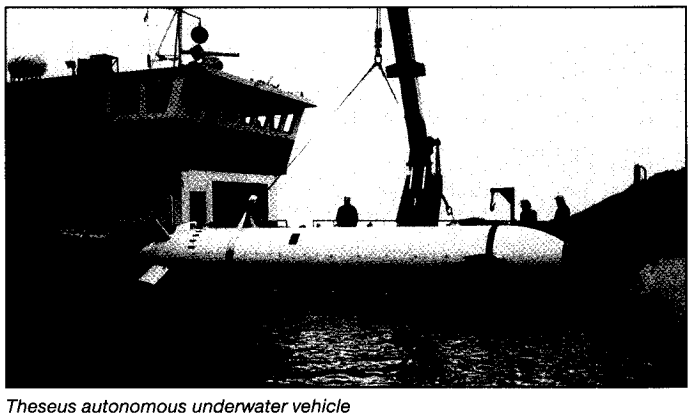
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Theseus

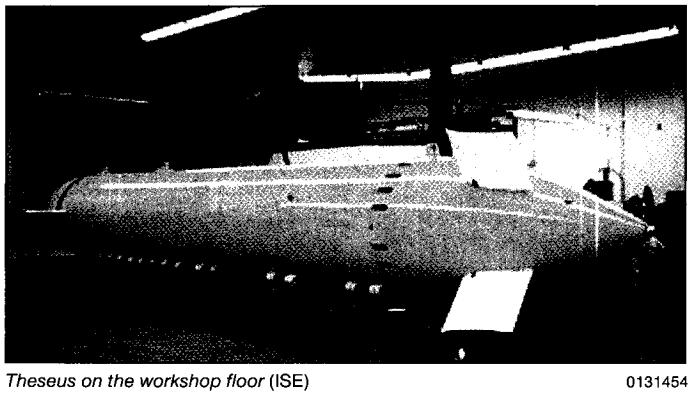
Type
Autonomous Underwater Vehicle (AUV).

Description
Developed in the early 1990s the Theseus is designed as a multipurpose, modular vehicle, the aluminium-hulled Theseus is an alternatively programmable, or remotely controlled, vehicle which is similar in shape to a torpedo. The 8,600 kg vehicle is 10.7 m long and 127 cm in diameter but can be modified in length to accommodate a variety of payloads. Designed operating depth is 1,000 m.

Theseus is controlled using an onboard MC68030 microprocessor which provides sufficient decision making ability to permit the vehicle to carry out complex missions requiring precision navigation over significant distances and under conditions where positioning information from external sources is infrequent or unavailable. Depending on configuration and proximity to a surface support station, it is also capable of being commanded with acoustic telemetry. Communication with the vehicle has been maintained, at various times, using a fibre optic cable being deployed by the vehicle, using acoustic telemetry, and using a radio link, via a surface-towed antenna.



Theseus autonomous underwater vehicle



Theseus on the workshop floor (ISE) 0131454

Navigation systems include: a Sea Phins INU; RDI 300 kHz Doppler Velocty Log; and Makine Electronics 6201 obstacle avoidance sonar.

The vehicle has a maximum speed capability of 5 kt and is driven by 6 hp brushless DC motor powered by 360 kW silver-zinc batteries to control a single 61 cm diameter propeller via a gearbox. Power is provided by 360 kW h AgZn batteries on operatoinal missions.

Range is variable, depending on overall power requirements of the mission and the selected power source.

Theseus is designed to be transportable to remote locations and can be broken down into modules for carrying by air or surface vehicles of more modest capacity.

Operational status

Theseus has achieved full operational status and has demonstrated deployment of fibre optic cable in ice-covered waters.

Upon completion of that task a series of varied tasks which benefit from the significant operational envelope of the vehicle are anticipated.

The Theseus AUV is owned by the Canadian Department of National Defence and operated by International Submarine Engineering (ISE), Port Coquitlam, British Columbia, Canada. It was developed by ISE in 1994.

Specifications

Length: 10.7 m
Diameter: 1.3 m
Displacement: 8,600 kg
Payload: 550 kg (in air)
Speed: 4 kt (cruise)
Range: >900 km
Operating depth: >1,000 m

Contractor

International Submarine Engineering (ISE), Port Coquitlam, British Columbia.

UPDATED

Trailblazer 25

Type

Remotely Operated Vehicle (ROV).

Description

The Trailblazer 25 mine disposal vehicle is capable of high underwater speeds and deep diving.

The basic concept of the vehicle is portability and the total MCM system, including displays, control, navigation, vehicle and umbilical cable, can be stowed, transported and operated in a standard IATA Boeing 747 Combi aircraft load ISO container.

The system is small, compact and lightweight and is easily handled, being capable of deployment from unsophisticated vessels as small as fishing smacks or workboats.

Although it forms part of a family of underwater vehicles, the version developed for MCM duties was designed to meet the following criteria:

- high-power propulsion system to permit easier and more accurate manoeuvrability in the presence of strong tidal currents, and to reduce overall mission time
- ability to carry out missions for extended periods unrestricted by the limited availability of onboard vehicle power
- low magnetic and acoustic signatures
- use of advanced telemetry systems to ensure ease of system operation and ready availability of sensor data
- provision of appropriate sonar equipment and high-resolution TV systems to allow rapid location and identification of underwater objects
- high payload capacity to allow carriage of a number of countermining charges when on extended missions.

The frame of the vehicle is constructed of thick anodised aluminium girders. A slightly positive buoyancy is maintained by means of high-density syntactic foam within the vehicle. Lead ballast is added to the structure to allow for adjustment of buoyancy when heavy payloads are carried. Additional foam may be added to increase the vehicle's maximum payload if required.

The vehicle is powered by five hydraulic thrusters. Two thrusters are mounted at the after end of the vehicle providing forward and reverse motion. Two amidships thrusters provide lateral movement. A fifth thruster amidships provides vertical motion. Variable thrust and directional control for each thruster are maintained by pressure-compensated servo-valves mounted on a control valve manifold unit.

Power for the 25 hp electric motor propulsion system is fed from the surface ship's supply via a transformer to the vehicle through the 900 m umbilical cable to drive a pressure-compensated hydraulic piston pump. Normally the vehicle's hydraulic power pack operates at a pressure of 210 bar, but provision is made for operation at low pressure where low-acoustic noise signatures are required.

The longitudinal and lateral thrusters are controlled from a single joystick on the control console, the stick controlling forward or astern movement, rotation of the stick (creating differential pressure on port and starboard thrusters) allowing the vehicle to be steered, while sideways movement produces lateral movement. A separate control is provided for the vertical thruster.

The use of an umbilical-powered electrohydraulic propulsion system offers considerable operational flexibility and provides almost unlimited endurance. The control package uses a half-duplex PCM telemetry system for transfer of command signals and system data between vehicle and control console. Video write-on facilities are provided for display of navigation and system function parameters.

The main console provides all vehicle control functions, data on system operation and displays for TV/sonar. To simplify operation during launch and recovery a portable control unit for use on the deck of the MCMV is provided.

For navigation, Trailblazer 25 is provided with a flux-gate compass; however, a gyrocompass can be fitted optionally if required and slaved to the flux-gate compass. Other systems include: a strain gauge depth sensor; scanning sonar (Imagenex 855 or similar); and responder/transponder (ORE or similar). Vehicle heading and depth is continuously displayed on the console monitor. If required, heading and operating depth can be set and automatically maintained, the data being displayed on the monitor.

Standard sensor fit includes an Osprey OE 1321 SIT TV camera but colour TV or still cameras can be added if required. An hydraulically operated pan/tilt facility is provided while surveillance is aided by the use of a 500 W variable intensity lighting unit. A wide range of sonar equipment can be fitted to meet varying operational requirements. A range of hydraulically operated manipulators is also available.

The vehicle can carry up to four 50 kg US Navy-type countermining charges or one NATO-standard 127 kg charge mounted on a carriage underneath the vehicle.

Operational status

The Trailblazer 25 is a proven mine countermeasures system. It has successfully completed 21 operations worldwide. Ten operations were undertaken with the US Navy and Coast Guard. Other demonstrations were for the Minister of Defence – Australia, Defence Research Establishment Pacific, and DARPA. The Trailblazer system has demonstrated its MCM capabilities in Australia, Denmark, Norway, the UK, the Middle East and South America. The system has been ranged on the Land Magnetic Range in the UK and Australia. The Trailblazer 25 was also used on the Swiss Air 111 site clean-up. The Trailblazer 25 forms part of the MCM modular fit on the Kingston class vessels of the Canadian forces.

Specifications

Length: 250 cm
Width: 100 cm
Height: 100 cm
Weight: 700 kg
Operating depth: 300 m; greater depths optional
Speed: 5 kt (typical)

Contractor

International Submarine Engineering, Port Coquitlam, British Columbia.

NEW ENTRY

France

ERATO

Type

Torpedo recovery vehicle.

Description

The ERATO (Engin de Ramassage de Torpilles — torpedo recovery vehicle) was developed to recover torpedoes from the seabed at great depths (for example, the MU90 torpedo has a maximum operational depth far in excess of 1,000 m).

The recovery system comprises four units:

- The ERATO underwater vehicle
- The handling system
- The power shelter
- The operating and control shelter.

The handling system, power and control shelters are all carried on board the support ship.

The submersible is built of syntactic foam which is formed around a light-alloy tube framing. This structure gives the vehicle a slightly positive buoyancy. ERATO is propelled using four identical four-bladed thrusters (two longitudinal, one transverse and one vertical) which are driven at 800 rpm from a 2 kW power unit. The thrusters are electronically speed controlled using PWM inverters and are immersed in oil for pressure compensation. The sensor package comprises two monochrome video cameras for target observation, a spotlight device, depth and immersion sensors, compass for course guidance, and an acoustic sensor tuned to detect the torpedo's pinger. A grab clip is provided for torpedo recovery. The vehicle is linked to the parent vessel by an umbilical coaxial cable 14 mm in diameter and 1,500 m long.

In operation ERATO homes on to the torpedo on the seabed using the torpedo's pinger, grasps the weapon with the grab and returns to the surface with it.

The handling system is used to transfer the vehicle from the parent vessel to the sea, recover it and hoist it back on board. It also handles and automatically feeds out the umbilical cable. The vehicle, umbilical cable and oscillating wire guidance system is carried on a motor-driven trolley running on two rails mounted on a support foundation. The oscillating arm provides compensation for heave motion as the vehicle is transferred between the parent vessel and the water.

The power shelter houses two alternators generating power for the units on board the parent vessel and the ERATO vehicle, providing a completely self-

contained recovery system. Surface power is provided by a 380/240 V, 50 Hz, 14 kW generator which powers the trolley, carrier cable hoist and parent vessel auxiliary units. A second generator delivers power at 208 V, 400 Hz, 15 kW to the ERATO vehicle. Power is supplied to the vehicle under high voltage (3,000 V) via the umbilical cable.

The operator control shelter is divided into two sections: one a high-voltage room incorporating safety devices; and a second room housing a control and monitoring station with a distribution panel and dedicated data processing system. The processing system handles and controls data using a power circuit and monitoring video terminal; a console which provides status monitoring of the surface equipment; a real-time graphic display terminal for the TV picture; a data and ERATO command processing console; a keyboard; and a vehicle control console (manual controls or navigation commands).

Operational status
In service.

Specifications
Length: 2.3 m
Width: 1.8 m
Height: 2.4 m
Weight: 12,000 kg
Operating depth: 1,000 m

Contractor
DCN, Paris.

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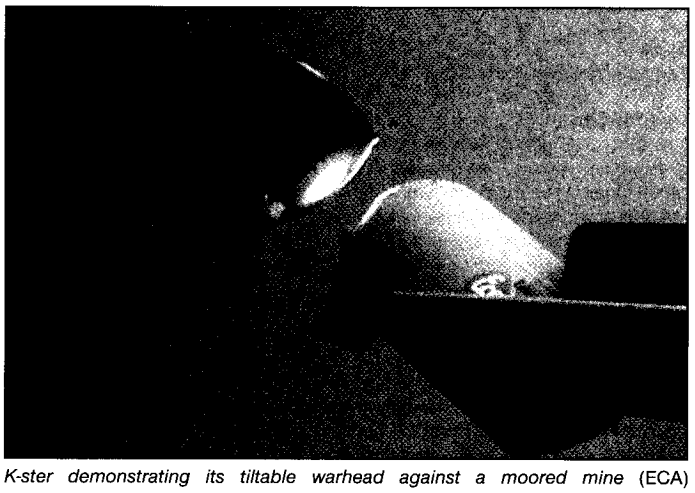
K-ster

Type
Mine destructor vehicle with tiltable warhead.

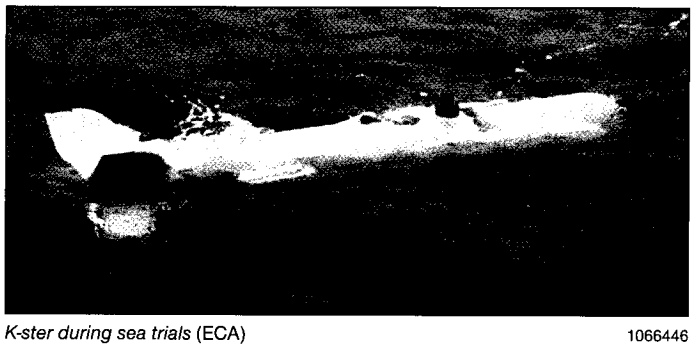
Description
K-ster is a low cost easy to launch mine destructor vehicle for the clearance of mine fields. The vehicle is automatically guided towards the target where it uses its unique tiltable warhead to detonate the mine accurately and efficiently. The tiltable head integrates both the warhead and the video/sonar sensors. The warhead comprises a shaped charge with insensitive explosive.

The vehicle is controlled from the parent vessels via a fibre optic link. Target localisation and identification are achieved using an automatic colour video camera with day/night function, a variable intensity searchlight, and a variable frequency sonar (from 500 to 1,200 kHz). The MMI features a hand held control console.

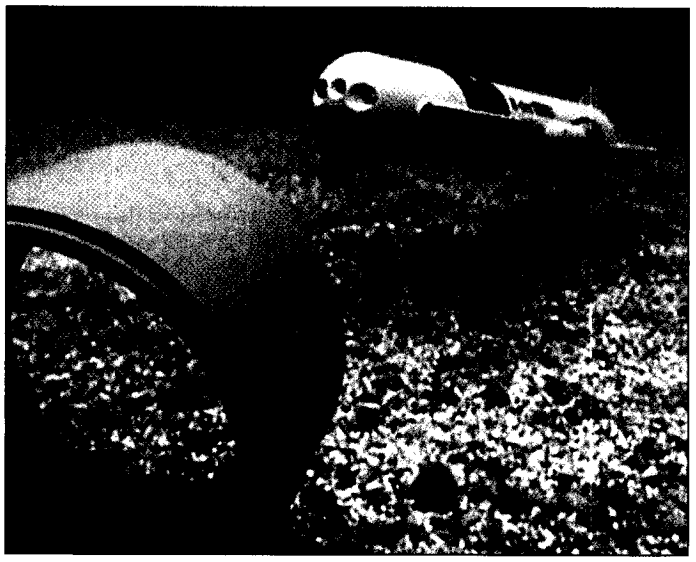
With its two horizontal and single vertical thrusters the vehicle features high stability in currents and a hovering capability in the firing position and its tiltable warhead (–90 to +90°).



K-ster demonstrating its tiltable warhead against a moored mine (ECA)
NEW/0568250



K-ster during sea trials (ECA) 1066446



K-ster approaching a seabed target during sea trials (ECA) ***NEW***/0568249

Specifications
Length: 1,400 mm
Diameter: 230 mm (main body)
Weight: 50 kg (in air)
Operating depth: 300 m (max)
Speed: >5 kt
Range: > 1,000 m (max)

Contractor
ECA, Toulon.

NEW ENTRY

OLISTER

Type
Multipurpose system for subsea mine warfare, search, survey and intervention.

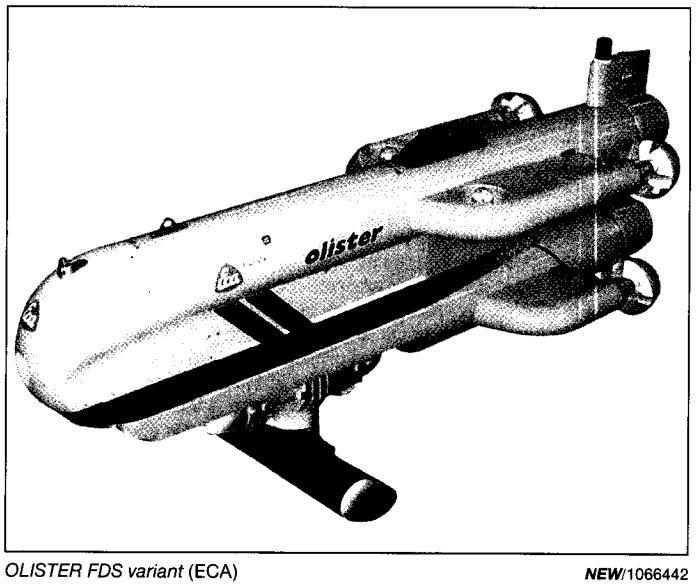
Description
OLISTER has been designed to present open software and modular architecture and can be configured in two different ways:

- As a Forward Detection System; OLISTER FDS, which is fitted with a long-range detection and classification sonar or
- A Mine Identification and Disposal System; OLISTER MIDS, which carries the high explosive NATO Mine Disposal Charge (MDC) weighing 120 kg in air, or the remotely controlled ammunition RECA shaped charge (see separate entry).

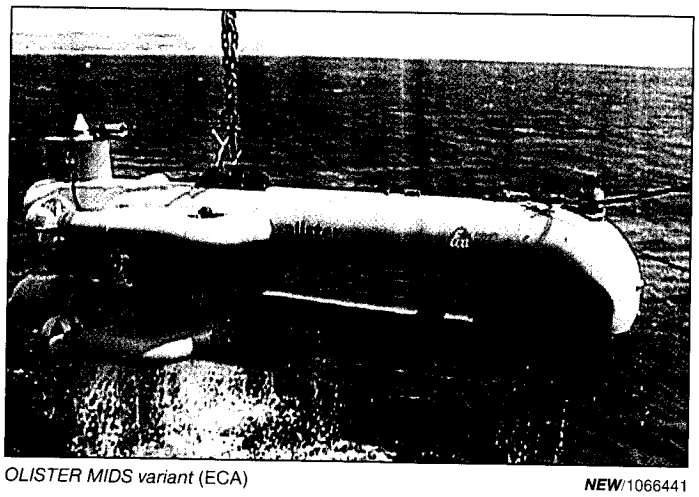
OLISTER can be powered either by a lithium battery pack or by A/C external power supply through an umbilical link to drive four horizontal and two vertical thrusters to provide precise manoeuvring. The main body comprises two aluminium-alloy horizontal hulls mounted one above the other. The upper hull houses the electronics module, communications module and various sensors, while the lower hull houses the battery pack for autonomous operation or the power module when power is supplied by the parent vessel.

The different missions of the OLISTER system are:

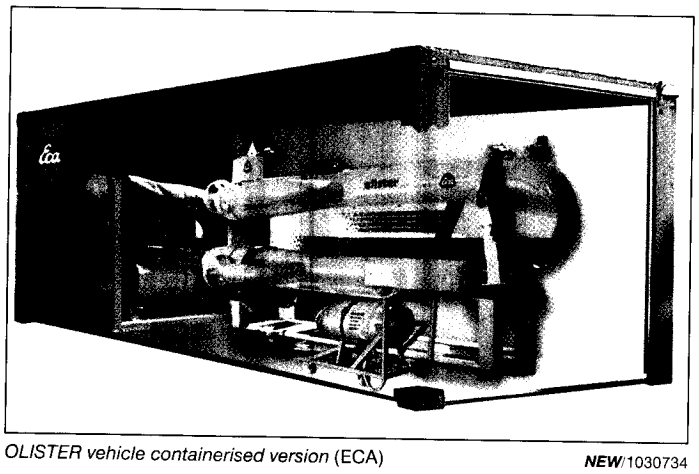
- Long-range detection/classification of mines



OLISTER FDS variant (ECA) ***NEW***/1066442



OLISTER MIDS variant (ECA) ***NEW***/1066441



OLISTER vehicle containerised version (ECA) ***NEW***/1030734

- Seabed survey
- Mine identification
- Mine disposal
- Subsea intervention

The OLISTER system is claimed by the manufacturer to be the only system currently providing such a wide range of operations and flexibility of use with the same basic system.

The system has been designed for rapid conversion from one configuration to the other.

The system is fully containerised and is quickly adaptable to equip different types of vessel from a COOP to a frigate. The vehicle-handling system and associated equipment is housed in a 20 ft ISO container, with the control console mounted in a separate 10 ft ISO container.

Operational status

Maiden sea trials were completed in 2000 and the first orders placed in 2001. One system has been sold to Malaysia.

Specifications

Length: 3.1 m
Beam: 1.10 m
Height: 1.10 m
Weight: 600 kg including 125 kg of payload (in air)
Speed: over 8 kt
Operational depth: 300 m (max)
Autonomy: unlimited with power umbilical
Range: 1,000 m with umbilical, 2,000 m with FO bobbin

Contractor

ECA, Boulogne-Billancourt.

UPDATED

PAP Mk 5

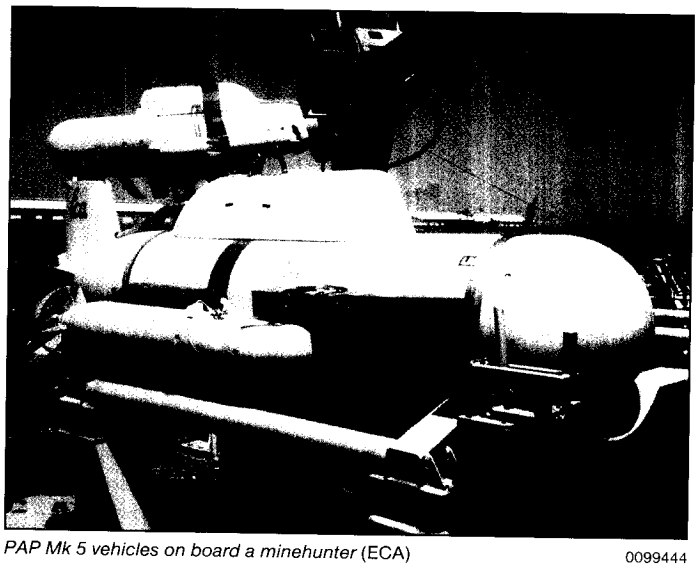
Type

Subsea mine identification and disposal system.

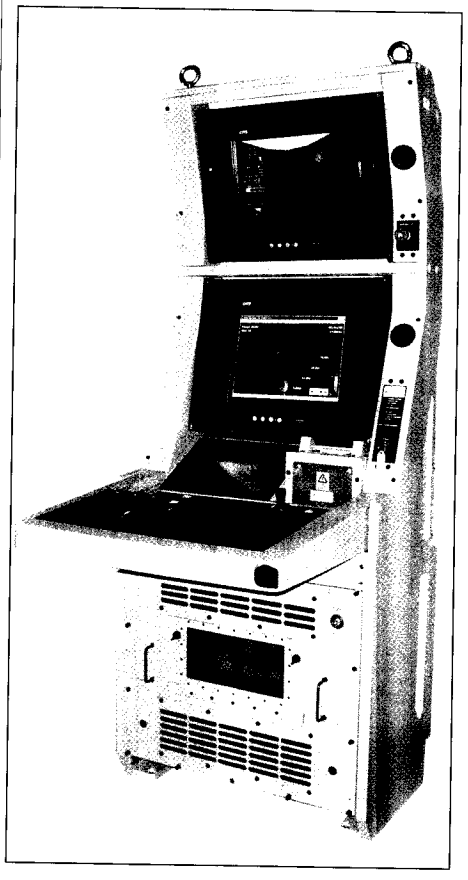
Description

The PAP Mk 5, developed and manufactured by Société ECA, is the fifth generation of the PAP 104 family.

The PAP Mk 5 has a capability to simultaneously hunt and destroy seabed and tethered mines by either placement and remote detonation of a charge or by cutting the mooring rope of tethered mines. To achieve these aims, the PAP Mk 5 embodies both new features and also those maintained from the former PAP versions. Recently two new options have been added to the PAP; an umbilical cable and CLAD, a new device to destroy tethered mines.



PAP Mk 5 vehicles on board a minehunter (ECA) 0099444



PAP Mk 5 control console (ECA) ***NEW***/1030732

The vehicle can be carried by MCMVs equipped for locating mines. This is achieved either by a minehunting sonar or a surface positioning system.

The vehicle is autonomous; it carries its own source of energy – a battery which can be recharged or changed on board between missions.

The vehicle is wire guided and remote controlled from a control console situated in the operations room. The wire is consumable and dispensed by the vehicle.

The vehicle is horizontally propelled by means of two side thrusters.

By means of a guide rope, the vehicle can navigate at constant altitude.

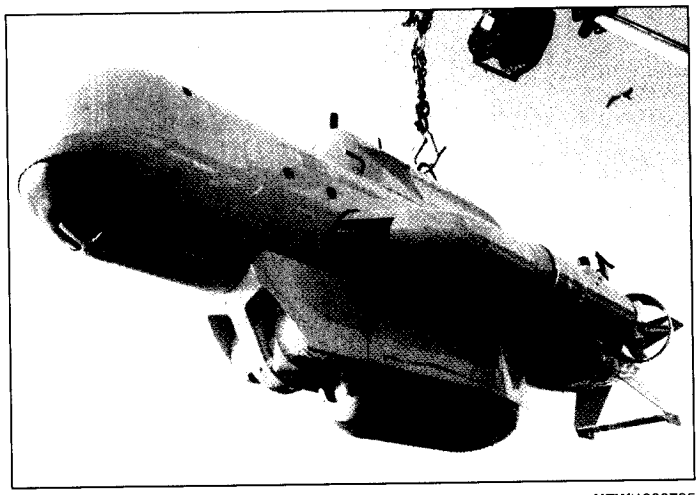
The PAP Mk 5 is able to carry the 126 kg NATO combat charge necessary to ensure the total destruction of the mine, or can carry the intelligent shaped charge, RGCA (Remote Control Ammunitions). Explosive cutters for moored mine disposal can be carried with the charge.

The PAP Mk 5 employs modern new electronics, based on microprocessors, providing reliable, high-rate data transmission. It includes an ergonomic control console and provides the operator with different navigation aids.

The front section of the vehicle is devoted to an optional sonar of the customer's choice and can be either a high resolution nearfield sonar or a mid-range relocation sonar.

Identification is carried out using a tiltable low-light TV camera and/or a tiltable colour TV camera.

Vertical thrusters are used which allow mid-water navigation. A new payload can be fitted in place of the charge, consisting of a manipulator with associated camera and projector.



PAP Mk 5 mine disposal system (ECA) ***NEW***/1030735

Other features include: sealed lead-acid batteries; guide rope length variation to allow fine adjustments of vehicle altitude during a seabed mission; radio control for surface recovery in case of cable severance; fibre optic wire.

The PAP Mk 5 has very low acoustic and magnetic signatures.

Operational status

More than 450 PAP vehicles including 100 PAP Mk 5 and 10 PAP Plus (improved version of PAP Mk 3) have been delivered and 16 navies are equipped with them. Navies operating the PAP Mk 5 include the Royal Navy, Japanese MSDF, Singaporean Navy, Saudi Arabian Navy and Turkish Navy.

PAP vehicles have carried out more than 40,000 runs including many successful combat missions in the Red Sea, the Falklands, the Persian Gulf and so on.

Specifications

Length: 3.1 m
Diameter: 1.2 m
Height: 1.3 m
Weight (in air): 890 kg (with NATO charge)
Speed: 6 kt (max)
Operating range: 2,000 m (max horizontal)
Operating depth: 300 m (max horizontal)
Endurance: 90 min

Contractor

ECA Boulogne-Billancourt.

UPDATED

PAP Plus

Type

Remotely controlled vehicle.

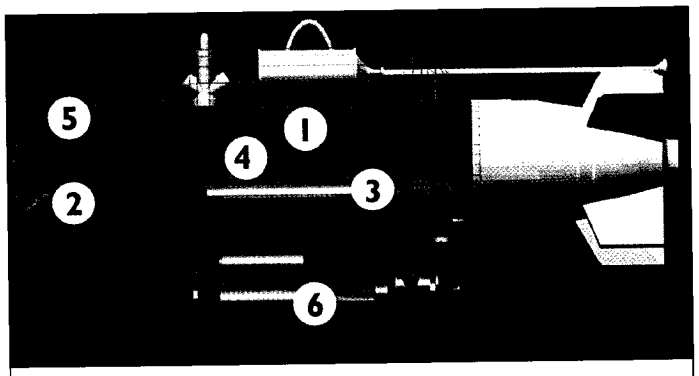
Description

The PAP Plus is an underwater vehicle developed for the identification and destruction of seabed and tethered mines. PAP Plus is an improved version of the PAP Mks 3 and 4 vehicles and incorporates features providing intermediate performance between the PAP Mks 3 and 4 and the PAP Mk 5.

The PAP Plus is co-axial wire guided and controlled from a console onboard the mother ship. Upgrades on the PAP Mks 3 and 4 include the following:



PAP Plus (ECA) ***NEW***/0017493





PAP PlusKey:
1. Video imaging and data transmission
2. Black and white video camera
3. MG horizontal thrusters
4. Vertical thrusters
5. Relocation sonar
6. RECA charge
(ECA)

NEW/0081928

- Improved standard video function (black and white camera)
- Addition of a colour camera and relocalisation sonar
- Improved magnetic signature (through use of a MG motor)
- Addition of a vertical displacement capacity (vertical propulsors)
- Automatic vehicle steering and ergonomic improvement of control console (new surface console)
- Vehicle retrieval by remote control surface radio

Specifications

Length: 2.7-2.9 m (depending on version)
Height: 1.17 m
Width:1.26 m (overall)
Weight: 700 – 730 kg (depending on version)
Speed: 5.5 kt (with MG propulsors) max
Operating depth: 120 m (300 m with MG propulsors)
Range: 1,000 m (max); 500 m with 2 kt current
Payload: RECA or NATO charge (126 kg in air)

Operational status

Several PAP Plus vehicles in operation with different navies.

Contractor

ECA, Toulon.

NEW ENTRY

TOSCA

Type
Towed subsea carrier.

Description
TOSCA (TOwed Subsea CArrier), which is capable of carrying out mine detection and identification, is a towed body carrying side scan sonar for automatic seabed survey at a constant altitude at high towed speed. The vehicle has very high dynamic performances including auto-controlled altitude, pitch, roll and overall stability.

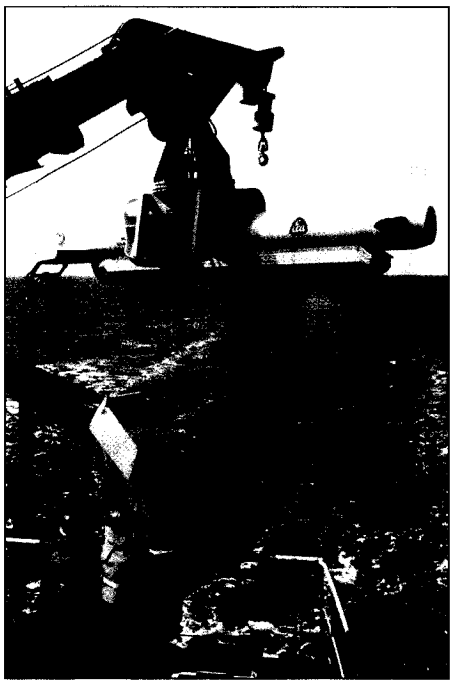
The vehicle is supported by an MCMV or remotely controlled vessel.

Operational status
Two vehicles have been operational in the French Navy since 1992. The system has also been ordered by one European navy in 2002.

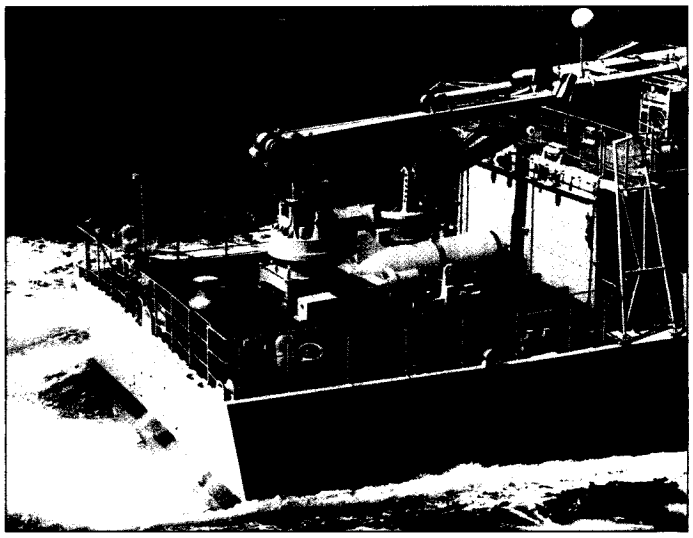
Specifications
Length: 3.50 m
Diameter: 0.50 m
Speed: 2-10 kt towed
Operational depth: 50-250 m
Payload: any type of side scan sonar up to 700 kg in air

Contractor
ECA, Boulogne-Billancourt.

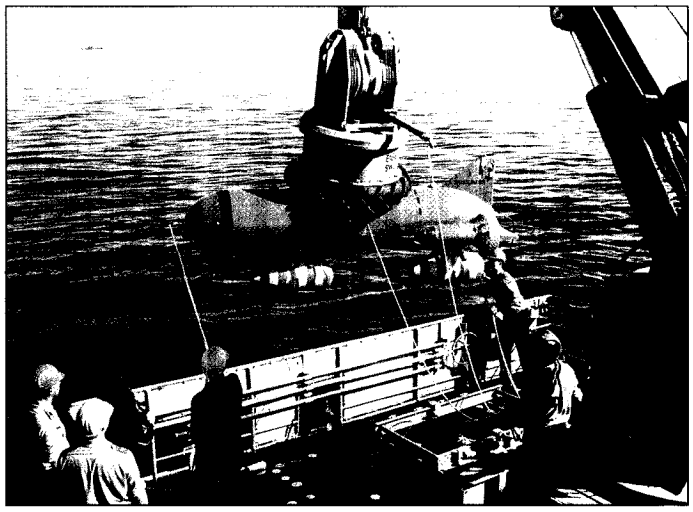
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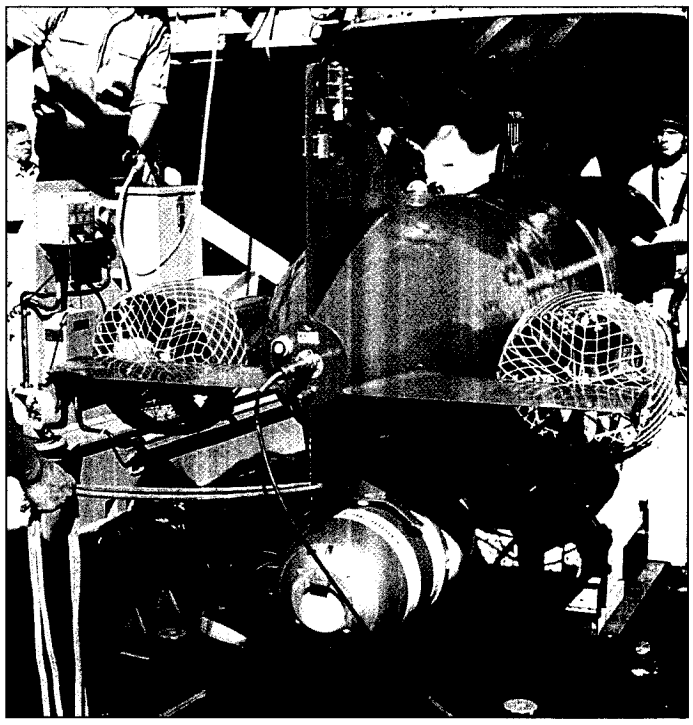
TOSCA
0103965



Pinguin B3 ROV mounted on its cradle on the poop deck of the MCMV Frankenthal. *The associated handling crane can be seen beside the ROV*



MCMV Weilheim *launching a Pinguin B3 ROV during the MCM Exercise Open Spirit 99* (Michael Nitz) 0059330



Crew of the MCMV Weilheim *preparing to launch a Pinguin B3 ROV during MCM Exercise Open Spirit 99* (Michael Nitz) 0059329

Germany

Pinguin B3

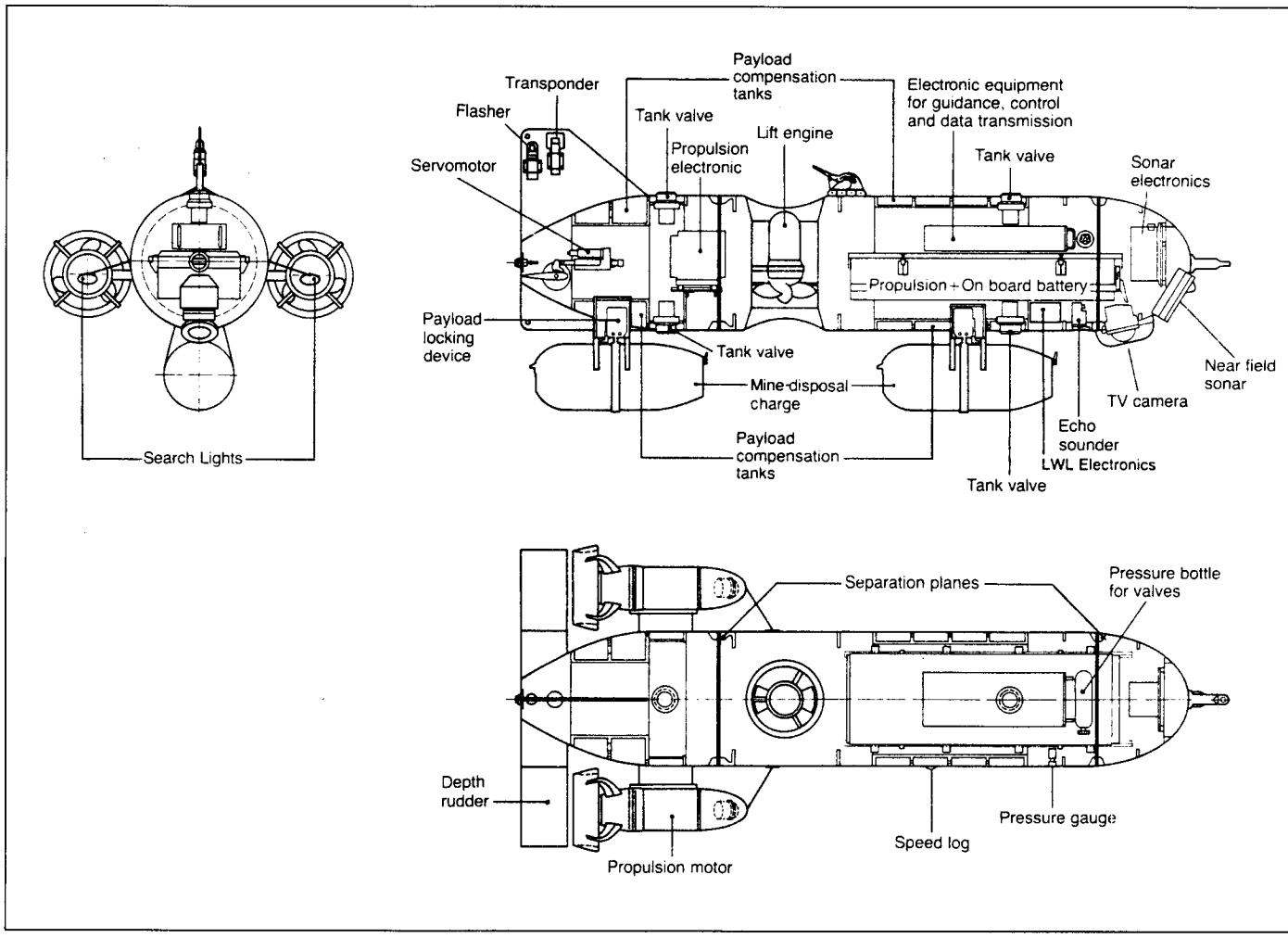
Type
ROV mine disposal system.

Development
The Pinguin B3 is a remotely controlled, reusable underwater vehicle designed for minehunting operations. With the input of target information (derived from minehunting sonars) Pinguin B3 is able to approach any mine-like object. The vehicle can then identify the mine and, if necessary, drop one of two mine disposal charges carried to destroy it. The second charge capability enables the vehicle to continue the mission and approach a second target in only one mission. Thereafter Pinguin returns to the minehunter for recovery and rearming.

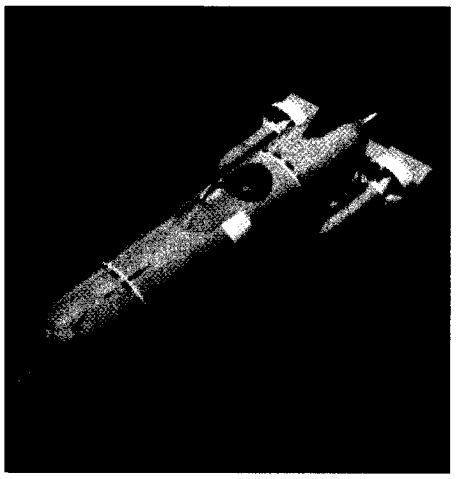
The Pinguin B3 provides different sonar options and is also fitted with a tilt TV camera. The vehicle is fitted with a 1,000 m reusable fibre optic cable for data transmission.

The propulsion system consists of two horizontal propeller thrusters, mounted laterally on the stern section of the vehicle. At low speeds the depth control is achieved by a vertical thruster mounted in the hydrodynamic centre point of the vehicle. At higher speeds (>2 kt) diving is dynamically controlled by flaps. The control system of Pinguin B3 provides ergonomic operator control of operation of the vehicle, only requiring sparse operator inputs for heading, depth and propeller speed.

The Pinguin B3 can be operated freely within the water column in the range of the minehunting sonars down to depths of 200 m. The vehicle carries two charges of up to 125 kg each. Equipped with a special moored mine disposal device, it can also counter moored mines very effectively by direct destruction of the mine casing (no cutting and thus floating mine results). The system offers a considerable growth potential for the adaptation of alternative sensors and of tools for salvage missions.



Pinguin B3 component arrangement



The Pinguin B3 remotely controlled and reusable mine disposal vehicle carries two mine destruction charges and sensors for vehicle navigation and target identification
0518651

Operational status
No longer in production or supported by manufacturer. In service with the German Navy's Frankenthal class minehunters (12 ships) and aboard the Republic of China Navy's Yung Feng class (four ships).

Specifications
Length: 3.5 m
Hull diameter: 0.7 m
Width: 1.5 m
Height: 1.2 m/incl MDCs 1.5 m
Weight: 1,350 kg incl MDCs
Propulsion: 2 variable speed thrusters, 1 automatic controlled vertical thruster
Power supply: internal rechargeable battery systems
Operating depth: 200 m
Speed: 6 kt (continuous), 8 kt (max)
Endurance: 60/120 min
Payload: 255 kg (2 mine disposal charges or other payloads)
Sensors: TV camera, different sonar options

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

Seafox

Type
Family of one-shot mine disposal vehicles.

Development
The German Seafox system one-shot mine disposal vehicle was developed in 1983 to meet the navy's advanced minehunting requirements.

The Seafox system is now qualified by the German Navy. The objective for the current Seafox development is to counter floating mines. This will be achieved in combination with the STN ATLAS multisensor platform (MSP 500). The stabilised platform consists primarily of an infra-red camera for mine detection and a laser ranger for tracking and positioning.

Description
Seafox is a one-shot mine disposal vehicle capable of ensuring the destruction of moored mines at varying depths and short-tethered mines using a shaped charge. Seafox C is an electric powered, guided underwater vehicle with onboard high resolution sonar and CCTV camera to identify targets and a shaped charge warhead. Seafox I is similar to Seafox C but has no warhead and is recoverable and reusable and is used for training.

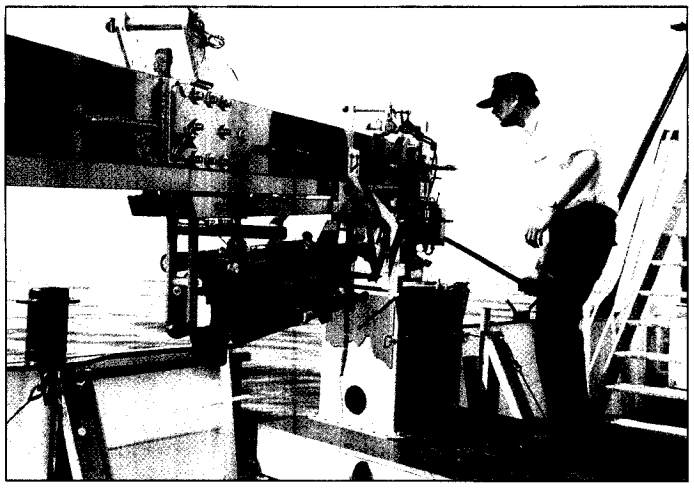
Seafox consists of five main subsystems:
- one-shot underwater vehicle;
- control unit with adaptation to MCM platform;
- stowage and launch facilities with adaptation to MCM platform;
- fibre optic data transfer cable between control unit and vehicle;
- data interfaces from the sonar system of the MCM platform to the control unit.

The Seafox vehicle is basically a self-propelled wire-guided (fibre optic cable providing a high bandwidth datalink between the vehicle and its MCMV) ammunition with a homing capability. It is controlled from a shipboard console, fitted with flat panels displaying the sonar picture, TV images and guidance data plus a touch screen for control input. In automatic mode the system guides the vehicle but allows the operator to override and control the mission manually.

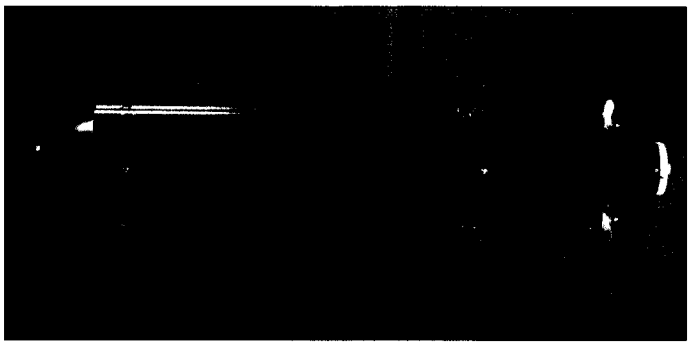
A typical combat mission time is less than 15 minutes and the vehicle can operate in currents up to 3 kt.

The vehicle is powered by four horizontal and one vertical thruster powered by lithium batteries. On board sensors include a high resolution HF scanning active panoramic sonar and TV camera with lights.

The sequence of operation involves two men loading the Seafox on to the launcher and connecting the fibre optic cable. Once the cable is connected, the vehicle is tested from the control console after which the restraining pin on the launcher is removed and the vehicle slides into the water. Separation from the launcher leads to the operation of the first interlock in the safety and arming unit. Once launched, the vehicle enters the initial in-water phase of the operation,



Seafox on a launcher being prepared for deployment (STN ATLAS Elektronik)
0059335



Seafox underwater vehicle

manoeuvring into the ship's sonar beam or the area covered by an underwater positioning system. The vehicle is then guided on a pre-programmed course from the control console.

The vehicle is fitted with a responder, which enables it to be tracked by the MCMVs sonar. Alternatively the responder can be tracked by an underwater positioning system.

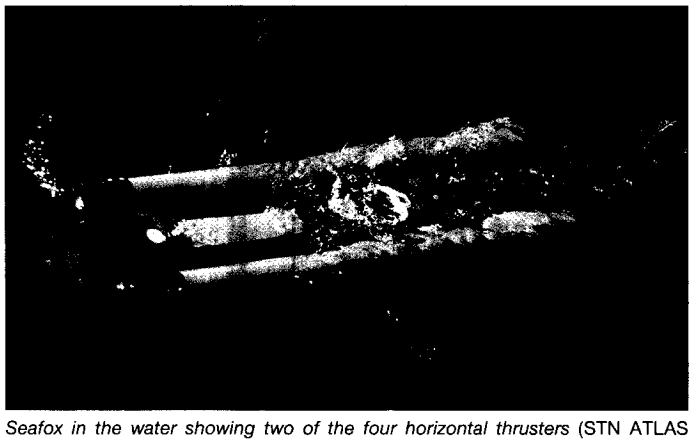
The control console automatically manoeuvres the Seafox into the sector covered by the tracking system, adjusting heading, speed and depth accordingly. Once the vehicle is positively tracked, it is automatically guided by waypoint navigation to a position downstream of the mine-like object, allowing the sonar to relocate the target. The approach phase of the operation commences when the ship's sonar or the underwater positioning system determines that the Seafox is in the area of the target where it can begin to use its own sonar to locate the target. During this phase of the operation the vehicle is guided on a pursuit course that ensures that the target remains in the beam of the Seafox's sonar. The operator can override the automatic guidance system at any time using a joystick, speed and pitch controls mounted on the console.

The control console displays both the target and any other objects detected by the Seafox sonar enabling the operator to designate the target and initiate the final terminal homing phase.

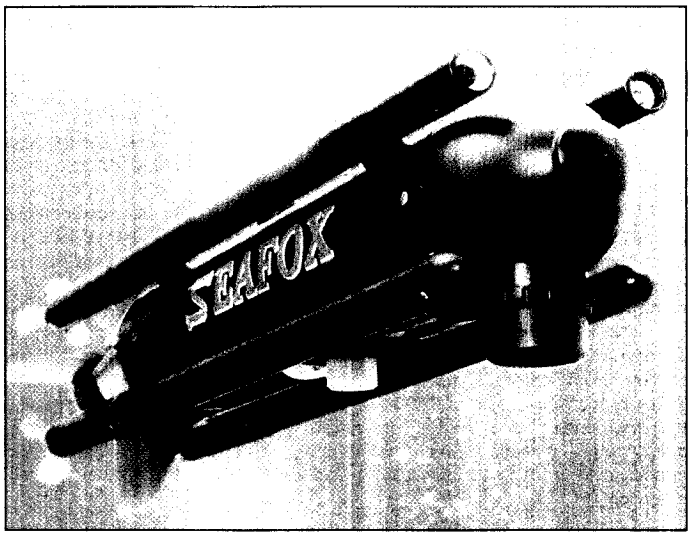
In the terminal homing phase Seafox approaches the target using its own sonar in conjunction with the CCTV camera for identification. This terminal approach phase is conducted independently of the MCMVs sonar. The warhead is then detonated at a typical stand-off range of 20 cm.

Operational status

Seafox is currently under contract for three major programmes. The first system is in service and more than 1,000 vehicles have been ordered. In summary more than 14 ship systems will be delivered plus additional Seafox systems for airborne



Seafox in the water showing two of the four horizontal thrusters (STN ATLAS Elektronik)
0059334



Seafox C combat version (STN ATLAS Elektronik) 0129071

application. The first ship systems are already in service and the serial production of combat vehicles has commenced.

In January 1998 Seafox systems were ordered by the German Navy for the SM 333 conversion programme. Ten ships have been equipped with Seafox. This comprises five advanced minesweepers (HL 352) and five converted minehunters (MJ 333). Seafox vehicles are in series production for this programme. Trials aboard the Hameln class MCMV *Kulmbach* were carried out in May 2000. *Kulmbach* was the first vessel to receive the Seafox system. In parallel, series production of more than 750 Seafox C vehicles for the German Navy has been started.

The Seafox has also been selected as the mine disposal vehicle for the new Visby class corvettes of the Swedish Navy and production is in progress with deliveries commencing in 2001.

The Belgian and Netherlands navies have also selected the Seafox for their Tripartite update programmes, for the mine neutralisation subsystem. The systems will be commissioned between 2004 and 2008.

Seafox has also been selected by the US Navy as part of the Lockheed Martin Naval Electronics and Surveillance Systems provision for the AMNS programme to equip the MH60S helicopter. Seafox is now in series production for the AMNS programme under which a total of 80 to 90 vehicles have been ordered.

A number of Seafox C vehicles were supplied from existing stock to the UK Royal Navy under a hire arrangement for deployment to the Gulf during the war with Iraq in 2003. Only vehicles expended in operations had to be paid for in full. Two Sandown class minehunters the *Blyth* and *Bangor*, are known to have been fitted to operate the vehicle in the Gulf.

Specifications

(Seafox C)
Length: 1.3 m
Diameter: 0.2 m (central body) 0.38 m (max)
Weight: 42 kg
Warhead: shaped charge 1.5 kg RDX or PBX-N9
Speed: >6 kt (max)
Range: approx 1,000 m (in currents below 1 kt), 600 m (in currents of up to 3 kt)
Mission time: approx 15 minutes
Operational Depth: 300 m

Contractor

ATLAS Elektronik GmbH, Bremen.

UPDATED

International

IBIS VII

Type

Propelled Variable Depth Sonar (PVDS) system.

Development

The IBIS VII PVDS, developed by Thales Underwater Systems of France in co-operation with Bofors Underwater Systems (SUTEC Division) of Sweden, is a third-generation minehunting sonar concept which seeks to meet the increased requirement for safety and efficiency in MCM. The aim of the PVDS concept is to provide a full minehunting capability covering survey, detection, classification and identification of all types of mine threat throughout the underwater environment, from a propelled underwater vehicle. It is intended that this will assure the complete safety of the MCMV by providing maximum range of detection and classification in front of the parent platform, without compromising the probability of detection and

classification of the various types of threat. Being a modular concept, the PVDS has the flexibility to offer adaptation to all existing and new types of MCMV platform.

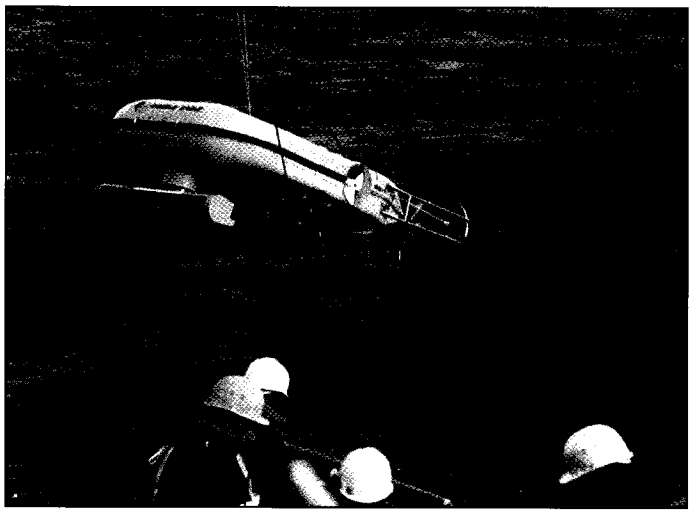
Trials off the Swedish coast in September 1995 demonstrated that this concept is particularly valid in areas where varying thermal layers create a mirror effect (in this instance at a depth of some 12 m, about 6 to 8 m above the seabed). In such conditions the 'dog-on-lead' concept allowed the sonar to be navigated in the layer where the threat was anticipated, and well ahead of the parent MCMV, ensuring it remained outside the danger area of any mine.

The trials showed the PVDS was capable of being accurately navigated near the seabed, maintaining a satisfactory performance from the surveillance sonar. In these conditions, the PVDS provided a detection range on Manta and Rockan mines (two of the most difficult types to detect) of about 300 m at a distance of some 500 m ahead of the ship. In other words, an overall range between ship and mine of some 800 m. However, due to the proximity of the PVDS to the seabed, shadow classification was not as clear as in normal conditions due to the very shallow grazing angle and multipath propagation.

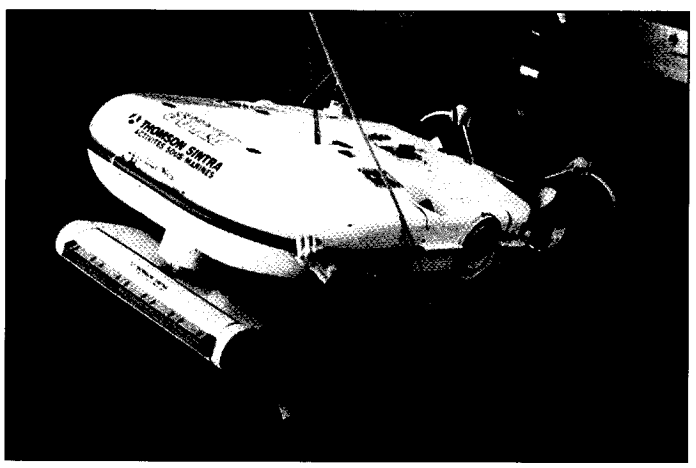
The production version of PVDS will feature improved performances including the incorporation of a third LF for long-range detection over a 90° sector; simultaneous detection and classification; computer-aided detection and classification; and a ×2 increase in resolution for VHF classification and HF detection.



Target mines being prepared for launch from the Swedish MCMV Ulvön



The vehicle being handled from an MCMV 0101103



Preparing to launch the PVDS Double Eagle vehicle from the Swedish MCMV Ulvön
(Anchor Consultancy Photo Library)

Description

The PVDS concept is based on a self-propelled vehicle linked to the MCM by an umbilical cable. This cable provides power to the vehicle and also incorporates a fibre optic cable which is used to pass the full range of sonar data, which its sonar gathers, to the MCMV for further processing.

To assure full safety and efficiency the PVDS can navigate in combination with its parent platform at a speed of 5 kt, at depths between 5 and 300 m and at a distance of 200 m in front of the MCMV, closing to within about 10 m of the target for classification.

These characteristics have enabled the designers to mount a shorter-range high-frequency sonar in the vehicle offering improved detection and classification performances. Furthermore, the ability to manoeuvre in three-dimensions enables the vehicle to place the sonar array in the optimum position, irrespective of the speed of the MCMV.

Such features can offer a considerable increase in mission effectiveness, placing the vehicle close to the threat to provide a highly accurate classification.

In 1990 Thomson Marconi Sonar SAS began development of a sonar to meet the above requirements. The aim was to develop high integrated front-end electronics using hybrid technology which could be located inside the array beam without the need for an extra electronic container. In addition, dual-frequency transducers were developed to perform detection and classification, resulting in a slim acoustic array just 0.7 m in length exhibiting low drag. These developments led to a sonar weighing just 80 kg, small enough to be fitted to a medium-size ROV. The vehicle selected to carry the sonar was the Bofors Double Eagle, a fully proven and highly manoeuvrable, low-magnetic and acoustic signature, ROV. Because the system has an almost coincident centre of buoyancy and centre of gravity, the vehicle can take up any attitude or position near a target to conduct observation, identification and place a mine disposal charge within a few centimetres of a mine.

The resulting PVDS design has realised a platform with much better performances than a VDS, at 500 m in front of the MCMV and using a detection frequency of 165 kHz (as opposed to the 30 to 80 kHz of a VDS) a bearing resolution of 3.6 m (compared to the 11 to 30 m of the VDS) is obtained.

The sonar is the TSM 2022 Mk 3 which is mounted at the front end of the Double Eagle with yaw and pitch mechanical stabilisation. Detection performance of the 165 kHz frequency sonar offers a search sector of 63° (mechanically steered) and a range on a sandy bottom of 500 m, an angular resolution of 0.7°, range resolution of 12.5 cm, and vertical beamwidth of 19°. The swept path is 300 to 400 m. The classification performance of the 405 kHz frequency sonar provides a 12° search beam which is electronically steered within the 63° classification beam operating to a range of 160 m, an angular resolution of 0.3°, range resolution of 6.25 cm and vertical beamwidth of 7°. For moored mine classification the vehicle is rolled through 90°. The Double Eagle weighs 400 kg (in air) and has dimensions of 1.9 × 1.3 × 0.8 m and a payload capability of 80 kg. Its maximum operating depth is 300 m and it can operate at a speed of 5 kt. The ROV is powered by eight thrusters (two forward, two lateral, four vertical) which can maintain the fish in any position. The umbilical cable is 600 m long and is very close to neutral buoyancy.

Operational status

The PVDS was demonstrated at Brest in October 1994. With the co-operation of the French Navy, and using the trials vessel *Thetis,* a series of demonstrations of the PVDS was given to a number of navies. Further demonstrations were carried out at Malmo, Sweden in September 1995 aboard the Landsort class MCMV *Ulvon.*

The IBIS VII system has been selected for the French Eridan class MCMV upgrade programme.

Contractors

Saab Bofors Dynamics AB, Motala, Sweden.
Thales Underwater Systems, Sophia Antipolis, France.

VERIFIED

Italy

Gigas

Type

Remote-control mine disposal vehicle.

Development

Gigas has been designed and developed to meet increasingly stringent operational requirements such as the ability to operate in sea currents up to 5 kt at great depths (down to 1,000 m), and at long ranges.

Description

Gigas is the latest vehicle to be developed by Gaymarine and is capable of operating in extremely demanding conditions such as river estuaries where currents of 5 kt may be encountered and in zero visibility. It can also be used in MCM operations in the open ocean where it can carry out surveillance missions to depths of 600 m or greater.

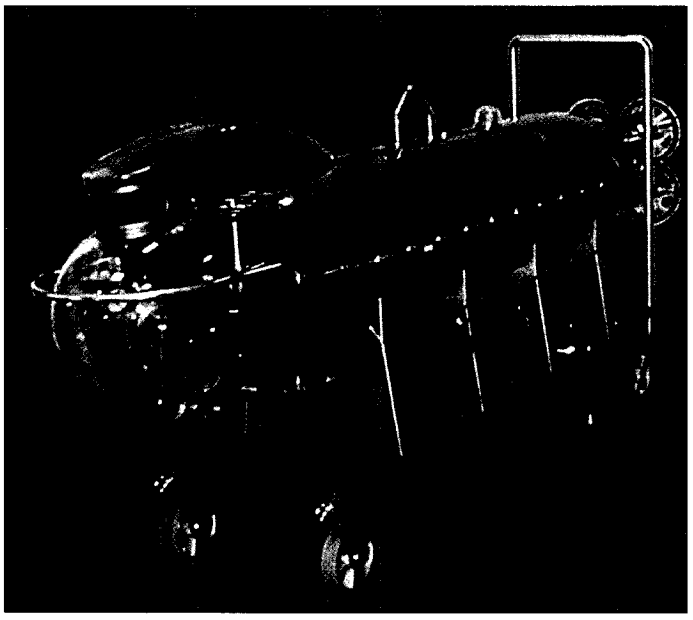
The vehicle is based on the proven technology of Pluto Plus and incorporates some 90 per cent of the components used in Pluto Plus (see Pluto Plus entry), thus improving logistics as many of the parts are interchangeable.

Gigas features a redesigned body constructed of carbon fibre composites; a new propulsion system with double the power of Pluto Plus and capable of giving

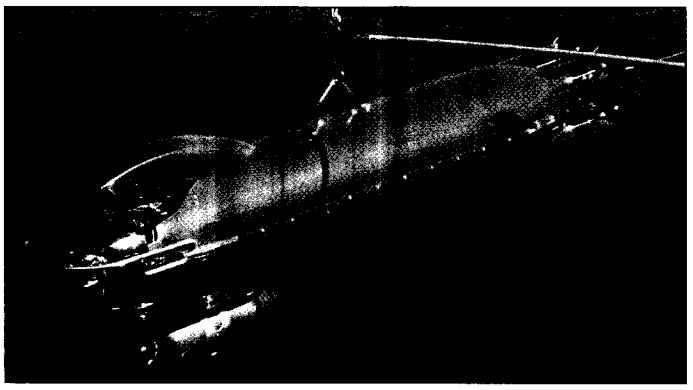
the vehicle a speed in excess of 7.5 kt; increased endurance; greater payload (1,000 kg in air); and greater depth (600 m). The propulsion system comprises four propulsors forward and four aft to control pitch, altitude and motion in three dimensions.

The vehicle carries a long-range (up to 200 m) high-resolution electronically scanned sonar for search and navigation in addition to the Gaymarine SID identification sonar fitted in Pluto Plus. The sector scanning sonar produces video maps of seabed objects covering a 60 m range on a 90° sector. In addition, the SID passive sonar with a 4 to 8 m range is used to identify located objects with its high resolution. A RESON long-range (100 to 120 m) sonar with a field of view of 90° is also fitted. Navigation has been improved with the installation of a Doppler log operating in conjunction with a computer system for automatic 'hands off' mission operation. An improved colour CCD TV camera is also fitted.

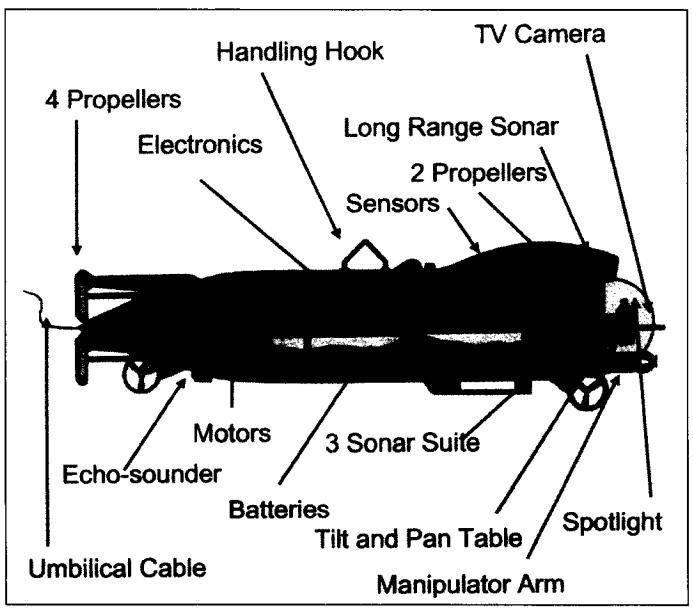
The vehicle can be preprogrammed for autonomous operation via an RF link or controlled using either fibre-optic or co-axial cable.



Gigas ***NEW***/1107990



Gigas (Gaymarine) 0064341



Gigas general arrangement (Gaymarine) ***NEW***/0589882

The umbilical link is a reusable, single-fibre, 2,000 m long optic cable, 4 mm in diameter with a breaking strain of 300 kg. The winch is similar to that used with Pluto Plus, but capable of generating an automatic constant pull up to 120 kg in currents between 3 and 5 kt. The control console and other equipment is identical to that used with Pluto Plus.

Operational status
Presented to the Italian Navy and an Asian navy in March and June 1997. Commencing in December 1999 the vehicle underwent a further period of intensive sea trials aboard an Italian Navy Gaeta class MCMV. Gigas will equip Yang Yang class minehunters of the South Korean Navy. Four systems have been ordered by the Italian Navy to replace the MIN Mk 2 ROVs. The system is also entering service with the United Arab Emirates.

Specifications
Length: 3.38 m
Width: 0.61 m
Height: 0.78 m
Weight: 600 kg (approx)
Operating depth: 600 m
Payload: up to 100 kg in air
Speed: 7-8 kt
Endurance: up to 12 h

Contractor
Gaymarine, Turate-Co.

UPDATED

MDS

Type
Mine disposal system.

Description
The MDS is based on a one-shot expendable self-propelled self-homing mini-torpedo derived from the A200 LCAW. It is designed for deployment from surface vessels or helicopters to counter drifting, moored and seabed mines. The device uses an advanced active acoustic seeker, which allows it to considerably reduce the time taken to clear a minefield or open a route through a minefield.

The system is not adversely affected by meteorological conditions or by underwater currents and can be deployed by day or night. The device consists of the Mine Disposal Torpedo (MDT), the control console and the launching system. The control console performs various computations to determine the best firing solution for the MDT, selects, presets and tests the weapon before firing, displays tube status and firing orders, tracks the target and MDT in real time, performs real-time cross correlation, and transmits orders for course, depth, activation of homing head and final attack procedure to the MDT via the guidance wire.

Specifications
Length: 1,250 mm
Diameter: 124 mm
Weight: 13 kg (approx)
Operating depth: 1-400 m
Speed: >15 kt
Range: 1,300 m (min)
Endurance: 3 min (approx)

Acoustic sensor
Detection range: 300 m
Mode of transmission: FM
Number of transmitted beams: 1
Coverage: 44° horizontal, 25° vertical
Number of received beams: 4
Coverage: 42° horizontal, 42° vertical

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Genoa.

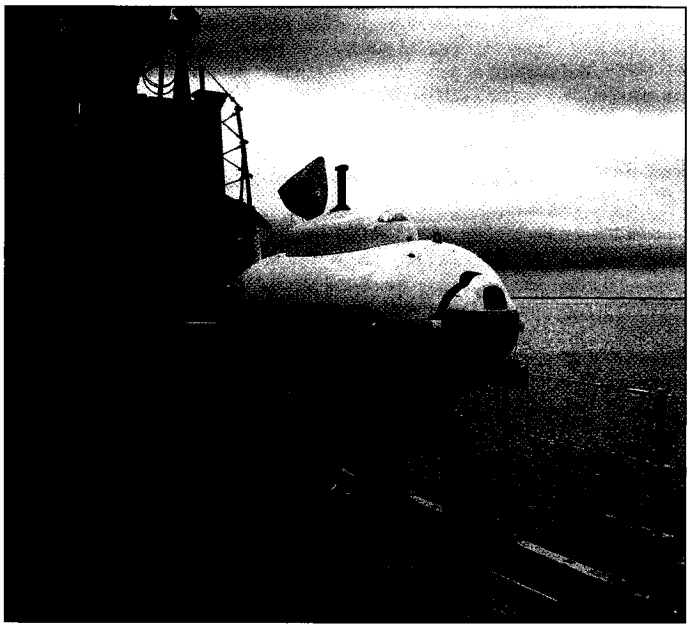
VERIFIED

MIN Mk 2

Type
ROV mine disposal system.

Description
The MIN (Mine Identification and Neutralisation) system, developed and produced for the Italian Navy by Whitehead Alenia Sistemi Subacquei and Riva Calzoni SpA, has the capability to identify and neutralise both bottom and moored mines.

The Mk 2 version has been developed from operational experience gained with the Mk 1, and is configured as follows:



MIN Mk 2 ROV on board an Italian minehunter

- one self-contained, hydraulically powered, wire-guided submarine vehicle
- a main console in the operations room for vehicle guidance and control
- a tracking system for autonomous localisation of the vehicle
- one portable auxiliary console for guidance and visual control of the vehicle during launch and recovery operations
- one set of operational accessories including: an auxiliary battery charging station and a device for oleopneumatic power pack recharging.

The Mk 2 vehicle is powered by a closed-circuit oleopneumatic accumulator, enhancing the low-noise profile and non-magnetic characteristics. A steerable main propeller allows the vehicle to approach the target detected by the minehunter's search and classification sonar. In addition, the employment of horizontal or vertical thrusters gives the vehicle a high manoeuvrability and hovering capability when submerged and high maneouvrability when surfacing for the recovery phase. Vertical manoeuvring, even to the maximum depth of the vehicle, is controlled through water ballast tanks which are filled or emptied by means of pressurised air; hydraulic power is consequently used only during transfer from and to the parent ship and during identification of the target. The TV camera and sonar are orientable through 150° in the vertical plane allowing flexibility of observation during both bottom and moored minehunting. The vehicle's operational depth has been increased to over 300 m.

The system can use two types of weapons (bottom charge and explosive cutter) thus enabling the hunting of either bottom or moored mines. The main console is of modular configuration and consists of separate processing units and an operator desk to minimise possible installation problems.

The desk on the main console is fitted with a control lever and a joystick for speed and direction control of the vehicle during the search and approach phases, and for fine positional adjustments of the vehicle when it is in close proximity to the target. The main console also incorporates the controls for the actuator of the high-resolution sonar in the MIN and for its tracking subsystem.

Two 9 in video display units are mounted on the operator's desk, a monochrome TV display and a high-definition display.

The sonar, which has been specially designed by Whitehead Alenia Sistemi Subacquei, is a HF unit allowing both identification of targets in conditions of poor visibility and a reduction in mission time by means of its target relocation capability.

The sonar features high resolution in both bearing and range, and is based on a transducer array specially developed using a diced-array technology. The sonar consists of a horizontal transmitting array, a horizontal receive array and a vertical receive array. It is a mechanical sectoral scan sonar with its own dedicated motor and comprises two major sub-units: the control and display unit which is integrated in the main console, and the underwater unit which is mounted on the vehicle and which consists of a sonar head and electronic assembly.

The detailed sonar image is displayed in either PPI presentation or B (linear) presentation. A profiling inform function is also available. The MIN Mk 2 and its control console is integrated into the MCMV combat system via serial datalinks with the command centre, parent vessel's search/classification sonar and parent vessel's gyrocompass.

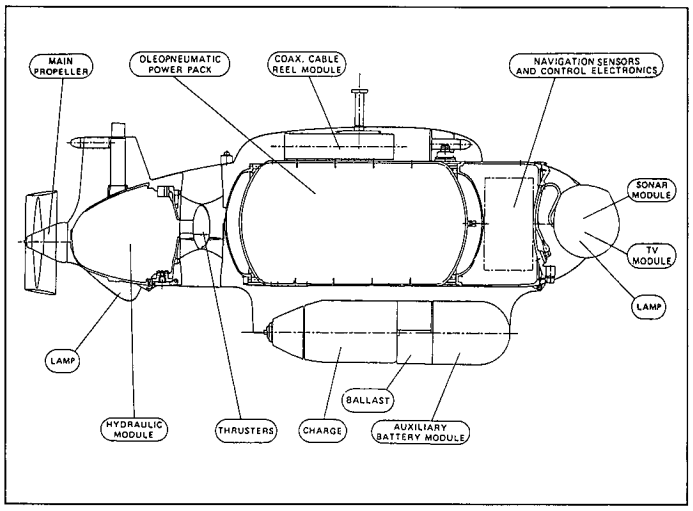
In addition, the MIN Mk 2 is fitted with an acoustic tracking system comprising an ultra-short baseline transducer mounted on the MCMV and a transponder on the vehicle.

The MIN Mk 2 system processes the data relating to the target under investigation, data from the combat information centre and the classification sonar, ship's data, vehicle data, vehicle position (from tracking and/or from the search sonar) in order to enable the operator to steer the vehicle towards the target following the optimum track and to manoeuvre the vehicle during transit from and to the MCMV.

Operational status

No longer in production.

Eight MIN Mk 2s are in service aboard the Gaeta class minehunters of the Italian Navy.



MIN Mk 2 vehicle arrangement

Specifications

Mk 2
Weight: 1,150 kg
Max diving depth: 350 m
Range: 1,000 m
Speed: 6 kt
Endurance: <1 h

Contractors

Whitehead Alenia Sistemi Subacquei SpA, Livorno, Italy. (subcontractor)
Riva Calzoni SpA, Bologna. (subcontractor)

UPDATED

Pluto

Type

Remotely operated mine disposal vehicle.

Description

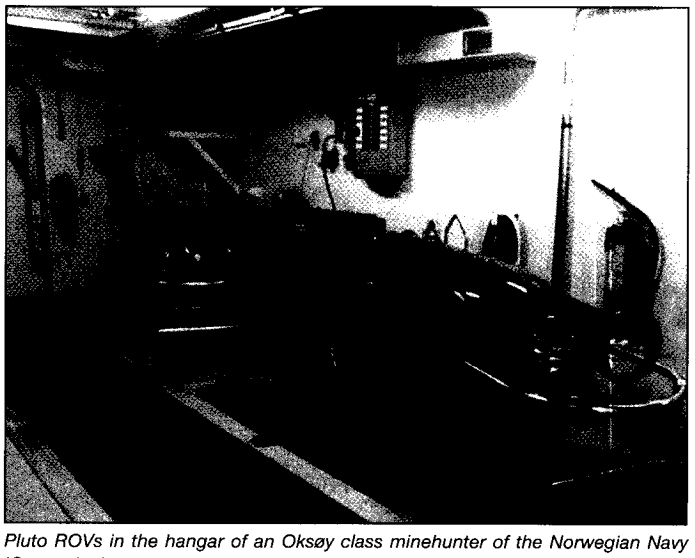
Pluto is battery-powered with a 6 mm, 500 m long umbilical cable. The vehicle is powered by five thrusters: two horizontal for forward/reverse, two vertical for vertical and lateral shift, and a transversal thruster. The thrusters are controlled by two joysticks. The vehicle can maintain automatic depth control within ±10 cm. Forward maximum speed is 4 kt and vertical speed 1 kt. The vehicle can operate in up to Sea State 4 and in sea currents up to 2 kt.

Sensors are mounted in the forward tiltable section of the vehicle. Optional equipment includes black and white LLTV, colour TV or still camera, search or scanning sonar (range 0 to 60 m), acoustic pinger, strobe flash, measuring instruments, manipulators and so on. There are 10 free channels for remote control and two four-digit telemetry channels for measurements.

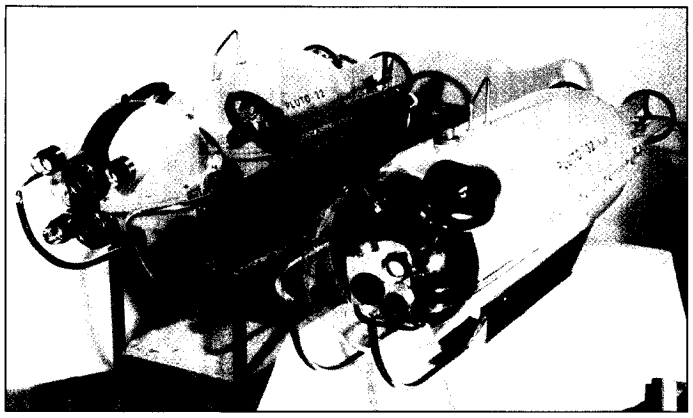
The console incorporates a 9 in TV monitor for display of information showing TV image, depth, compass, head tilt angle, elapsed time and sonar diagram. All displayed data can be video recorded.

Operational status

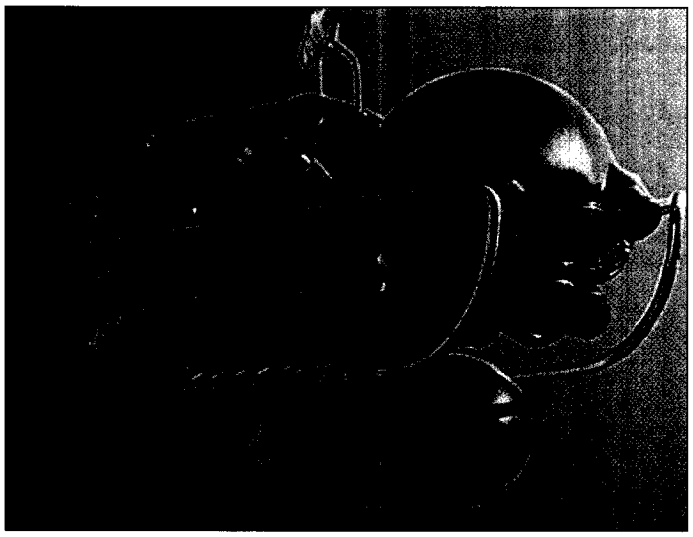
To date 80 units are in service with 10 navies.



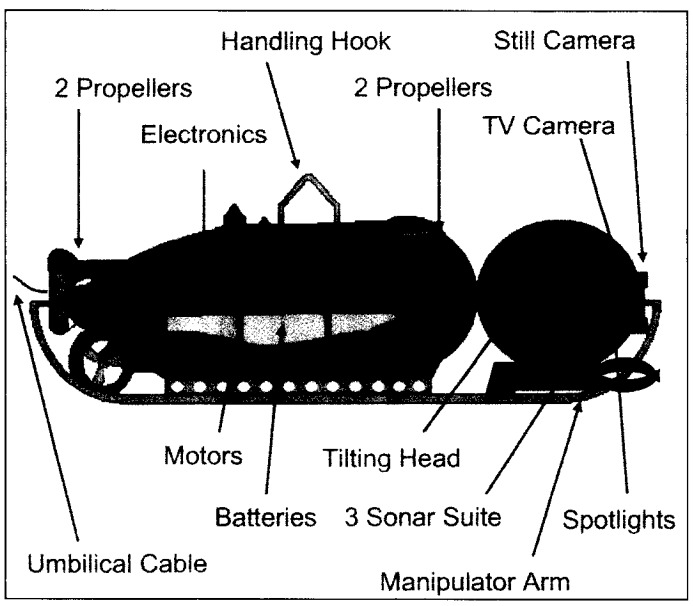
Pluto ROVs in the hangar of an Oksøy class minehunter of the Norwegian Navy (Gaymarine)
0143758



Pluto Plus (right) and standard Pluto (left)



Pluto (Gayrmarine) ***NEW***/1107994



Pluto general arrangement (Gaymarine) ***NEW***/0589880

Specifications
Length: 1.68 m
Width: 0.6 m
Height: 0.65 m
Weight: 160 kg (in air)
Operating depth: 300 m
Payload: 45 kg in air
Speed: 4 kt (battery), 5 kt (with power cable)
Endurance: 1.5 h at 2 kt(on batteries)

Contractor
Gaymarine, Turate-Co.

UPDATED

Pluto Plus

Type
Remote-control mine disposal vehicle.

Description
The basic configuration of Pluto Plus uses the latest fibre optic, floating, reusable 2,000 m long cable and hydrodynamic design to provide improved observation capabilities, extreme standoff range, an increase in speed to 6 kt, an increase in endurance from 2 to 6 hours (battery capacity has been doubled) and the lowest possible drag factor. The vehicle can be fitted with a wireless link that allows control to be exercised without the need of a cable.

The vehicle is fitted with special sonar sensors for navigation, search, obstacle avoidance and identification. The sensors are all mounted in a single package featuring ±100° tilt and ±80° pan. A single control console monitor gathers and displays the video picture, navigational data, sonar graphics and maps of the investigated area.

The vehicle exhibits low-magnetic and acoustic signatures and is resistant to shock and vibration to MIL-SPEC standards for minehunting.

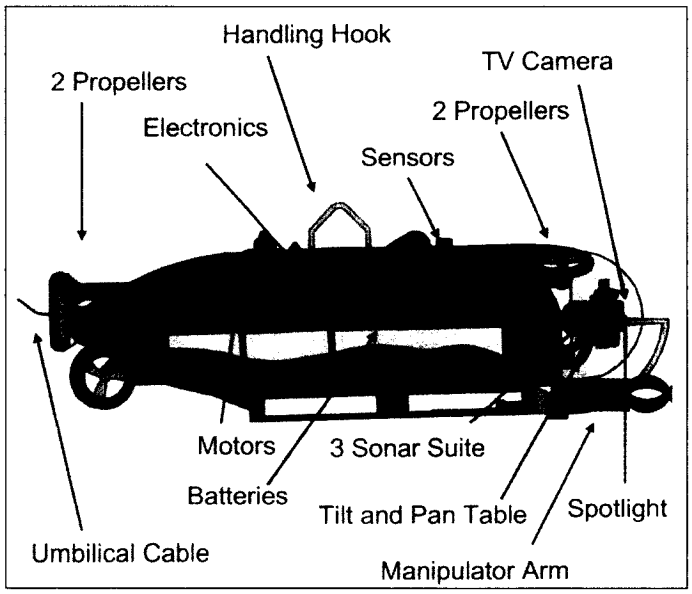
The lightweight, compact Pluto Plus is designed to operate from all kinds of vessels without special or expensive handling equipment.

Operational status
To date 36 units are in service with four navies (Nigeria, Norway, Spain (two on each Segura class MCMV) and Thailand).

Specifications
Length: 2.1 m
Width: 0.58 m
Height: 0.77 m
Weight: 320 kg
Operating depth: 300 m
Payload: 100 kg
Speed: 6 kt
Endurance: 2 h @ 3 kt (on batteries)

Contractor
Gaymarine, Turate-Co.

UPDATED



Pluto Plus general arrangement (Gaymarine) ***NEW***/0589881

Norway

Hugin 3000

Type
Autonomous underwater vehicle.

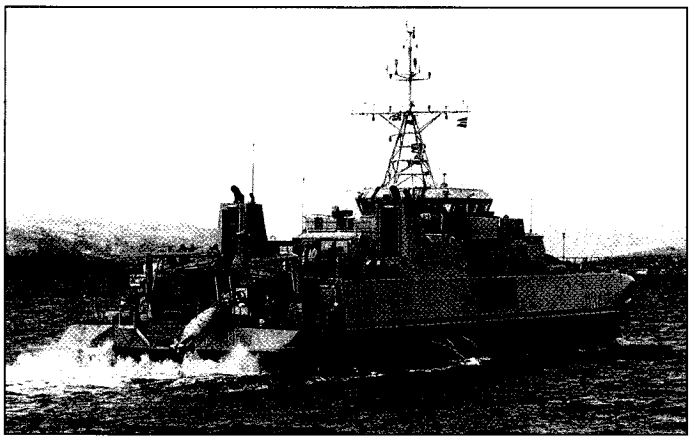
Development
The Norwegian Defence Research Establishment (FFI) initiated the AUV programme in 1991. Since then, three more vehicles have been designed and built, the Hugin 3000 being the third generation of these Hugin prototype vehicles, which have been developed and operated in partnership with the Norwegian oil company Statoil, the Norwegian Defence Research Establishment (FFI) and Norwegian Underwater Intervention (NUI). In order to develop a successful programme FFI has sought to pool the resources of the military and civilian communities.

Description

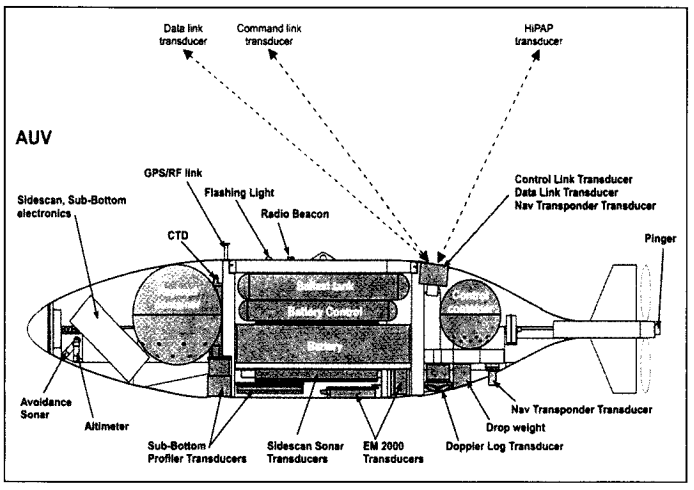
The Hugin 3000, rated to 3,000 m water depth, is 5.3 m long and is powered by a 40 kW aluminium oxygen fuel cell battery, providing a mission endurance of more than 60 hours before needing to resurface to recharge the battery. Aluminium anodes are changed every 120 hours. To reduce turnround time to a minimum two batteries can be cycled and battery maintenance is performed during normal operations. The battery operates using a chemical reaction between aluminium and oxygen using hydrogen peroxide fluid as an oxidant. To comply with environmental regulations all waste is stored for later recycling.

For survey operations, the vehicle is integrated with a variety of sensors including the Simrad EM 2000 and 3000 multibeam echo-sounder for swath bathymetry and imagery. Other survey sensors include chirp side scan sonar, a chirp sub-bottom profiler, and CTD. Underwater positioning is performed using an Aided Inertial Navigation System (AINS) integrating navigation sensor data from a Doppler Velocity Log, acoustic altitude and forward looking sensors, depth sensor and for surface reference, DGPS. In surface support mode the AINS is updated regularly, with inputs from the HiPAP SSBL (Super Short Base Line) system. This is presently achieving real-time positioning accuracy of less than 10 m, with post-processed accuracy of 2 to 3 m water depths down to 2,500 m. Acoustic links for control of the vehicle, reading of sensor data and emergency control is also part 6 of the delivery.

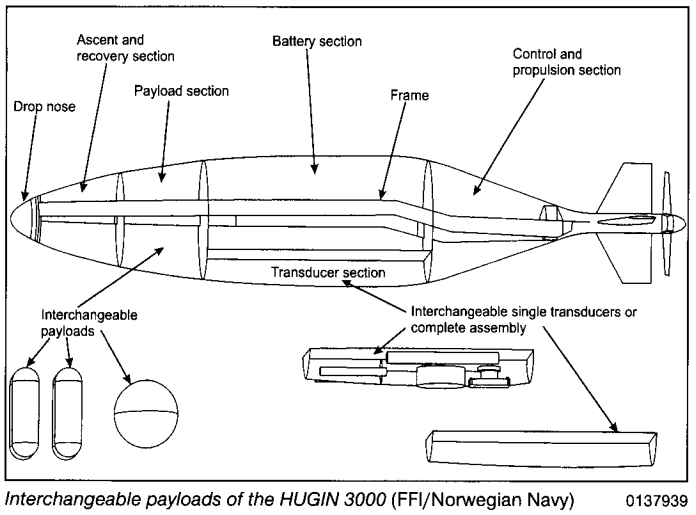
During survey operations, 10 per cent of data is transmitted in near-realtime to the surface for quality assurance. During normal dive duration of 50-60 hours over 60 Gb of data is collected and stored in the vehicle.



Preparing to launch the Hugin 3000. Note the cradle angled ready to tilt down to the water to slip the vehicle into the water. (FFI/Norwegian Navy) 0137943



Block schematic of HUGIN 3000 (FFI/Norwegian Navy) 0137942



Interchangeable payloads of the HUGIN 3000 (FFI/Norwegian Navy) 0137939

The Hugin is deployed from the stern of the vessel, the vehicle being supported on a cradle until securely in the water, thus at no time is the vehicle left hanging in the air. The launch and recovery system guides the vehicle all the way from its storage container into and out of the water. The system is housed in a container mounted at the stern of the parent vessel. During launch, the cradle with the vehicle on it is tilted down into the water with the ship slowly moving ahead against the wind and waves, whereon the vehicle is released into the sea. In recovery, the ship positions itself some 50 to 100 m to the side from where the vehicle will resurface. When the vehicle broaches the surface, it releases its nosecone to release a recovery line, which is captured by a standard air-driven rescue harpoon. The Hugin is then drawn on to the cradle, raised, and returned to its storage container.

The vehicle consists of four sections: the control and propulsion unit (aft); the battery section (centre top); the transducer bay (centre bottom) and the payload control section (forward). The aft titanium pressure container in the control section houses the control processor, navigation processor, inertial measurement unit, and electronics for the acoustic command and datalinks, while the large titanium pressure container in the payload section provides space for the different payload instruments. The transducer bay can be easily disconnected and replaced to enable rapid reconfiguration of the vehicle for different missions.

In the minehunting mode, Hugin can operate autonomously for around 24 hours providing an accurate map of the mine threat situation in the area of interest. The main sensor for mine detection and classification is either synthetic aperture sonar or commercial multibeam focused side scan sonar. For accurate autonomous positioning terrain-aided navigation system will supply the traditional Doppler-aided inertial navigation system.

Apart from survey and minehunting operations, the vehicle could also be used as a tool in submarine navigation research.

Operational status

The first Hugin 3000 was delivered to C & C Technologies in mid-2000. It is now operational in the Gulf of Mexico on behalf of British Petroleum. To date the vehicle has operated at depths to 2,400 m. Demonstrations of Hugin in the minehunting configuration for autonomous mine detection, classification and positioning were carried out in December 2001. A risk reduction activity designed to prove general functionality and operation in the MCM role, it saw an adapted Hugin I vehicle employed in two different mission modes. On its first run, the AUV was controlled from on board Oksøy class minehunter *Karmøy* and continuously sent back bottom map sonar pictures to the support vessel. The second run saw the AUV preprogrammed to operate autonomously and deployed 'up threat' to conduct a covert survey in a field of dummy mines. In both missions, the AUV vehicle was 'flown' at a depth of approximately 125 m, around 50 m above the sea floor. The vehicle was equipped with a multibeam echo-sounder and a side scan sonar. An improved sensor package (to incorporate a higher resolution side scan sonar or a synthetic aperture sonar) is being planned by FFI and Kongsberg Simrad for future trials.

A full capability demonstrator system (most probably based on the Hugin 3000 vehicle) is planned for delivery to the RNoN around 2005 for an operational evaluation. The RNoN sees the vehicle being used for route survey, forward mine reconnaissance and mapping, and rapid environmental assessment.

Specifications

Length: 5.35 m
Diameter: 1.00 m
Weight: 1,200 kg
Speed: 4 kt
Operating depth: 3,000 m
Nominal battery power: 1,000 W
Endurance: 60 h at 4 kt
Sensors: Simrad EM 2000 and 3000; Edgetech side scan sonar and Chirp 120/410 kHz sub-bottom profiler, Chirp 2-16 kHz magnetometer (optional)

Contractor

Kongsberg Simrad A/S, Horten.

UPDATED

Minesniper

Type

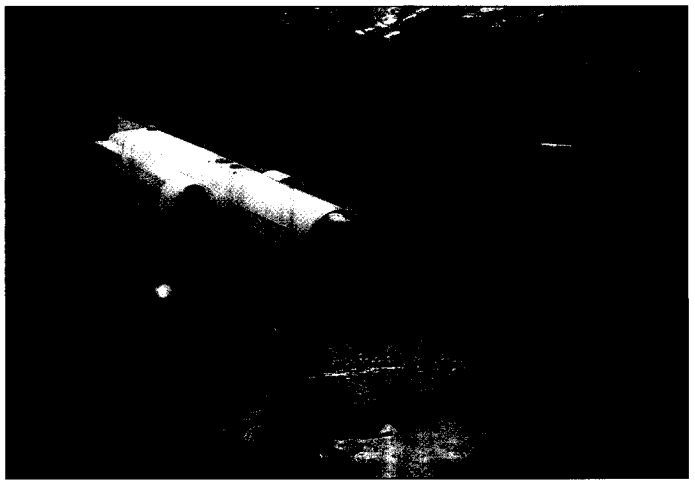
Expendable mine destructor vehicle.

Development

Development commenced in 1990 as a technology demonstration project in co-operation between the Norwegian Defence Research Establishment (FFI) and Bentech Subsea AS (acquired in 1993 by Simrad and now part of Kongsberg Gruppen). In 1992 the Norwegian Naval Material Command awarded a contract for a prototype system of five vehicles. The system was installed on the Norwegian minehunter *Tana* in May 1994 for tests and sea acceptance trials were undertaken in September 1994.

Description

The Minesniper is a lightweight mine clearance system utilising an expendable ROV-type weapon for mine verification and destruction against both moored and seabed mines.



Minesniper mine clearance system 0009514

Minesniper is guided automatically towards the target by the ship's sonar using position updates from the sonar, when the operator takes over manual control to carry out inspection and destruction. A specific acoustic responder ensures that the weapon is clearly visible on the sonar screen, together with the target. Alternatively the weapon may be fitted with a relocating sonar enabling it to attack mines in a general geographic co-ordinate system. Minesniper comprises a dedicated short baseline acoustic positioning system to bring the weapon rapidly into the sector covered by the sonar beam.

The communication cable to the weapon consists of a 0.25 mm optical fibre. The weapon is self-powered with a rated operation time of 60 minutes and a maximum travelled distance of 4,000 m. The maximum speed is 6 kt. The weight of the weapon is about 25 kg in the standard version which is depth rated to 500 m.

The weapon carries a short-range scanning sonar for relocation of the target, an LLLTV camera mounted behind a glass nose for inspection/verification and a lightweight shaped charge for detonation of the mine. In the inspection phase, the weapon is controlled manually by use of a joystick. A dedicated navigation display in combination with the camera picture and a model-based navigation system enables the operator to manoeuvre the vehicle accurately during the final homing operation. The vehicle features high manoeuvrability (4° of freedom in surge, heave, pitch and yaw) is intrinsically stable in roll with a hovering capability all achieved with a minimum of movable control surfaces. Two horizontal thrusters are mounted at the midpoint of the vehicle allowing zero turn radius for inspection and alignment of the warhead. A vertical thruster acts through the centre of buoyancy to decouple heave and pitch and ensure stability without the need for complex and extensive thrust and control surfaces.

The existing version of Minesniper is fitted either with a 72 mm shaped charge (M72) of 300 g of Octol explosive or a 122 mm shaped charge of PBXN9 or PBXN110. A new SAP warhead fired from a semi-armour piercing gun developed by QinetiQ in the UK has been successfully demonstrated by the Norwegian Navy. A laser pointing device highlights the point of impact for the gun. The Mk 2 version may also incorporate a new 360° sonar, a 6,000 m long fibre optic link and a new control surface to improve manoeuvrability. The Mk 2 consists of three modular sections: sensor, payload and control and propulsion unit. This enables a variety of sensors and warhead payloads to be fitted, but retain the same control and propulsion module for all configurations. The Mk 2 version is under consideration for modernising the Norwegian Oksoy class minehunters.

A typical operation will take between 10 and 15 minutes from the time the decision is taken to deploy the weapon until destruction of the mine is verified at a range of around 500 m. A training vehicle is available along with a built-in simulator in the navigation computer.

Minesniper can use existing equipment for launching, positioning and display, and requires a small amount of explosives stored on board. Significant reductions in personnel risk combined with an increased system performance can thus be obtained in return for moderate investments in additional equipment.

Operational status
In development. Initial sea trials with Norwegian Navy aboard minehunter *Tana* in 1994. The first operational system was installed in the Norwegian MCM fleet in 2001. The Spanish Navy has also ordered four inspection and training Minesniper systems for the Segura class vessels *Duero* and *Tajo*. Options provide for the four Segura class units already in service to be subsequently fitted with Minesniper. Combat rounds armed with a 137 mm shaped charge warhead will be procured by the Spanish Navy at a later date.

Specifications
Mk 2
Length: 1.9 m
Diameter: 200 mm
Weight: <30 kg
Speed: 6 kt
Operating depth: 500 m
Range: 4,000 m

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

UPDATED

Sweden

Double Eagle Mk II

Type
Remotely operated mine disposal vehicle.

Description
The Double Eagle Mk II is the new improved version of the proven Double Eagle system. The ROV is a comparatively lightweight system with extremely good manoeuvrability fitted with powerful high-speed thrusters for use in currents up to at least 3 kt. The vehicle is driven by eight thrusters giving over 6 kt forward speed, 3 kt reverse and 2 kt horizontally. Double Eagle Mk II is fitted with a computerised stabilisation control system and is extremely manoeuvrable, exhibiting unlimited movements in 6° of freedom (pitch ±180°, roll ±180°) which gives an operator the possibility to dive the maximum depth with maximum speed (>6 kt). Control is exercised through two joysticks: one for yaw, sideways, forward and reverse movement and one for movement in the vertical plane, roll and pitch.

The display comprises a monitor (or several) displaying the picture from a colour camera. Digital data such as heading, depth, pitch and roll angle, cable twist, leakage warnings, real-time clock with date and time and diagnostics are superimposed on the TV monitor. High-quality video is assured through the fibre optic link in the umbilical cable the standard length of which is 1,000 m. The link can carry two video/sonar channels with additional serial data channels should these be required.

The vehicle can be equipped with several types of sensors and tools such as sonars (electronic scanning mounted tiltable 0 to 90° or conventional), echo-sounders, Doppler logs, tracking system, automatic navigation system, lights and manipulators.

The vehicle uses a unique precision charge placement technique using an aiming sight to position the mine disposal charge with very high precision. The vehicle remains in an absolutely stable attitude as the charge is released which allows the operator to accurately control the operation and handling of the vehicle.

The system uses a tool which allows the vehicle to be launched and recovered from any ship equipped with a sea crane.

The vehicle has unlimited endurance which allows it to be moved from target to target for as long as necessary.

The Double Eagle Mk II is equipped with two 5 kW brushless motors for forward motion and six 0.4 kW brushless motors for movement in other planes.

Operational status
The ROV is in service with the navies of Australia, Denmark, Finland (who have acquired a containerised Double Eagle system for COOP operations) and Sweden (it has also been specified for the new 'Visby' corvettes as the ROV-5 variant equipped with a CDC/Reson sonar) and in commercial versions in France and South Korea.

The Mk II has also been ordered by the French Navy in the PVDS version for the upgrade of the Eridan class MCMVs.

Specifications
Length: 2.2 m
Width: 1.3 m
Height: 0.5 m
Weight: 350 kg (in air)
Payload: >80 kg
Speed: >6 kt
Operational depth: 300 m (optional 500 m)

Contractor
Saab Bofors Dynamics AB, Karlskoga.

UPDATED

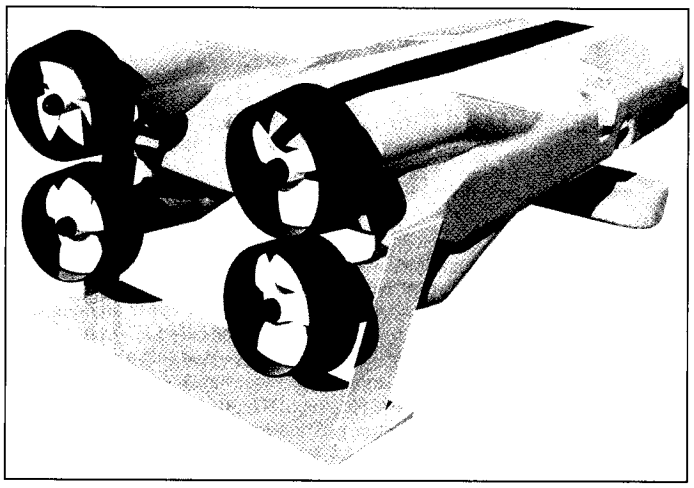
Double Eagle Mk III

Type
Remotely operated mine disposal vehicle.

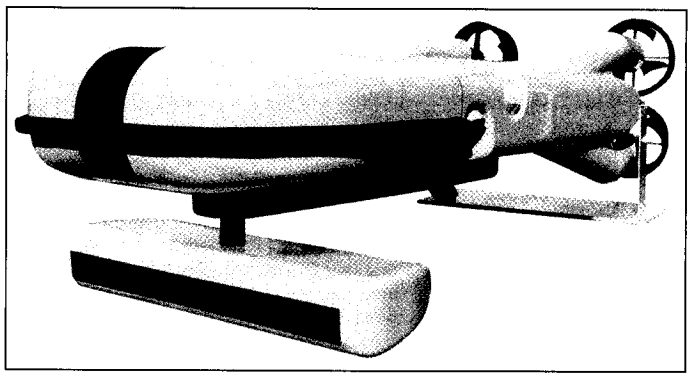
Description
Saab Bofors Underwater Systems AB has developed a new ROV, the Double Eagle Mk III. The primary mission of the Mk III is to act as a platform during MCM operations that could be minehunting and/or mine disposal.

The Mk III is a new generation of ROV and offers significantly improved performance when operating in strong currents. This has been achieved by doubling the power to the vehicle and by increasing the number of motors for the main forward propulsion system from two to four 5 kW brushless motors. The amount of available thrust therefore will be twice that of the Double Eagle Mk II.

The Mk III could be offered to existing Double Eagle operators as a way to further expand the flexibility of their ROV operations. The control and support equipment for the Mk III are to a great extent common to that for the Mk II. The main differences are that there are two 400 Hz power converter units rather than the single unit of the Mk II.



Mock up of the Double Eagle Mk III stern view 0114957



Mock up of the Double Eagle Mk III bow view 0114958

In addition the Mk III requires a different tether. The tether can be operated using the same winch as with the Mk II. The tether can be changed at sea, so that during one mission a minehunter or COOP can operate both the Mk II and Mk III versions.

Double Eagle Mk III has the same dimensions in height and beam as the earlier version, but will be extended in length from the 2.2 m of the Mk II to approximately 3 m, and will exhibit an increase in weight from 360 kg to 500 kg.

Together with the improved hydrodynamic performance offered by the lengthened body and the existing lateral propulsion system from the Mk II, the Mk III will be able to perform precision manoeuvring in high currents up to 5 kt. The longer body will also allow an increase in mission payload, for example by installing further sensors or charges.

A stabiliser has been added underneath the aft part of the Mk III for even better controllability of the vehicle underwater when operating at the higher speed.

Operational status

A developed version of the Mk III is on order for the Visby class corvettes and Landsort class MCMVs for delivery between 2005 and 2007. Standard Mk III vehicles are being delivered for the Belgian and Netherlands navies for the Tripartite mid-life upgrade.

Contractor

Saab Bofors Dynamics AB Karlskoga.

UPDATED

United Kingdom

Archerfish

Type

Self-propelled MCM munition.

Description

Archerfish is a low-cost, self-propelled, torpedo-shaped, one-shot mine disposal munition, which has been developed to reduce time on task, operator workload and risk. The vehicle is powered by two multi-orientation electrically powered propulsors, The thrusters operate in conjunction with a device that rolls the battery through ±90° and move it fore or aft for pitch and roll control. This arrangement allows the vehicle 6° of movement in the hover mode, enabling it to operate in currents of 3 kt so that it can position its nose against the target. The power units can operate in either transit mode for rapid movement (4 to 6 kt) between ship and target, or in hover mode during identification and destruction of the target.

The battery-powered munition is deployed from the MCMV and is automatically navigated to the target area using an acoustic positioning system. Using either auto height or auto depth the vehicle approaches the target area, relocating the contact using either the vehicle's sonar or camera. Following target identification the vehicle is precisely positioned adjacent to the mine which allows it to be control detonated using the vehicle's directed energy warhead.

Archerfish receives commands via the 2,000 m fibre optic telemetery and communication link dispensed from the rear of the vehicle. As the target is approached speed is reduced and the hover mode engaged, allowing Archerfish to manoeuvre around the contact in all axes.

An electronic scanning sonar with a range of 50 m and LLTV camera are used to provide visual display from which the vehicle can be terminally guided on to the target using a joystick control. In the terminal approach, the vehicle's own short-range sonar and video link acquires the target and transmits more detailed information to the ship. The onboard sonar is dual mode and can be switched to imaging for use in turbid water. The vehicle also carries a light and an altimeter. Beamforming and processing take place in a console aboard the launch platform.

The warhead is a dual function directed energy/blast warhead charge of Plastic Bonded Explosive (PBX) developed by SNPE of France which is effective against the latest composite explosives in ground and moored mines.

The system includes a comprehensive PC-based simulation package for operator training or exercise simulation. Operators can customise and upgrade the software to meet their own requirements.

A typical mission time for Archerfish lasts between 5 and 12 minutes, the vehicle operated at depths between 0.5 and 300 m at speeds of 4 to 6 kt.

Operational status

Archerfish was to have been offered to meet the requirements for the UK Hunt class mid-life update (HMLU) programme. However, since this programme has been scaled down in scope to a Hunt Minimum Update (HMU), an 18 month feasibility study has concluded that the single-shot mine disposal technology was not sufficiently mature for the commencement of the HMLU, and will not be included in the HMU.

The US Navy has selected the Archerfish system for the AMNS programme. Main trials for Archerfish have been scheduled for October 2004 with a final announcement regarding contract to be made in the first quarter of 2005.

Contractor

BAE Systems, Underwater Weapons Division, Waterlooville, Hampshire.

UPDATED

Hyball

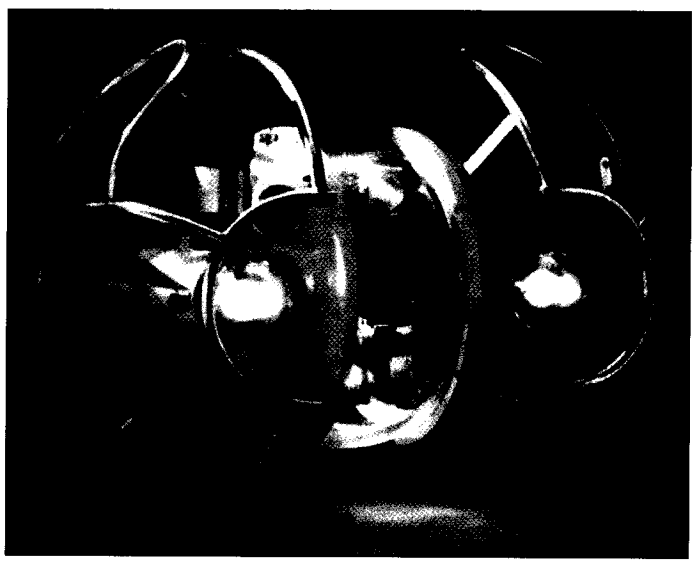
Type

Remotely operated underwater vehicle.

Description

The Hyball is a small, portable vehicle designed principally for inspection of ships' hulls, harbour installations, buoys and moorings, seabed installations and so on. The vehicle's standard equipment fit includes a low-light CCD colour TV camera with wide-angle auto-iris lens mounted on a chassis which pitches through 360° and allows the camera to view up, down, forward or backwards through the unique patented Meridian viewport. TV pictures are relayed to a 15 in colour monitor in the surface platform. For poor visibility conditions a low-light monochrome SIT camera may be mounted on the standard camera chassis together with the stills and colour cameras. The vehicle is also fitted with two fixed 75 W quartz halogen lamps pointing forward and two 75 W lights mounted on the camera chassis which follow the camera.

Vehicle status information is displayed along the bottom edge of the monitor screen and includes text lines for information such as customer name, job number or location which is defined by the operator at the beginning of each dive. The video overlay may be dimmed or switched off by the operator.



Hyball from the front (Hydrovision Ltd) 0131455

The Hyball is powered by four thrusters, two for forward, reverse and rotational motion and two for vertical and lateral movement. Power is derived from 0.5 hp 24 V DC brushed motors through 10.5:1 reduction gearboxes driving 5 in diameter propellers mounted in Kort nozzles. Thruster speed and direction are controlled by digital signals proportional to movements of the joystick. Vehicle movement is controlled by the single three-axis joystick and dive and surface buttons on the hand controller. Any combination of vehicle movement control may be held by the use of the trim button for hands-off operation or for recentering the joystick when operating in a cross-current. Vertical thrust power may be preset from the surface unit panel.

Operational status
In service with the navies of Germany, Iran, Italy, Philippines, Turkey and UK.

Specifications
Length: 0.535 m
Width: 0.65 m
Height: 0.565 m
Weight: 42 kg
Speed: >2.5 kt
Operating depth: 300 m
Payload: 4.5 kg

Contractor
Hydrovision Ltd, Aberdeen.

VERIFIED

Marlin

Type
Autonomous Underwater Vehicle (AUV).

Description
The electrically propelled Marlin demonstrator UUV is intended to be capable of being launched from 'Trafalgar' class submarines using the water ram discharge system. The interfaces with the submarine have to reflect the portable nature of the system and the consoles will have to be located within the weapon stowage compartment for space availability reasons and the interface with the boat's cabling and discharge systems has to be local to the torpedo tubes. Ancillary equipment such as communications transponders and homing beacons also has to be fitted on a temporary basis. Although the UUV is designed for operation from a submarine, for development and trials purposes it will also be launched in a swim-out mode from a towed or static launcher.

Marlin is designed to operate in littoral waters and has a depth rating in excess of 350 m. It has a nominal transit speed range from 3 to 15 kt. It features a seabed-following mode and is capable of decoupled pitch/heave, yaw/sway and yaw/roll motions by virtue of its extendable fore planes. Endurance is 4 hours, but can be increased by using alternative battery cell technologies.

Marlin can operate fully autonomously, or in an operator-influenced mode via the fibre-optic communications link. Missions are structured to consist of a series of discrete life cycle phases. A typical mission life cycle will start with the mission download stage where a mission plan, once validated using a real-time simulator, is downloaded from the console via a pre-launch umbilical which is routed through the submarine's wiring.

After loading into the torpedo tube, the navigation system is initialised from the submarine's navigation system via the console. Launch is carried out using the UUV's own console. Immediately on exiting the torpedo tube, Marlin starts its propulsion and is commanded to maximum sprint power (circa 20 kW) in order to manoeuvre away from the submarine. Once safely clear and fibre optic communication link and acoustic communications have been established, the vehicle will conduct a fast transit run to its operational area.

During the main mission, the vehicle may conduct navigation assistance manoeuvres to update its navigation fix or it may change to an alternative mission plan. Navigation is waypoint-based with reference to absolute geographical co-ordinates. Positional accuracies of better than 10 m are expected. At the end of a mission, the UUV adopts a holding position at a predetermined location to await instruction from the host submarine to conduct the docking manoeuvre. Marlin homes on a docking beacon and, by means of a series of planned and validated manoeuvres, progressively homes onto a point in close proximity to the docking mechanism on the submarine. Once final lock-on is commanded, Marlin moves forward to dock with a mechanism that will re-insert it into the torpedo tube, thus allowing it to be recovered back into the submarine for turn-around for a second mission.

As the primary role of the UUV is to demonstrate operation from a submarine, the payloads are notional to demonstrate only generic capability. Data from the payloads can be passed to the console via a fibre-optic link. This real-time link provides the operator with the facility to monitor and control the payloads and to intervene in the conduct of a mission. The modular console is arranged such that payload monitoring and control is achieved by means of stand-alone console units that do not necessarily have to be present for all mission scenarios.

Propulsion and manoeuvring systems are based on adaptations of proven torpedo technology. However, because of the lower speed requirement a brushless DC electric propulsion motor has been chosen for the main propulsion. Actuators are digitally controlled electric systems.

The guidance subsystem is based around a BAE Systems 600 kHz concave transducer head Workhorse Navigator-based Doppler velocity log and an inertial navigator with updates from Differential GPS (DGPS). Initialisation is from the submarine's navigation system (or by the operator for routine trial purposes). The design allows for future fitting of a precision navigator. A terminal homing sonar system is incorporated into the nose section.

Data logging of UUV functional and performance parameters is carried out on board the UUV using a ruggedised hard disc drive. Data is also transmitted to the console via the fibre optic link. Console and payload data will be logged on recorders within the console.

The Mission Management Software (MMS) is the core of the system and is split between the console and the UUV. The UUV MMS allows for the full conduct of the mission while the console MMS provides the operator with a Graphical User Interface (GUI) and the facilities of mission planning and post mission data analysis. Linking into the UUV MMS are manoeuvring, guidance, payload control and data logging tasks distributed across a number of PC processors. Owing to the 'real time' aspects of the UUV software, the vehicle's operating system is 'VXWorks' with code written in ADA. The use of ADA has been carefully considered and this language was chosen to make provision against the possibility of safety critical or safety related software. At present, although there are clear third-party safety concerns about the operation of UUVs in littoral waters, the overall system design has been managed such that the software does not become safety related or safety critical.

Console software does not need to operate in true 'real time' mode so, in order to provide future flexibility and in order to use standard tools and applications, Windows NT has been used as the operating system. The core of the software remains as ADA, however the GUIs are coded in C++.

The Marlin UUV is a torpedo-shaped vehicle, externally similar in form to the Spearfish torpedo. A modular approach has been followed whereby sections can be re-arranged or replaced if payload or operating requirements change. The tail configuration is visually similar to Spearfish in order to negate any risk of discharge damage from the torpedo tube. The parallel portion of the pressure hull is a single pressure vessel apart from the nose that carries the payload units. A major difference from Spearfish is, however, the fore plane section which houses horizontal and vertical manoeuvring planes to allow precise control at low speed and decoupled motion. A maximum of 6° of freedom manoeuvrability is achieved using traditional aft-mounted control surfaces driven by digitally controlled electric actuators, supplemented by the controllable fore planes.

Owing to its requirement to operate at low speed, Marlin has to be configured to maintain its weight and centre of gravity within very tight constraints. The forward payload section (nose) is free-flooding (unpressurised) to allow COTS payloads to be fitted, however, while giving flexibility in the payload attachment, this causes difficulty with mass properties. In an extreme case, over 100 litres of water may become entrapped within the structure. To militate against the effect of this, syntactic foam blocks are fitted to displace the majority of the water. The nose structure also includes several safety related systems. To assist with recovery, a flotation bag is fitted, which also acts as a visible marker against the possibility of a collision from any inshore craft during development activities. A xenon light and tracking transponders are also fitted. A terminal homing system is fitted to enable the vehicle to dock with a submerged submarine. This unit is also located within the nose and operates through a polycarbonate acoustic window.

The remainder of Marlin's payload capacity is provided by a further 1 m of empty pressure hull spanning the centre of gravity. At present this is occupied by the side scan electronics, torpedo range tracking equipment and ballast.

Aft of the nose is an empty spacer section that is available for payloads or could be replaced by a new section incorporating horizontal and vertical manoeuvring thrusters. Adjacent to the tail is a further spacer section capable of carrying thrusters. These two 'thruster' sections are spaced as far apart as is practical in order to make provision for the greatest possible manoeuvring capability.

Following the concepts of modularity and low cost operation, the battery section has been designed to house physically interchangeable battery stacks. Within the current contract, two alternative batteries are provided, lead acid and silver zinc, however alternatives such as Lithium Ion could readily be fitted. The power distribution system is located at the aft end of the battery section and is engineered such that the risk of electromagnetic interference within the vehicle is minimised. Power converters are distributed throughout the vehicle, but all are synchronised to a master clock within the power distribution unit. The heart of the vehicle is the control section that is split into two physical units. The aftermost of these units contains all of the hull penetrating sensors such as the Doppler velocity log, pressure transducer, communications transducers and range tracking transducers. Also housed within this section are the navigation and guidance sensors and the safety interlock systems necessary for the operation of Marlin from a submarine. These safety interlocks are based on those proven in the liquid-fuelled Spearfish torpedo.

Within the forward part of the control section is the main processor system and data logging facility. This has been designed to be expandable for future upgrades. Marlin also includes internal monitoring and fault detection systems, which are located in this area. Navigation processing is a function of the main processor system. However, an interface has been provided for future upgrading by the installation of a precision navigation system.

Marlin carries a fibre optic communication system providing the operator with the ability to monitor the payloads in real time. The electronics for this are housed within the aft control section, however, the major impact of this sub-system upon the vehicle design is the provision of a large dispenser housing within the aft spacer section. This is a free-flooding pressure vessel capable of containing well in excess of 50 km of 250 µ optical fibre or shorter lengths of more ruggedised fibre. This fibre exits from the vehicle via a payout tube routed through the tail.

The submarine element of this communication system will be based on a hosepipe and tube-mounted dispenser concept similar to that used with wire-guided torpedoes. As Marlin is a relatively low-speed vehicle, an active release device has been incorporated into the design to avoid the need for shear pin mechanisms (since the vehicle may lack sufficient power to break it). The geometry of the tail is determined by the need to interface with the torpedo tube interfaces. This includes the umbilical interface to the submarine's combat system and safety lanyards to detect launch and to prevent propulsion start up within the torpedo tube.

The console consists of five separate units that can be individually embarked into a submarine through either the weapon embarkation route or the normal personnel access hatches. Within the submarine, the console will be set up on empty torpedo stowage and will link into the submarine combat system via the torpedo tube service modules. Because of its location within the magazine area of the submarine, the console units have had to be designed in accordance with the magazine safety regulations. The units are thus ruggedised and sealed and have zero RF emissions.

The console provides for mission planning and mission control and acts as a post mission data processing facility. Prior to a mission the console can be used to conduct system level testing of the UUV and, when used in conjunction with the RTS, provides a full mission simulation facility whereby missions can be 'bench tested' prior to the UUV going into water. The console system also provides the means of initialising the vehicle's navigation system. The console units used for any particular mission depend on the payloads fitted to the UUV.

The front panel carries all of the interconnections to the other consoles and provides the operator with the non-software driven launch enable and launch initiate controls.

The MMS console provides the facility for mission planning, mission control and post mission data processing. Like the interface console it is a fully ruggedised unit and is equipped with a low-emission LCD and sealed, magazine safe keyboard and joystick. The joystick provides the facility in certain mission phases for the operator to take over direct control of the UUV.

The payloads control console depends on the payloads fitted for a specific mission, however, for the current UUV payload configuration a further three console units are used. One of these is simply a recorder unit for video data; the other two are based on the MMS console and display sonar and video data. The system is arranged such that the payload console, equipped with keyboard, can be used as a backup to the MMS unit in the event of a system failure. Data from individual consoles is available on an Ethernet link between the consoles, thus allowing payload data to be shown in windows on the MMS console. In normal usage, two operators would operate the console during a mission. One operator would launch then monitor the UUV; the second would monitor and control the payloads. Associated with the console are the communications and terminal homing transducers. The terminal homing beacon is a stand-alone unit fitted to the submarine's hull, however the acoustic communications transducer is linked to the interface console. The operator at the MMS console thus has the ability to receive data from the UUV and can establish a command link in the event that the fibre optic link is exhausted from its spool or otherwise breaks.

The payloads currently fitted are COTS-based and are only intended to demonstrate a very limited set of objectives. The basic vehicle can be adapted to carry a wide range of future payloads including high-resolution minehunting sonars using wideband and synthetic aperture processing techniques. This is accomplished by means of the empty spacer sections adjacent to the nose and tail of the vehicle and the large payload section spanning the centre of gravity.

Marlin will be used to assess how submarine launched UUVs could contribute to the UK Royal Navy's operations.

Operational status
The vehicle has been used in a series of technological demonstrations. The overall vehicle integration activity commenced in February 2000 and in-water tests commenced on 31 August 2000.

Specifications
Displacement: 1,200 kg nominal
Length: 6 m
Diameter: 0.533 m (excluding protrusions)
Operating depth: greater than 250 m
Endurance: 4 h

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

NASP

Type
Non-Acoustic Sensor Platform (NASP).

Description
The NASP was designed and built by QinetiQ at Bincleaves, Portland as part of the Applied Research Programme investigation into non-acoustic sensors for mien detection. The vehicle features extremely low-magnetic self-noise so that it could be used to mount magnetic anomaly detection sensors to detect mines and other seabed objects. To date it has only been possible to operate such sensors from towed bodies deployed from ships and submarines.

The flexible unmanned underwater test vehicle enables the performance of several different types of non-acoustic sensors to be evaluated. These include an optical sensor and a chemical sensor. The platform features radical new forms of construction using plastics and other non-magnetic materials and power including two Waterjet-40 units. The vehicle is powered by electric motors whose speed is controlled by field-effect transistors. Power for the platform is provided by gel electrolyte cells located in battery pods mounted externally. These are positioned low down on the hull so that they enhance the stability of the device when in use. Thrust is provided by the waterjet units mounted at the aft end of the hull and the vehicle is steered by the rudder unit so that tight manoeuvres can be executed. Vertical control is effected by flow over the fore and aft planes while in motion and by the variable ballast system, which can be set to make the vehicle neutrally buoyant at a point in the water column.

The magnetic sensor comprises two 5-axis gradiometers mounted about 1 m apart in a carbon-fibre tube that decouples them from flow noise. An inversion algorithm calculates the location of potential targets using data from the vehicle's position and altitude sensors. The gradiometer is configured to operate in two modes, one which seeks out a single target and the other which plots the location of mines whilst the platform performs a ladder search.

The E/O suite features a solid-state blue-green linescan laser (wavelength 530 nm, power output 80 MW) and a silicon-intensified target (SIT) camera. This sensor is also able to operate in two modes: snapshot of a target providing a single image of the target and waterfall in which the region underneath the vehicle is plotted as a continuous scrolling image.

The chemical sensor detects trace concentrations of dissolved explosive (which can be found on the surface of a mine) together with other materials such as plasticizers and metals which leach out from the structure.

The modular design of the NASP allows sensor packages to be changed relatively easily and alternative payloads could be accommodated as required.

Operational status
Sea trials of the sensor suite using the vehicle were undertaken in the summer of 1997, where the NASP and different types of sensor including magnetic gradiometers, electro-optic sensors and olfactory sensors were tested against mine-like objects.

Specifications
Length: 2.5 m
Speed: 5 kt (magnetometer mode); 2 kt (laser mode)
Turning circle: 4 m
Range: 2 km
Endurance: 1.2 h
Operational depth: 25 m

Contractor
QinetiQ, Farnborough, Hampshire.

VERIFIED

United States

21UUV

Type
Autonomous underwater vehicle.

Description
The 21UUV testbed, is a tactical sized UUV, based on a Mark 48 torpedo, for integration and testing of advanced UUV payloads. The 21UUV is used to integrate and test advanced MCM sensors and payloads, advanced energy storage and propulsion systems (both electrical and thermal), systems and methods for low-speed control in energetic environments (thrusters, variable buoyancy, directed thrust axial propulsors, and advanced autopilot algorithms), signature reduction systems (both acoustic and electromagnetic quieting), autonomous mission control systems (for mission planning and re-planning, onboard fault diagnosis and corrective action, and collision avoidance), high data rate acoustic communications systems, and advanced non-traditional navigation systems.

The vehicle design allows for submarine tube-launch configurations. However, the system design is modular and expandable. The over-the-side surface craft launcher allows for vehicle configurations from 6.35 up to 8.89 m in length. The primary energy source for propulsion will be silver zinc batteries. In the standard configuration, the vehicle will have the capability to run continuously for 6 hours at 8 kt. The speed range of the vehicle (without transverse thrusters or variable buoyancy) in a submarine tube launch configuration will be 3 to 15 kt.

The 21UUV baseline configuration will be 6.35 m long, with a displacement of approximately 1,290 kg. The vehicle is divided into six sections joined together to form one continuous pressure hull (no flooded sections).

The propulsor to be used is the Thrust Vectored Pump Jet (TVPJ), a quiet, efficient propulsor, with control surfaces aft of the propulsor for additional steering control at low speeds. The propulsion motor is a 20 hp electric radial field motor, using COTS components. The motor is designed for quiet operation and high efficiency across the entire speed and torque range, and is capable of reverse operation. Acoustic signature reduction systems are implemented throughout the

design, the majority of these components included in the motor and propulsor sections (location of the major acoustic noise sources).

The control section houses the vehicle controller, a COTS computer system. The vehicle controller controls all vehicle subsystems. External communications (pre-launch, to the launch control system) is performed via an ethernet link (A-cable or fibre optic link (10Base-FL or proprietary single fibre). An INS provides navigation information to the vehicle controller. The INS is capable of 0.25 n miles/hour navigational accuracy (unaided). It also provides vehicle body angles, rates and velocity for use by the vehicle autopilot. A Doppler velocity sonar is used to track vehicle speed to the ocean bottom. The INS and Doppler velocity sonar data, integrated by a Kalman filter software algorithm, will provide positional accuracies of better than 0.18 per cent of distance travelled. The control section also houses power distribution (DC-DC converter modules), fail-safe power switching assemblies, depth sensors, and range tracking systems. For safety, a remote shutdown (acoustic) capability is also included.

The propulsion battery system (baseline configuration) consists of secondary silver zinc cells. The hotel battery consists of sealed lead acid cells, although the design does not preclude the use of other power plants. The payload and nose sections are reserved for payload systems. Possible payloads are forward looking acoustic sensors, side looking sonars, acoustic communications systems and bottom looking sensors.

The 21UUV vehicle has been performing in-water demonstrations since June 1997.

The vehicle is fitted with a Klein 2000 side scan sonar and a Boeing forward looking sonar. Recent trials have included the integration of SEADeVil, an advanced navigation system that tracks seabed imagery using an optical camera.

Specifications

Length: 6.35 m
Diameter: 0.826 m
Weight: 1,273 kg
Speed: 4.5 to 15 kt
Speed accuracy: ±0.1 kt
Operating depth: 0-500 m
Depth accuracy: ±150 mm
Pitch angle: ±30°
Heading accuracy: ±1°
Change rate: 1°/s/kt
Range: 48 n miles at 6 kt

Contractor

Naval Undersea Warfare Centre, Division Newport, Rhode Island.

UPDATED

AN/BLQ-11 (LMRS)

Type

Unmanned, untethered underwater vehicle for mine reconnaissance.

Development

The AN/BLQ-11 LMRS (Long-term Mine Reconnaissance System) is currently in development under a parallel contract. It is a considerably enhanced version of the NMRS and will be completely autonomous in operation. Like NMRS, the AN/BLQ-11 will detect, classify and localise mine-like objects. However, it will provide improvements in areas where, due to its near-term focus, NMRS is inherently limited. For example NMRS is limited by the overall number of systems available, as well as its endurance, reliability and search rate. AN/BLQ-11 is addressing these specific limitations. As the LMRS begins to enter service in FY03, the NMRS will be phased out of service.

Description

The autonomous LMRS offers improved sensor, energy and processing performance over the tethered NMRS that it will replace in operational service. As part of its mission profile, the LMRS must be able to locate a mine-like object with a circular error of probability (CEP) of 71 m without approaching any closer than 18 m or generating a signature that would cause a mine to detonate.

The modular LMRS is capable of being airlifted and quickly installed in a submarine's torpedo room taking up the space of no more than 10 torpedoes. Each submarine will carry two UUVs and five interchangeable battery packs. The UUVs are recovered using a telescopic robotic arm mounted in the topmost starboard torpedo tube. The UUV approaches the arm from the stern area of the submarine where it is grabbed by the arm, pivots and slides into the lower starboard torpedo tube, where it is attached from within the submarine and withdrawn into the boat. The UUV can be recovered at speeds between 0.5 and 3 kt.

The vehicle is capable of acquiring, processing, formatting and transmitting reconnaissance data via standard SSN communications links to the rest of the fleet. This will primarily be to platforms such as amphibious warfare vessels rather than the host SSN.

The standard acoustic sensor suite for the AN/BLQ-11 LMRS is being provided by Sonatech of the US. This includes a forward-looking sonar for search and obstacle avoidance, side scan sonar for object classification, and a homing and docking sonar. Sonatech are also providing the acoustic link between the vehicle and its parent submarine.

The enhanced sensor suite and new propulsion system have necessitated an increase in length over the NMRS. Although the diameter of the torpedo tube is currently considered adequate, this may be increased if it is considered that the LMRS would benefit from increased volume/payload, in which case it might be housed in a DDS.

Boeing has been working on three alternative energy designs using different battery technologies. These feature a rechargeable Ag/Zn battery with an endurance of 12 to 14 hours; a lead acid battery with 4 hours endurance (to be used for training); and a lithium thionyl chloride battery allowing missions of between 48 and 60 hours endurance. The lithium battery propulsion system is of significantly higher density than the NMRS system. This is necessary to provide the required 40 to 48 hours at 4 kt endurance and the requested range of 120 n miles. However, at present the range is in the region of 70 to 75 n miles. A sortie is considered to cover between 35 and 50 sq n miles a day. A typical mission would involve up to six such sorties.

Upgrades are already being integrated in the AN/BLQ-11. These include:

- precision underwater mapping navigation aid intended to enhance littoral operations;
- synthetic aperture sonar;
- renewable energy source.

The precision mapping system consists of a 12-stave cylindrical array incorporating 96 elements in each stave. This will offer a much higher performance in conditions of severe clutter with greater probability of detection and improved false alarm rate. The precision mapping system will be installed in addition to the existing HF forward-looking sonar array mounted on the submarine.

The Northrop Grumman SAS (synthetic aperture sonar) has now been successfully incorporated in the AN/BLQ-11 offering much greater range and resolution than the standard sonar originally fitted in the vehicle.

The system will form part of an integrated organic mine warfare system for the US fleet whose elements will comprise: LMRS vehicle; ALMDS (Airborne Laser Mine Detection System); RMS (Remote Minehunting System); AMNS (Airborne Mine Neutralisation System); OASIS (Organic Air and Surface Influence Sweep); and RAMICS (Rapid Airborne Mine Countermeasures System).

Operational status

Scheduled to achieve initial operation capability in December 2004. Boeing is under contract to manufacture eight LMRS systems. System level testing was due to commence in November 2002 followed by sea trials and then three submarine trial deployments. The system will become operational aboard Los Angeles and Virginia class SSNs of the US Navy.

Specifications

Length: 6,100 mm
Diameter: 533 mm
Range: 120 n miles
Speed: 7 kt (max)
Operating depth: 12 to 450 m
Endurance: >40 h

Contractor

The Boeing Company, Communications & Information Management Systems, Anaheim, California.

UPDATED

AN/SLQ-48 MNS

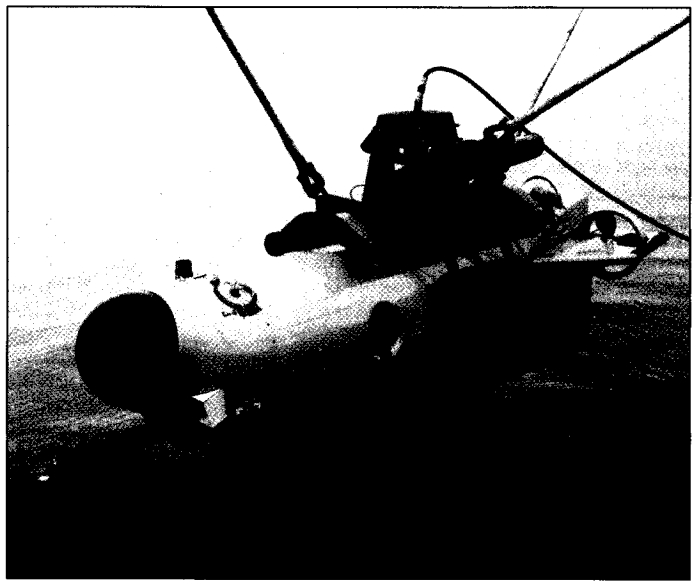
Type

Remotely operated mine disposal system.

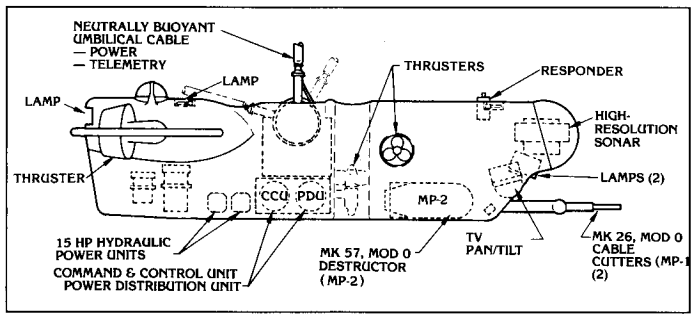
Description

The AN/SLQ-48 MNS (Mine Neutralisation System) developed by Alliant Techsystems Marine Systems (now Raytheon Company) and the US Naval Sea Systems Command, has completed production for the US Navy's new MCM and MHC ships. In operation since 1987, it is designed to detect, locate, classify and neutralise moored and bottom mines, using high-resolution sonar, low-light level TV, cable cutters (Mk 26 Mod 0) and mine destruction charges (Mk 57 Mod). The

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MNS vehicle showing handling arrangement



Arrangement of the MNS

tethered underwater vehicle carries these sensors and countermeasures and is controlled from the parent vessel out to a range of 1,000 m.

Initial target detection and vehicle guidance information is provided by the ship's sonar. Initial vehicle navigation is plotted and monitored within the MNS acoustic tracking system. The vehicle high-definition sonar is used during the mid-course search and final homing phases. An intensified CCD low-light TV is used in conjunction with sonar during the precision guidance phase near the target. Underwater launch and recovery of the MNS vehicle assists operations in high sea states.

Vehicle power is provided to the two 15 shp electric motors via a neutrally buoyant, constant tension 1,067 m long umbilical cable, which also carries signal and control links between the vessel and the MNS vehicle. Aboard the parent vessel sonar screens on the control console display sensor and vehicle status information in alphanumeric form. Display facilities include vehicle sonar, vehicle TV, deck TV, vehicle control and navigation, and provision for monitoring system status.

The vehicle has been upgraded to enable it to deploy a Mk 57 destructor charge with a flotation device for attaching to the mooring cable of a mine. The flotation device causes the destructor charge to rise up the cable to the vicinity of the mine case where it is exploded by remote audio signal from the parent vessel. This enables the vehicle to destroy a moored mine *in situ* instead of just cutting the mooring wire as before, and allowing the mine to float to the surface for destruction.

Operational status

In production since 1986. MNS was successfully used by USS *Avenger* and *Guardian* in the Persian Gulf during Operation Desert Storm.

A total of 28 full systems including 57 vehicles have been delivered to the US Navy and are installed on all Avenger and Osprey class MCMVs.

Specifications

Length: 3.67 m
Width: 1.2 m
Height: 1.2 m
Weight: 1,247 kg (in air)
Operating depth: >200 m
Speed: 6 kt
Thrusters: horizontal/vertical/lateral
Power requirements: 43 kVA

Contractor

Raytheon Company, Integrated Defense Systems, Tewksbury, Massachusetts.

UPDATED

AN/WLD-1 RMS

Type

Remote minehunting vehicle.

Development

The AN/WLD-1 RMS (Remote Minehunting System) is under development to meet the US Navy requirements for organic MCM for deployment from surface ships. The system is designed to provide an off-board capability to meet the demand for over-the-horizon mine reconnaissance in operating areas in support of individual vessels and task forces, enabling them to avoid mined areas.

The requirement for the RMS was that it should be equipped with computer aided detection and precise navigation systems to detect, classify and localise mines to enable ships to avoid the threat and provide precise data for the subsequent neutralisation of any detected mines.

The system, with its organic handling, control and logistic support had to be capable of being air transportable to forces anywhere in the world.

The operational prototype (RMOP) - Remote Minehunting Operational Prototype) was completed in August 1994 and underwent extensive tests. This prototype integrated the ANB/AQS-14 minehunting sonar on a variable depth winch and carried SeaBat 6012 forward-looking sonar. The equipment was mounted in a Dolphin semi-submersible vehicle acquired from Canada. This was followed by a second prototype that could be launched from a Spruance class destroyer. Successful trials with this variant were carried out using the USS *Cushing* in the Arabian Gulf in 1997.

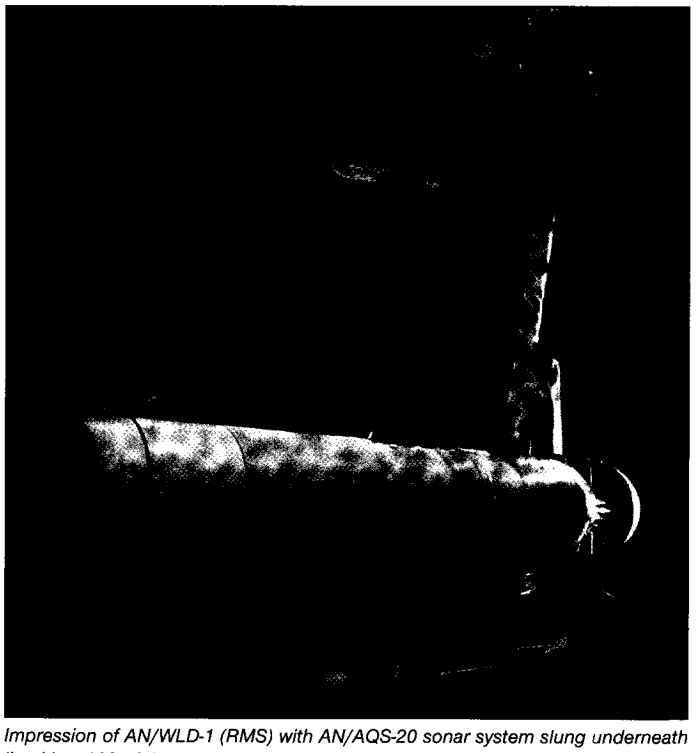
A third prototype, RMS (V)3, conducted successful builders trials in late 1998. This variant was based on a larger semi-submersible towing the AN/AQS-14 sonar. It used a new launch and recovery system developed for the Spruance class, with operations conducted from a container located on the ship's Harpoon deck. The data output was interfaced to the AN/SQQ-89(V)6 sonar system via its LAN for onward transmission to the combat information centre.

Description

The AN/WLD-1 (RMS) consists of a diesel-powered, low observable, 7 m long remotely piloted vehicle that uses global positioning system satellites for navigation and a tethered VDS, a modified version of the airborne AN/AQS-20. The system is designed to be deployed by a destroyer; using its advanced sensors and datalinks to sweep shallow and deep water for a variety of mines and alert the battle group.

The vehicle is powered by a 370 hp Cummins diesel marine engine and high-efficiency propulsor that drives the 7 m vehicle at speeds exceeding 16 kt. The vehicle operates just below the surface of the water with only a streamlined snorkel-cum-mast visible above water to draw air into the engine, and provide a platform for RF antennas and GPS and a low-light obstacle avoidance video camera. The nose module incorporates forward-looking sonar for detection and avoidance of underwater objects. The vehicle can operate effectively in a wide range of sea conditions from the very shallow water region to deep water. To preserve fuel when rapid recovery is not practicable, the vehicle can loiter until it is commanded to make a new rendezvous.

The RMV is launched and recovered using a single hydraulically operated davit, which provides a 4.5 m reach from the parent ship. On the Flight IIA Arleigh Burke class the vehicle is carried on a shock-mounted cradle housed in a shelter on the starboard side of the destroyer just aft of the RIB davits. To preserve the stealth characteristics of the ship this shelter is enclosed by a moveable screen. In order to accommodate the vehicle within this housing, the mast is hinged and lowered before the vehicle is brought inboard.



Impression of AN/WLD-1 (RMS) with AN/AQS-20 sonar system slung underneath
(Lockheed Martin) 0097738

The vehicle consists of five modules:

- the nose module with forward-looking sonar
- electronics module with computers to process and transmit data from the VDS and provide communications with the parent vessel
- fuel module carrying either marine diesel fuel or JP-5 to power the diesel
- winch and capture module
- propulsion module

Real-time command and control data to/from the vehicle, including operational status, are relayed to the host ship via one of two data communications modes. For line of sight minehunting, a high data rate (3.1 Mbps) UHF RF link will send back continuous VDS sonar data. At over-the-horizon range, a lower data rate (64 kbps) VHF RF bandwidth is used to send back continuous sonar data and video imagery as well as vehicle and sensor control and status information. Future systems could incorporate satcom links.

For its mine reconnaissance mission, the vehicle deploys and tows a version of the AN/AQS-20 minehunting variable depth sonar that is designed to provide full water column, single pass coverage for the detection, classification, localisation and identification of seabed and moored mines. The AN/AQS-20 carries port and starboard side scan sonars, forward-looking sonar, gap-filler sonar, volumetric search sonar or an E/O laser imager for mine identification.

From the parent vessel (initially planned to be the Flight IIA Arleigh Burke class destroyers) a single operator exercises control over the vehicle from an AN/UYQ-70 multifunction console. All control and display operations are fully integrated with the AN/SQQ-89 (V)15 undersea warfare system. Mine contact data is linked to the AEGIS combat system and to the global command and control system – maritime, for distribution to the task force and shore commands under the network centric concept of operations using Link 11/16. The vehicle is programmed prior to launch with the required search parameters that are then carried out autonomously. However, the operator can take over manual control of the vehicle at any time via the datalink, even when the vehicle is over the horizon.

Operational status

The vehicle has now completed the first Critical Item Test (CIT). This involved 28 days of testing off West Palm Beach, Florida, and included demonstrating RMV stability and control; underway launch and recovery and RMV speed and endurance. It accomplished more than 144 hours of at-sea testing, including 19 launch and recovery evolutions; stable, controllable flight in excess of 17 kt and simulated VDS towing. It is predicted that the navy will buy at least 20 of the systems to outfit Arleigh Burke class destroyers, hull numbers DDG-91 to DDG-101, and to meet training, replenishment and possibly other war fighting scenarios. Early in 2002 Lockheed Martin Naval Electronics and Surveillance Systems was awarded a US$130 million contract to carry out Phase II of the engineering and manufacturing development programme. Lockheed Martin began delivering the RMS to the US Navy for testing in 2003 and the vehicle completed a series of tests with the US destroyer *Pinckney* of the Arleigh Burke Flight IIA class in October 2003. Initial operational capability is set for 2005. The system underwent manufacturer's trials that concluded in June 2004.

Contractor

Lockheed Martin Naval Electronics and Surveillance Systems, Syracuse, New York.

UPDATED

BPAUV

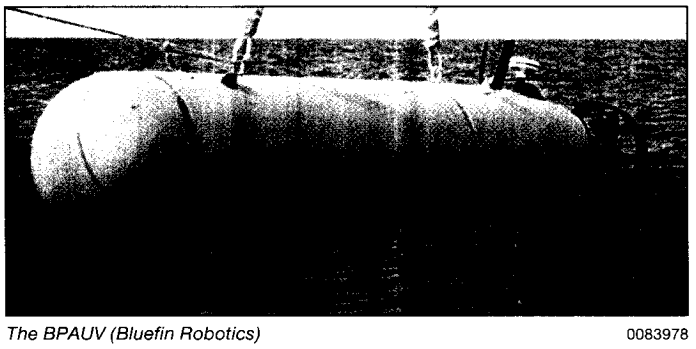
Type

MCM AUV.

Description

The BPAUV (Battle-space Preparation Autonomous Underwater Vehicle) is a variant of the Bluefin 5000 designed for commercial applications. It has been developed to provide the capability to collect, rapidly and covertly, high-resolution side scan sonar, bottom classification and oceanographic data for mine countermeasures (MCM) applications.

The vehicle is powered either by silver zinc batteries giving it a range of 40 n miles, or by a fuel cell with a range of 400 n miles. A variety of sensor packages can be fitted, but the standard unit is a Klein Associates Series 5400 455 kHz side scan sonar with a Seabird CTD and for navigation a Litton LN250 inertial system, and RD Instruments Doppler velocity log (300 kHz) and DGPS.



The BPAUV (Bluefin Robotics) 0083978

The version used by the US NSWC, Reliant, features a dual frequency (HF/LF) synthetic aperture sonar integrated into the side of a Mk 48 torpedo shell.

Operational status

Two BPAUV vehicles were supplied to the US Navy for participation in the Fleet Battle Experiment – Hotel (FBE-H), which took place in August/September 2000. Further demonstrations of BPAUV were conducted during Exercise Kernel Blitz 01 in March/April 2001. Variants of the vehicle are in service with QinetiQ (as Gambit), and at the USNSWC Dahlgren Division Coastal Systems Station (as Reliant) where it forms part of the UK/US collaborative research programme.

Specifications

Length: 3.3 m
Diameter: 0.53 m
Weight: 330 kg
Speed: 3-4 kt
Operational depth: 200 m (full ocean depth is possible)

Contractor

Bluefin Robotics Corporation, Massachusetts.

UPDATED

CETUS II

Type

Commercial autonomous underwater vehicle.

Description

CETUS II is a new vehicle developed for commercial applications. It is constructed from Rotary Moulded HDPE and weighs between 50 and 56 kg. The vehicle has been designed with the ability to hover and can be operable as an AUV or ROV. A lithium battery with an endurance of 14 h powers CETUS II. The vehicle is designed to locate, detect, classify and identify mines in shallow waters from 10 to 160 m using an on-board MIRIS high-resolution sonar. The vehicle proceeds to detected target co-ordinates fed to it. The dynamic localised search function is performed using factored environmental data and navigational inaccuracies. Target inspection is supported via the collection of high-resolution imagery of bottom objects; onboard archiving of digital image sequences; computer-based extraction of feature data for identification; and comprehensive inspection when in hovering mode. Mine neutralisation is supported by the placement of marker pingers and vectoring of neutralisation assets. The small, light vehicle is easily handled by two people and capable of hovering and other precise underwater movements.

Operational status

CETUS II participated in the US Navy Fleet Battle Experiment-Hotel, which took place in August/September 2000. The sensor package during the experiment was a low-light video and the Mine Reacquisition and Identification Sonar (MIRIS) developed by the API at the University of Washington. Further demonstrations of CETUS II were conducted during Exercise Kernel Blitz 01 in March/April 2001.

Specifications

Length: 1.37 m
Body width: 0.53 m
Tail width: 0.686 m
Height: 0.304 m
Weight: 50-56 kg
Speed: 3-4 kt (max)
Operating depth: 10 to 160 m
Range: 80 km at 3 kt
Endurance: 14 h

Contractor

Lockheed Martin, Perry Technologies, Riviera Beach, Florida.

UPDATED

DARPA UUV

Type

Autonomous Underwater Vehicle (AUV).

Development

The US Defense Advanced Research Projects Agency (DARPA), together with the US Navy and Charles Stark Draper Laboratories, has built two prototype UUVs to demonstrate the feasibility of developing a design for a vehicle capable of undertaking covert high-priority missions. The vehicle is intended for deployment from submarines as well as surface ships. A third prototype was due to be delivered in 1998. The US submarine Memphis is currently being adapted as a trials boat for testing the UUV concept.

The UUV will be fitted with a range of advanced acoustic sensors, communications, signal and data processing systems for trials that will demonstrate the vehicle's ability to carry out autonomous operations. Missions envisaged include MCM, surveillance and communications. Three mission systems are being developed for the UUV: a Tactical Acoustic System (TAS), Mine Search System (MSS) and Remote Surveillance System (RSS).

The hull is of titanium and pressure tests on the first hull were carried out in December 1990. An internal pressure hull contains the payload that occupies a section some 1.5 m in length. Power for the 12 hp electric motor will be provided by batteries housed in two 1.3 m long sections while the vehicle's control electronics will be contained in another 1.3 m section in the centre section. The electric motor and its control unit will be housed in a 3.5 m aft section.

Specifications
Length: 11 m
Diameter: 1.12 m

Contractors
DARPA, Arlington, Virginia.
Charles Stark Draper Laboratories, Cambridge, Massachusetts.

VERIFIED

EMD

Type
Expendable Mine Destructor (EMD).

Description
The EMD is a small, self-propelled device for the destruction of seabed, moored and floating sea mines.

It features fully automatic operation from launch to target impact to minimise operator workload and training requirements and maximise speed to target. Acoustic ultra-short baseline navigation or ship's sonar guides the EMD to an automatic terminal homing approach via a sophisticated acoustic seeker head. A bidirectional fibre optic link provides real-time high-resolution video to the operator from two separate EMD onboard cameras with visual clarity provided by four selectable lights. Sonar target image and ability to manually override EMD controls are also provided. Trials have also been carried out to test a sonobuoy control link offering increased stand-off capability.

The device is fitted with a choice of warheads including modular, blast, shaped or advanced types including four shaped charge warheads which are symmetrically angled and designed to detonate the mine's explosive charge. In the event of this not being achieved, the detonation of the EMD is sufficient to disable the mine's triggering mechanism.

With its shrouded propulsor and manoeuvring surfaces the EMD is usable in currents up to 5 kt and in very shallow waters of only 2 m. The device is fitted with a seeker head which has a range of 30 to 50 m.

The EMD can be handled easily and deployed from ships, helicopters or drones. It is designed to be used with a mine-hunting sonar for kill verification, but can be used independently with expendable bottom transponders.

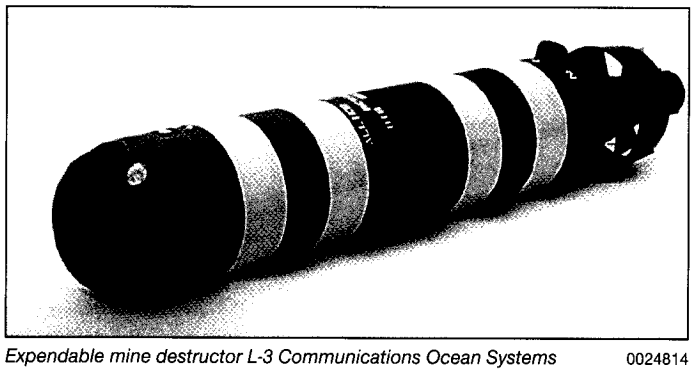
A recoverable reconnaissance/training version with a TV camera and optical fibre link is available.

Operational status
Under development as a future project.

Specifications
Length: 1.05 m
Diameter: 0.2 m
Weight: 28 kg
Speed: 12 kt
Operational depth: 300 m
Endurance: 15 min @ 8 kt or 1 h @ 4 kt

Contractor
L-3 Communications Ocean Systems, Sylmar, California.

UPDATED



Expendable mine destructor L-3 Communications Ocean Systems 0024814

LDUUV

Type
Autonomous underwater vehicle.

Description
The Large Diameter Unmanned Underwater Vehicle (LDUUV) is an electrically powered, torpedo shaped vehicle which is 7.6 m in length and 670 mm in diameter. The LDUUV has conducted at-sea demonstrations at speeds in the range of 4 to 12 kt and depths ranging from 3 to 200 m. The LDUUV has an endurance of 30 n miles at 6 kt.

Vehicle subsystems are housed in seven watertight composite hull sections. Payloads with a dry volume of up to 0.56 m{3}, lengths of 1.8 m and weights up to 454 kg can be accommodated by the LDUUV. A number of seawater inlet and outlet ports are provided for payloads which require direct water measurements or which have been designed to operate in free flooded environments.

Vehicle propulsion is provided by two axial field, brushless DC motors driving counter rotating ducted propellers that are located in the tail of the vehicle. Electrical power is provided by two isolated battery systems: one dedicated to propulsion power, the other to hotel or subsystem power. The propulsion battery consists of 140 Ah secondary silver-zinc cells which provide a 90 V DC bus voltage at 120 A. The hotel battery consists of sealed lead acid cells which provide a 120 V DC bus voltage at 10 A.

The vehicle controller is an embedded multiprocessor computer, based on COTS technology, which executes a 'Unix like' real-time operating system and kernel. The vehicle controller performs supervisory, casualty monitoring, guidance and navigation functions as well as sensor fusion (Kalman filtering), data recording and subsystem communication. The LDUUV has demonstrated a high-level intelligent mission controller developed by Texas A&M University. The intelligent mission controller is capable of making mission level decisions based on vehicle self-health, energy consumption and subsystem or payload sensor input.

The LDUUV is capable of two navigational modes, dead reckoning and waypoint. Most in-water runs are conducted in the waypoint navigation mode, where the vehicle is guided to absolute (latitude and longitude) locations. To date, (Kalman filter) aided navigational accuracy of better than 0.18 per cent of distance travelled has been demonstrated in water. The navigational sensors consist of an Allied Signal and Aerospace model RL34 ring laser gyro INS, an EDO Corporation Model 3050 Doppler velocity sonar, a Sensotec Inc pressure sensor and a Trimble Navigation GPS receiver.

Dynamic control is provided by the duct propellers, four individually controlled, tail mounted fins arranged in an 'X' configuration and two (fore and aft) independently controlled variable ballast stations. The autopilot uses non-linear sliding mode control, which contains an embedded vehicle hydrodynamic model to ensure stable operation over a wide speed range.

To date, most in-water demonstrations of the LDUUV have been conducted in the NUWCDIVNPT Shallow Water Test Facility. This test range is approximately 6 n miles long by 1.5 n miles wide. Littoral waters provide depths from 18 to 6 m over varying bottom terrain. Once launched, the LDUUV can be acoustically tracked with the shallow water acoustic tracking system (SWATS), a real-time portable 2-D short-baseline tracking range. Typically SWATS is comprised of 16 moored sonobuoys that are capable of synchronously tracking the LDUUV within a nine sq mile area. Tracking accuracy is to within a 4.5 m radius. SWATS can be deployed in water depths ranging from 4.5 to 180 m.

The LDUUV has been designed to swim out of a launch cage. The cage has been designed to be deployed from the sea bottom in shallow water scenarios, or a submersible elevator for testing on the NUWCDIVNPT Shallow Water Test Facility range. The vehicle can also launch from a surface ship or firing barge to support continental shelf scenarios, or from the dry deck shelter of a submarine for spec war scenarios.

Operational status
To date the focus of the LDUUV has been on the gathering of oceanographic and environmental data. The vehicle has gone to sea with a comprehensive suite of sensors consisting of CTD, optical absorption and attenuation, wave height and small scale turbulence payloads. This sensor suite coupled with the platform's navigational accuracy has provided oceanographers with previously unavailable measurement capability of the small scale environments within an estuarine environment.

Specifications
Length: 7.6 m
Diameter: 0.67 m
Weight: 2,359 kg
Operating depth: sea level - 183 m
Speed: 4-12 kt
Endurance: 30 n miles at 6 kt
Navigational accuracy: 0.18% of distance travelled

Steady state dynamic control
Depth error: ±15.24 cm
Heading error: ±0.1°
Roll error: ±0.1°
Pitch error: ±0.6°
Speed error: (over ground): ±0.1 kt

Payload accommodations
Length: 1.8 m
Weight: 454 kg
Dry volume: 0.56 m{3}

Contractor
Naval Undersea Warfare CentreDivision, Newport, Rhode Island.

VERIFIED

MANTA test vehicle

Type
Technology demonstrator.

Description
The Naval Undersea Warfare Center (NUWC) MANTA is a concept of autonomous, re-usable reconfigurable UUVs having multimission capability. Several MANTAs, mounted conformally within depressions in a future submarine's hull, would be launched and recovered external to the submarine pressure hull. These vehicles would be deployed from great standoff distances, and would transit clandestinely to forward shallow water areas. Carrying their own sensors, weapons, and countermeasures, MANTA could operate independently or, if needed, could be directed by other manned platforms via the local undersea network or via above-surface communications. These communications via acoustic, electromagnetic, or optical channels would enable the UUV to robustly exchange data with the parent ship or with other network nodes. With weapons and countermeasures, they would have the capability to provide further protection to the battlegroup.

A typical arrangement would involve four MANTAs grouped around the parent submarine's forward hull, being semi-recessed into divot-shaped depressions in the outer casing. While attached, they could fire their own weapons to augment the submarine's defensive or offensive armament. Following release, they would operate independently or under control from a remote platform (which may include the parent vessel). Various sizes of MANTA have been studied, with lengths ranging from approximately 15 m to more than 25 m and typically weighing 50 tonnes. A 90 tonne 'Super Manta' would have a range of 1,000 n miles.

The MANTA Test Vehicle (MTV) was completed in 1999. The MTV was built to demonstrate the Manta concept and was designed to be a modular, reconfigurable UUV with a very large payload capacity, high-accuracy navigation, acoustic communications, RF communications, and low-speed control. MTV is a large size vehicle, approximately 10.5 m in length, and weighs 8 tonnes (nominal dry weight). It is designed to accommodate large size payloads, such as: surveillance masts, large acoustic arrays and/or transducers, and multiple small-size UUVs. MTV, with a large volume available for energy storage, is capable of extended operating duration using low-cost energy sources. It uses subsystems and designs common to the LDUUV and 21UUV and implements industry standard software and electrical interfaces, and has large volumes available for both dry and wet payloads.

The MTV design allows the incorporation of a full length heavyweight or lightweight torpedo in the forward centre bay offering a low-speed swim-out capability. The MTV was designed with a low-profile shape in order to enable a 'piggyback' deployment on a submarine. For future concepts such as MANTA, the shape may be required to be conformal to the submarine bow. This requires a 'flattened' shape to allow it to be fitted into a shallow pocket on the submarine outer hull.

The MTV design is modular such that the vehicle can be easily reconfigured to carry various payloads (wet or dry). Dry space is allocated for hotel electronics and batteries. Flooded volume (external to the pressure hulls) is allocated to allow installation of wet hardware (sensors, payload subsystems and so on). Also, the outer hull can be easily modified to incorporate various payload configurations, requiring the concept of using dry pressure hulls tied together by a flooded superstructure and surrounded by an outer hydrodynamic fairing.

The MTV comprises four pressure pods (forward payload, aft hotel, starboard energy, and port energy). These pods consist of a combination of 21 in diameter pressure hulls and custom UUV shells. The pressure pods and ballast tanks are supported by a glass fibre space-frame, which consists of transverse and longitudinal ribs. This superstructure ties the vehicle components together. The volume between the pressure pods and the outer fairing is available for wet payloads.

The forward payload pod is available for payload electronics. The aft hotel pod contains the hotel battery; a section which houses navigation, guidance and control electronics, an actuator section (houses actuators for fin control), an afterbody hull (houses the DC brushless motor for propulsion power), and then the propulsor (pump jet generates thrust to drive the vehicle). The hotel battery provides the power for all hotel subsystems. This battery is 144 V; it contains 24 commercially sealed lead acid batteries (two parallel connections of 12 batteries each. Each battery is 12 V with a capacity of 26 Ah). This battery configuration provides a nominal hotel power duration of 13 h.

An INS, Doppler velocity sonar, and a GPS receiver determine vehicle position, velocity and attitude. The position accuracy of the navigation system is 0.2 per cent of distance travelled. The vehicle controller consists of a set of embedded computer processors that execute the vehicle control software; it performs navigation, vehicle supervisory control, subsystem communications and the autopilot function.

The two side pods (port and starboard) house the propulsion batteries. At the end of each pod, volume is available for additional batteries, additional payload subsystems, or for payload batteries. Ballast tanks are mounted at the ends of the side pods. The overall propulsion battery is 288 V, providing power to the propulsion motor system. The battery is split equally among the two side pods; each pod contains a 288 V battery; they are wired as a parallel connection. Each side pod contains 24 cells, which are physically separated into two series modules, each consisting of 12 sealed lead acid batteries (each cell is 12 V with a capacity of 70 Ah). This battery configuration provides a nominal duration of 13 h at 5 kt and will have a range of 65 n miles. The vehicle will be capable of burst speeds up to 10 kt. Longer ranges are obtained by implementing higher energy density sources.

Waterproof cables and connectors provide electrical interconnections between the dry hull sections and the wet hardware. The various dry sections are interconnected using conduits to allow dry cables to interface between subsystems. Mechanically, the pressure sections are interchangeable. Electrical and software interfaces are primarily industry standard and are commercially available.

In 1999, the MTV performed its inaugural at-sea trials in Rhode Island's Narragansett Bay. The purpose of these tests was to verify the vehicle's stability and manoeuvrability, and to perform initial system checks. Because the MTV has a non-traditional, unique body shape, the hydrodynamic characteristics of the vehicle were modeled using theoretical methods as no empirical data existed to pre-validate the models. The design of the vehicle autopilot control system was performed in simulation. At-sea tests allowed autopilot validation and confirmation of vehicle controllability and stability to be completed. NUWC worked with Draper Laboratory, Cambridge, Massachusetts, on the control system design.

During these initial at-sea tests, limited to several minutes of run time, information was obtained concerning the MTV's performance characteristics. For both of the two in-water runs, the MTV was commanded to 5 kt. The operating depth in the area of operation was less than 20 ft, therefore the commanded depth was limited to 3 ft. During both runs, the MTV successfully demonstrated the ability to dive off the surface. During both of the short duration runs dynamic control was established. The speed control loop was able to reach a steady state speed of 5 kt. The roll control loop obtained roll control in less than 30 seconds. The optimum dive pitch was observed to be 3°.

Operational status
The centre has worked with industry partners - including Boeing, Draper Labs, BAE Systems, Raytheon, General Dynamics, Kearfott, SenSyTech and Sensors Unlimited - to install and test subsystems aboard the MTV. Trials during August and September 2000 included operation of a basic ISR and communications payload consisting of a visual imager employing inexpensive commercial cameras (one forward-looking and two side-looking), a radio-frequency direction-finder, and a communications link. The last of these allowed the MTV, running in shallow water off Newport, Rhode Island, to transmit imagery to the submarine USS *Providence* docked at Groton. In return, the SSN was able to control the UUV's sensors.

Testing of the MTV during 2001 included operation of a thermal imager provided by Threshold Unlimited, a SenSyTech Bobcat radar intercept receiver, a bottom bathymetric mapping package for 'non-traditional' navigation, and a modified commercial wireless Ethernet link able to handle data at 11Mb/s. The MTV has also deployed REMUS mini-UUVs from its wingtips.

Tests continued during 2002, including launching torpedoes from the vehicle.

An MTV II is presently under development. This will have an operating depth of 800 ft and a speed of 2 to 10 kt. The weight will be between 11,000 and 43,000 kg, depending on payload.

Specifications
Length: 10.4 m
Width: 2.4 m
Height: 0.9 m
Width between elevator tips: 2.5 m
Height of the vertical stabiliser: 1 m
Overall height of the vehicle: 1.9 m
Speed: 0-10 kt
Endurance: 5 h at 5 kt; 0.7 h at 10 kt
Operating depth: 244 m
Weight: 7,000 kg in air
Free flood region: ~8 ton
In-water run trim: neutral +-90.72 kg
Dry payload capacity: approx 1,614 kg

Contractor
Naval Undersea Warfare Centre Division, Newport, Rhode Island.

UPDATED

Morpheus

Type
MCM AUV.

Description
Morpheus, also known as Ocean Explorer Mini UUV, is a member of the Ocean Explorer family of vehicles developed at Florida Atlantic University. The vehicle, which may be from 1.2 to 2.4 m long, is built up from a series of interchangeable

modular pressure vessels some 300 mm long constructed from injection-moulded plastic. Optionally a 600 mm double modular section is available. A cabling system allows the modules to be rearranged without rewiring the bulkheads. The plastic vessels are inexpensive, can be mass-produced, are extremely corrosion-resistant and have a low-magnetic signature. Optional cross-body thruster sections allow the vehicle to hover. Actuators include independent top/bottom rudder right/left stern planes and a thruster to provide depth, altitude, pitch, and heading and roll control. A main computer manages the autopilot, mission control, navigation and data logging. Navigation and tracking is achieved through dead reckoning with INS and DGPS, an acoustic modem-based interoperable communication system, navigation (passive LBL) and tracking (passive LBL) system.

Morpheus can carry a range of payloads including such standard sensors as: CTD, DVL, compass, tri-axis gyro with 3-axis acceleration, DGPS (mounted on a pop-up antenna), side scan sonar, video and forward looking sonar.

A NiMH battery module giving 4-hour endurance at 3 kt powers the vehicle.

Operational status

Morpheus participated in FBE-H (Fleet Battle Experiment - Hotel), which took place in August/September 2000, in which the objective was to demonstrate emerging MCM technologies (with particular emphasis on UUVs) suitable for use in water depths of 3.05 to 12.2 m. It conducted five missions from very shallow water to a depth of 23 m. It successfully reacquired and identified (using a video camera) 10 mines and two 'non-mine bottom objects' in the shallow and very shallow-water zones. This is the first time that an autonomous underwater vehicle had performed these functions against a mine-like object that had originally been detected by another such vehicle. Further demonstrations of Morpheus were conducted during Exercise Kernel Blitz 01 in March/April 2001.

Specifications

Length: 1.2 to 2.4 m
Speed: 2-5 kt (1-2.5 m/s)
Endurance: 4 h at 3 kt per NiMH battery module
Operational depth: 200 m
Range: 30 km at 1.5 m/s per NiMH battery module

Contractor

Florida Atlantic University, Institute for Ocean and Systems Engineering, SeaTech Ocean Engineering Department, Dania Beach, Florida.

UPDATED

MRUUV

Type

Mission Reconfigurable Unmanned Undersea Vehicle (MRUUV).

Development

The US Navy is developing a submarine deployed MRUUV that could enter service in FY07. The vehicle could be assigned to undertake a number of operations including intelligence, surveillance and reconnaissance (ISR); detecting weapons of mass destruction (currently of considerable significance in the aftermath of the war in Iraq); ocean survey; and power projection.

The initial variant of the vehicle features a 533 mm diameter platform using the structure and propulsion system being developed for the AN/BLQ-11 LMRS vehicle (see entry on AN/BLQ-11). This 1,275 kg vehicle would be used to demonstrate clandestine ISR and covert mine neutralisation capabilities. It is anticipated that some 3 to 6 vehicles of this type may be purchased for service in FY07.

The MRUUV is intended to operate from Los Angeles and Virginia class submarines. The initial vehicle would be followed by a second larger diameter variant for deployment from platforms such as the converted Ohio class SSGN submarines. This 2,270 to 9,000 kg vehicle (various designs are being prepared) would commence development in FY04 with an in service date of FY09. A variety of payloads will be developed for the modular vehicle, allowing easy adaptation for different tasks.

According to the US Program Manager the aim is for the MRUUV to be capable of conducting all four tasks envisaged by the Autonomous Operations future naval capability concept outlined by the ONR (Office of Naval Research). Three of the tasks (maritime reconnaissance, communication/navigation aid and search and survey) will run from FY03 to FY05. The fourth tasks (submarine track and trail) will run from FY04 to FY07.

It is also envisaged that MRUUV could be launched from surface warships such as the new DD(X) which are being designed from the outset to support and deploy UUVs and unmanned surface vehicles. Currently this involves deploying vehicles over the side using davits, a difficult and dangerous operation, which can be severely restricted by environmental conditions.

Operational status

Under development. Lockheed Martin Naval Electronics & Surveillance Systems, Undersea Systems, Perry Technologies has been awarded a US$6,750,000 contract for the MRUUV. Work is expected to be completed by August 2005.

Contractor

Lockheed Martin Electronics & Surveillance Systems, Undersea Systems, Riviera Beach, Florida.

VERIFIED

MUST Lab

Type

Underwater test laboratory vehicle.

Description

Developed in 1985 the Mobile Undersea Systems Test (MUST) Laboratory is designed to carry both wet and dry payloads. A versatile test facility, the MUST Lab provides rapid turnaround and multiple dives without a requirement to return to port. Rough weather does not impede the vehicle. An innovative segmented pressure hull design with unprecedented modularity and payload capacity supports a wide range of programmes.

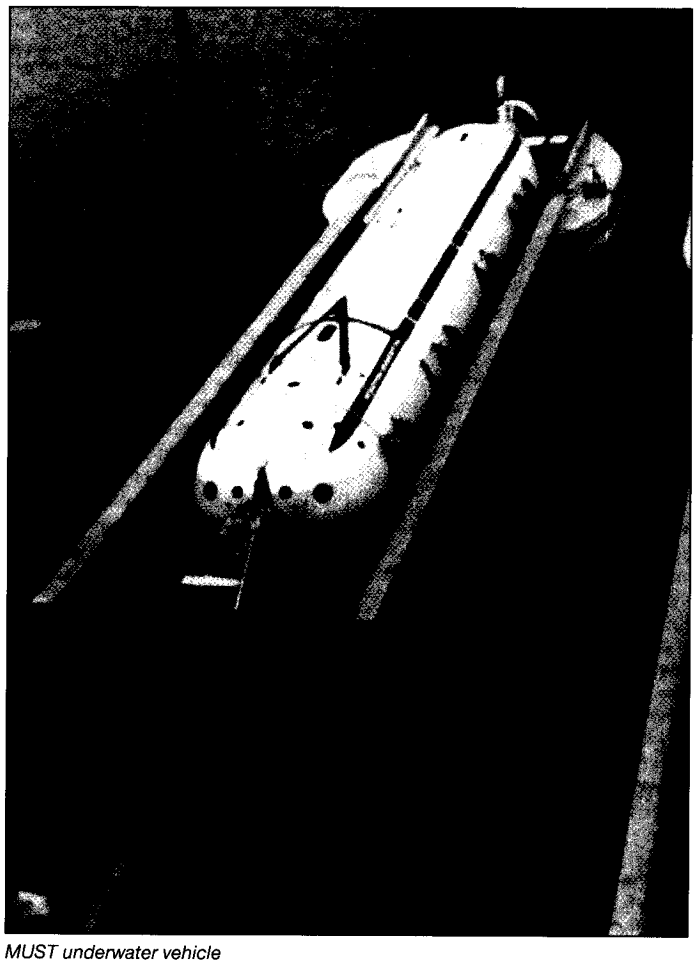
The baseline vehicle is 9 m long and made up of five hull sections. Configurations with three to seven hull sections result in overall lengths of 7.5 to 10.5 m. The main pressure vessel arrangement permits the use of standard 19 in rack-mounted equipment. This eliminates the need to repackage each project. Nearly one tonne of payload capability and 1,500 litres of payload are available in the baseline five section vehicle. Maximum depth of the vehicle is 610 m. Vehicle endurance ranges from 8 hours at full propulsion and payload power to 24 hours at lower propulsion loads. Electrical power consists of 24 V DC and 120 V DC. Lead-acid batteries supply power.

A unique launch and recovery system allows UUV operations in sea conditions that were formerly considered unsafe. Minimal manpower and deck rigging are needed to maintain a positive control of the vehicle. The heart of the system is an articulated ramp and deck-mounted trunnion. Together they decouple the ship's motion from the motion of the vehicle in the water. Typically the launch phase requires about 10 minutes and the recovery phase about 30 minutes or less. Ship speed during launch and recovery is 1 to 3 kt. Over 200 successful launches and recoveries have been performed in sea conditions up to and including Sea State 4.

Operation is monitored and piloted from the control/maintenance van containing the surface control console. Predive planning, software development, simulation, and post-dive analysis are also conducted in this van. The launch and recovery system, with vehicle hangar van, provide for vehicle handling, maintenance and storage during all phases of at-sea operations. MUST Lab's entire at-sea system is air-transportable to any location.

A complete UUV simulation and integration facility — Dry Lab — performs almost any preliminary work necessary for successful sea trials. This exact physical mock-up of the MUST Lab vehicle supports installation of rack-mounted electronics inside the pressure vessel, and sensor/actuator packages in the forward and aft fairings. The power distribution, vehicle operating system, and distributed input/output network duplicate the actual systems found in the vehicle. Dry Lab's capabilities allow independent verification and validation of MUST or payload software, operator training, mission planning and post-dive data analysis and mission reconstruction.

The vehicle is used to test a variety of underwater vehicle configurations, roles and payloads including autonomous mine surveillance, detection and destruction, route survey and autonomous clandestine surveillance roles.



MUST underwater vehicle

Operational status
The vehicle has conducted over 200 successful launches and recoveries in conditions up to and including Sea State 4. Over 100 dives have also been undertaken since 1989.

Contractor
Lockheed Martin, Perry Technologies, Riviera Beach, Florida.

VERIFIED

NMRS

Type
Unmanned underwater vehicle for mine reconnaissance.

Development
In August 1994, Northrop Grumman was awarded a three-year development contract to design and build an unmanned prototype vehicle for deployment from submarines to carry out mine reconnaissance operations. Northrop Grumman teamed with Lockheed Martin, responsible for developing the platform's control and propulsion systems.

Description
The NMRS (Near-term Mine Reconnaissance System) vehicle is an interim development that will lead to the fully autonomous and capable LMRS (Long-term Mine Reconnaissance System) (see LMRS entry). The vehicle is designed for deployment from submarines to carry out remote surveillance, precise location and classification of mine-like objects in the littoral zone and shallow water areas to ensure a mine-free operating environment for the submarine. Among the missions envisaged for NMRS are the detection of gaps in minefields which can be exploited by covert and amphibious forces (including submarines) and the surveying of the coastal environment (tides, seabed contours and so on) before an amphibious assault.

The vehicle will provide minefield reconnaissance in deep to shallow water using a multibeam active search sonar and a side scan classification sonar.

NMRS is a tethered, torpedo-shaped vehicle which can be launched and retrieved through standard 533 mm Mk 67 torpedo tubes in US Navy submarines using the swim out method of launch. The vehicle is subdivided into five main sections:

- The nose section housing a medium-frequency multibeam, active Forward Looking Sonar (FLS) and its processing electronics, and a probe which enables the vehicle to connect with the drogue and a small targeting array used to acquire the homing beacon on the submarine when returning from a mission
- The forebody which houses the main electronics and the sides of which contain the transducers of a high-frequency classification Side Looking Sonar (SLS) and the Doppler sonar mounted centrally on the bottom of this section
- The mid-body which houses the battery providing electrical power for the propulsion motor and hotel services
- The after body with free flooding tanks and a canister containing the fibre optic communications link
- Tail section with two electric motors, motor controllers and fin and tail actuator units. The control fins and propellers are located externally to the body of the vehicle.

The vehicle is controlled and data handled using a fibre optic link carrying simultaneous two-way communications between the vehicle and the operators. Separate communication paths are used to carry FLS data and commands, SLS data and commands and vehicle status data and commands.

The FLS (essentially a repackaged version of the AMDS - Advanced Mine Detection System) is used for obstacle avoidance and the detection of objects on the seabed and the detection and classification of moored objects. It consists of two hydrophones and projectors mounted to port and starboard on the wedge-shaped nose of the vehicle. Preprocessed data from these is fed to the parent submarine via the fibre optic link. From this, data beams are formed from the individual elements, each beam being scanned for contacts. This data is then combined with data from previous pings to provide target classification. The operator selects pulse length, power levels and pulse repetition rates according to water depth.

The SLS (based on the AN/AQS-14 side scan sonar) is used to classify bottom and close tethered targets. The transducers of the SLS are recessed along both sides of the forebody and mounted at 45° below the vehicle's centreline. This allows the hull of the vehicle to provide a baffle against surface-reflected noise in shallow water. Each transducer is attached to the vehicle's body at its mid-point to prevent mechanical distortion due to the hull decompressing at depth. Glass fibre fairings filled with syntactic foam are installed all around the sensors to provide a smooth surface and ensure a clean water flow past the hull and a flat area across which the return acoustic wave can be received.

Two NMRS vehicles are stored in the torpedo room of a Los Angeles class submarine. This reduces the torpedo payload by seven weapons. The vehicles are loaded and handled using conventional torpedo handling equipment. While one vehicle is out on a mission the other is being prepared ready to undertake the next mission when the other returns. The two vehicles and their associated drogue assemblies used for launch and recovery are stored beside the submarine's starboard torpedo hoist. The vehicles are controlled from two operator consoles sited in the upper inboard and outboard torpedo stowages adjacent to the torpedo handling gear.

To conduct operations in the littoral zone, the NMRS is equipped with a high-rate (nominally 140 Ah), rechargeable Zinc-Silver Oxide (Zn-AgO) battery. This is a reliable and robust power source that enables the vehicle to carry out autonomous operations for up to five hours. The battery can be recharged and rapidly maintained on board the submarine in 12 hours or less.

The fibre optic link is paid out from both the submarine and the vehicle. The drogue also carries a reserve amount of fibre optic cable (20 out of 50 n miles) that is used to compensate for the submarine's movement during a sortie. The drogue also provides a docking point for the vehicle on completion of a mission. If the fibre optic link should break, the vehicle is programmed to autonomously return to and mate with the drogue using a preset rendezvous point. Homing and docking beacons located on the drogue are used by the vehicle to locate, position and dock before recovery.

On completion of a mission, the vehicle returns to and mates with the drogue and both are then winched back into the submarine's torpedo tube using a traction winch located in the torpedo room. A special breech door penetrator is installed in the torpedo door to allow the tow cable to pass through while still providing an adequate seal against sea pressure. A hydraulic penetrator is also added to the breech doors to operate latches that release and secure the vehicle/drogue combination inside the torpedo tube. Once docked, the assembly is hauled back into the torpedo room and prepared for the next sortie.

Operational status
2002 - System begins entering operational service.
April 1999 - Testing completed aboard a Los Angeles class submarine.
March 1998 - Two prototype vehicles and shipboard control units commence trials.

Specifications
Length: 5,230 mm (vehicle), approx 6,430 mm (vehicle and launch and recovery assembly)
Diameter: 533 mm
Speed: 4-6 kt
Operating depth: 12 m

Contractor
Northrop Grumman, Baltimore, Maryland.

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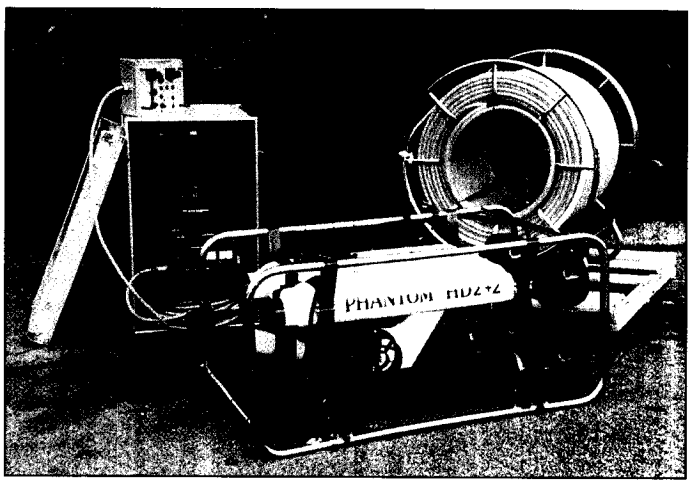
Phantom Series

Type
Remotely operated vehicles.

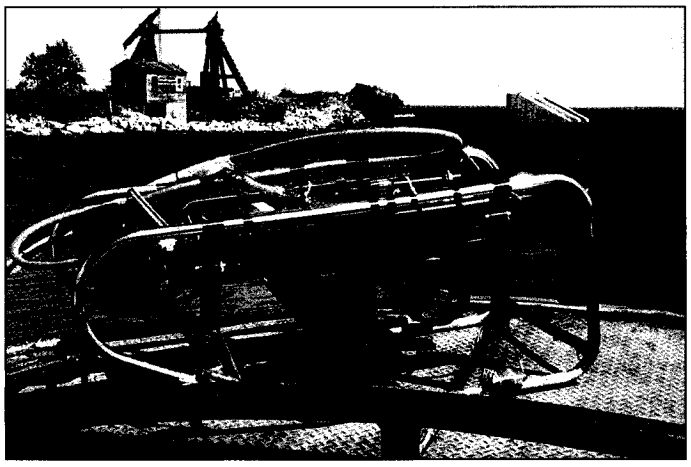
Description
The Phantom ROV has been utilised in a variety of commercial and military applications including mine countermeasures, harbour and port security, submarine rescue, ship hull inspections, bottom surveys, general diver support, and drug enforcement.

The fully streamlined Phantom HVS4 (deployed from COOP) and Phantom HVS2 (for airborne deployment) were specifically developed for the US Navy as powerful MCM/neutralisation vehicles. The Phantom vehicles use control consoles, umbilical cables and accessories that are interchangeable. Other models that are frequently used in MCM applications include the Phantom S4, Phantom HD2 and Phantom 300.

All Phantom ROVs feature a highly manoeuvrable vehicle platform protected within a full-perimeter stainless steel crash frame. High-resolution colour and optional STI monochrome video cameras are mounted to tilt with a pair of high-intensity quartz halogen lamps. The system may be equipped with a high-definition scanning sonar, built-in acoustic navigation responder, manipulator, and a payload deployment mechanism. Other accessories include laser-scaling devices, video on-screen display, remote joystick control, fibre optic cables, and a cable cutter.



Phantom HD2+2 with associated umbilical and control and display unit



A Phantom HD2 vehicle similar to the type delivered to the Swedish Navy 0009515

The vehicle is guided from the ship via a neutrally buoyant umbilical cable connected to the 19 in rack-mounted control console. Umbilical cable lengths are available up to 1,200 m. The vehicles use a hard-wired system, which minimises the complexity of subsea electronics and the cost of repair should the vehicle be flooded or lost.

Operational status
Phantom ROVs are in service with military departments of Australia, Brazil, Egypt (six units for the Border Guard), New Zealand (HDX), Portugal (52), Singapore, Sweden (12 HD2), the UK, and the USA. US Navy Phantom operators include the Explosive Ordnance Disposal teams; Naval Facility Engineering Support Center, Naval R & D, Naval Surface Warfare Center, Navy Research Lab, and Naval Coastal System Center. The latest system to enter service is a 450 m rated Phantom Ultimate vehicle which completed acceptance trials with the Brazilian Navy in the Summer of 1996. The vehicle will be used to handle equipment and tool packages for the rescue of crews from sunk submarines.

Specifications

	HD2	DHD2+2	DS4
Length	1.4 m	1.4 m	n/k
Width	0.68 m	0.68 m	0.857 m
Height	0.67 m	0.67 m	0.698 m
Weight	91 kg	132 kg	148 kg
Speed	2.5 kt	>3 kt	>3 kt
Payload	4 kg	2 kg	11 kg
Operating depth	300 m	600 m	610 m

Contractor
Deep Ocean Engineering Inc, San Leandro, California.

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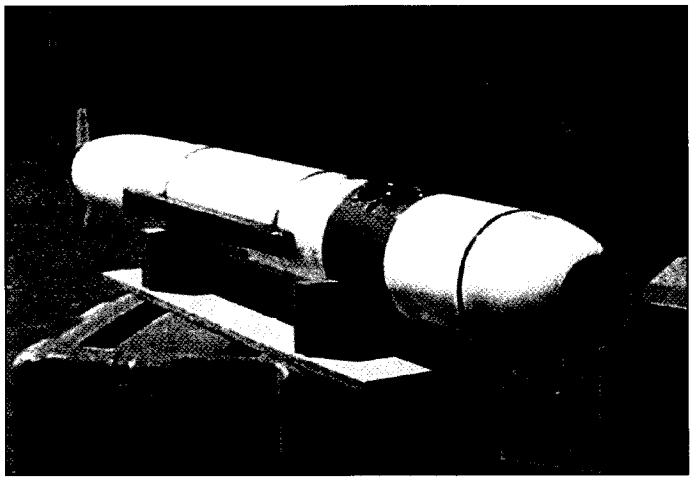
SAHRV

Type
Semi-autonomous hydrographic reconnaissance vehicle.

Description
The SAHRV (Semi-Autonomous Hydrographic Reconnaissance Vehicle) is a member of the Remote Environmental Monitoring Unit System (REMUS) family of UUVs developed by Woods Hole Oceanographic Institute. The vehicle is compact and weighs only 36.5 kg in air, allowing it to operate from small surface platforms such as a combat rubber raiding craft. It incorporates three motors, a direct-drive thruster, together with sprocket-driven rudder and pitch motors, mounted immediately forward of the propeller. This combination is optimised to sustain a forward speed of 3 to 4 kt, with an endurance of 8 hours and a range of 71 km (using lithium batteries).

The UUV carries a comprehensive sensor package, including Marine Sonic Technology's Sea Scan PC 600 kHz side scan sonar (which covers a 40 m wide swath, providing an ACR of 0.036 n miles^2/h); an RD Instruments 1.2 MHz acoustic Doppler current profiler; an Ocean Sensors OS200 CTD sensor; and a Seatech optical backscatter sensor that measures water turbidity and suspended particulate matter. These allow the vehicle to collect sonar, bathymetric and environmental data from the outer edge of the surf zone (in a typical water depth of 3 m) to about 150 m deep.

Operational status
USN SEAL (Sea, Air, Land) special forces, together with the service's very shallow water MCM Detachment, employed the (SAHRV) during FBE-H. The objective of Fleet Battle Experiment – Hotel (FBE-H), which took place in August/September 2000, was to demonstrate emerging MCM technologies (with particular emphasis on UUVs) suitable for use in water depths of 3.05 to 12.2 m. The SAHRV conducted eight missions involving 32 h on task over three nights during FBE-H, totalling



The SAHRV (Woods Hole Oceanographic Institute) 0083964

125 km of travel and covering an area of 3,400 × 900 m (divided between two beach approach lanes), during which it provided 100 per cent bottom coverage. The vehicle entered service with the SEALs in 2001 to take on some of the roles now performed by swimmers.

The US Naval Sea Systems Command has ordered 14 SAHRV together with four spares and support from Hydroid Inc, for use by the Naval Special Warfare forces for MCM and hydrographic reconnaissance in very shallow water.

Specifications
Length: 1.60 m
Diameter: 190 mm
Displacement: 36.5 kg (in air)
Speed: 3-4 kt
Range: 71 km
Endurance: 8 h

Contractor
Woods Hole Oceanographic Institute, Woods Hole, Massachusetts.

VERIFIED

SAUVIM

Type
Development Semi-Autonomous Underwater Vehicle (AUV).

Description
SAUVIM (Semi-Autonomous Underwater Vehicle for Intervention Missions) is a US Navy Project designed to dive, locate, tag and retrieve submerged military artefacts in test ranges. It will be an open-framed aluminium structure enclosed by a flooded composite fairing rated for 6,000 m depth. The vehicle will have eight thrusters; four internally mounted vertical thrusters; two internally mounted, horizontal thrusters; and two externally mounted horizontal thrusters.

The SAUVIM will be fitted with a seven Degrees of Freedom (DoF) electro-mechanical robotic manipulator with 1.4 m reach, and 8 kg lift capacity at full extension. The supervisory controller will be capable of communication with a land-based station to plan, verify and configure the vehicle and manipulator operations. Sensors include: four unidirectional sonars; a scanned sonar; controllable beam laser ranging system; passive optical homing system; passive arm

With two vehicle-mounted low light colour video cameras; an arm mounted colour video; and a rear-mounted monochrome video. The scientific payload includes: mission sensor package, including CTD, SeaTech LSS, magnetometer, methane sensor, radon sensor, and hydrogen sulphide sensor.

Operational status
The project is a two-phase R&D programme, with Phase I (feasibility and research), completed in 2000. Phase II (refinement and application) involves application testing at the Pacific Missile Range Facility (PMRF) and the Hawaii Undersea Geophysics Observatory (HUGO).

Specifications
Length: 6.1 m
Width: 2.1 m
Height: 1.5 m
Weight: 6,000 kg (in air)
Speed: 3 kt (max)
Operating depth: 6,000 m
Range: 10.75 n miles (max)

Contractor
University of Hawaii, Autonomous Systems Laboratory.

VERIFIED

Seahorse

Type
Oceanographic Autonomous Undersea Vehicle (AUV).

Description
Seahorse is a large modular Autonomous Undersea Vehicle developed at the Applied Research Laboratory of Pennsylvania State University for the Naval Oceanographic Office (NAVOCEANO), oceanographic and hydrographic surveying of shallow water areas world wide. Four segmented vehicle sections provide 24 bays within which separate pressure hulls holding batteries, vehicle electronics or instruments can be housed.

Autonomous navigation makes use of an aided Inertial Navigation System (INS). Control of the vehicle is hierarchical; an overall mission controller analyses mission requirements and remaining vehicle capabilities to produce high-level commands for passage to a vehicle controller, which carries out the detailed activities needed for full execution of the commands. The mission controller reacts to vehicle subsystem status and performance reports and may adapt missions in response to its findings. A centralised junction box permits access to critical signals produced by all major electronic subsystems without requiring extensive vehicle mechanical disassembly. The AUV has a high-efficiency ducted propulsor system driven by a small DC motor and is designed for minimum maintenance.

The modular design provides flexibility for use of a variety of payloads and for configuration of the operating envelope for the circumstances encountered. The current 10 cu ft payload features a high-resolution side scan sonar, ADCP and a CTD sensor, but other payloads under consideration are a 'SEAMAP' multibeam bathymetric mapping system, a sub-bottom profiler, ocean current measurement systems and additional bathymetric measurement devices.

The nose section is closed with either a structurally strong plate providing an eyelet for vehicle towing or a command released float with approximately 180 ft of rope for use in the recovery process. The vehicle is deployed and recovered between the tending service craft and in-water operation using a cocoon designed to both house the AUV and mitigate the inevitable rigors of at-sea transitions.

To maintain dynamic vehicle trim for efficient propulsor (power) usage and use of the vehicle in dynamic oceanographic circumstances, the AUV has both fore and aft Variable Ballast System (VBS) components. Each VBS reservoir is essentially a rubber inner tube into or out of which water can be pumped to increase or decrease vehicle in-water weight. Each VBS is individually activated and each has dedicated pumps and water inlets. The VBS system can be operated in ambient conditions in excess of 1,000 ft depth and each pump subsystem, though adjustable, are currently set to add or remove 20 lb of water per minute.

The first section houses five battery units and the upper sector of the current prototype unit houses an erectable antenna mast. The mast houses a neon blinker locator light for night recoveries, an RF satellite antenna for vehicle communications and a GPS antenna for navigation purposes. RF communications can be used for command and control purposes, as well as data download, if required. Later units will employ a different configuration to support those functions.

The second battery/payload section has one battery cylinder in the keel position, flotation units of Divinycell in the port and starboard locations above and below the centreline and an oil-filled junction box in the upright position. This box allows access to all subsystems electrically and electronically.

Each flotation unit is occupied by a number of individual 'pie slices' to allow for a very fine scale static trim and balance adjustments.

The third section contains battery cylinders in the keel and mast positions, buoyancy units port and starboard above the centreline and electronics canisters port and starboard below the centreline. Located in the same bays as the electronic canisters are the side scan sonar transducer arrays. In the starboard canister is the controller electronics (both vehicle and mission level) the INS and the GPS and RF Interface. The INS consists of a Kearfott ring laser gyro (RLG)-based SEANAV inertial sensor and Kalman filter, an RDI 300 kHz Workhorse Doppler Velocity Log and a Trimble GPS receiver. Also located in this bay are the CTD sensor electronics and CTD Sensor. Data storage units are located in both electronics canisters. There is an umbilical cable port for on-deck (or along-side the host ship) linkage to command and control points and data storage locations in the AUV. Under normal operating circumstances the umbilical cable is used for data download, system status checks and mission control inputs. The command and control hierarchy has been developed with the emphasis at the vehicle level. Mission level control is limited to reaction to vehicle status and mission requirements, with the capability to adapt to changing or unexpected circumstances provided.

The fourth and final section has the ADCP located in the keel position, flotation in the mast position and battery cylinders port and starboard, both above and below the centreline. Co-located with the ADCP transducers, is its electronics package. The ADCP transducer unit is mounted such that its profile is within the vehicle skin profile. The aft VBS pump assembly is located in the centre position of this section. Also located in this section is the second acoustic communications/tracking range transducer.

The VBS reservoir is immediately behind the fourth battery/payload section, followed by the housing containing the 5 hp propulsor motor and associated electronics. Operating at 232 rpm the propels the vehicle at approximately 4 kt; and at 360 rpm, 6 kt. For the lower speed, the current drawn is less than 200 mA; for the higher speed the current is still kept at a low value by addition of battery units. The rated efficiency of the propulsion system is over 80 per cent.

The propulsor, a highly efficient, three-bladed, ducted pumpjet system, rated at a nominal 225 rpm to develop a minimum power for the nominal speeds of 3 to 8 kt.

Operational status
March 2004 - Seahorse I and II undergoing certification tests and in demonstration phase. Seahorse III in production.

Early 2003 - USS *Florida* launched Seahorse from a Trident tube to carry out route survey in advance of landing by SOF on an advanced ASDS. Seahorse detected a mine even though it was not originally designed for this role. The Seahorse was controlled by the USNS *Mary Sears* (T-AGS 65).
Pre-operational integration aboard the T-AGS 60 class platform is virtually complete.
January 2001 - Integration of the prototype vehicle with deployment and recovery equipment aboard USNS *Bruce C Heezen* (T-AGS 64).
Early Winter 2000 - Testing continued in the Gulf of Mexico.
May 2000 - Initial testing of the vehicle in Lake Erie, at Erie, Pennsylvania.

Seahorse is operated and maintained by NAVOCEANO, headquartered at Stennis Space Center, Mississippi.

Specifications
Length: 8.35 m
Diameter: 0.99 m
Weight: 4,770 kg
Power: alkaline 'D' cell batteries (initially)
Speed: 3-8 kt
Range: 300 n miles at 4 kt
Endurance: 100 h at 4 kt

Contractors
Pennsylvania State University, Applied Research Laboratory,

UPDATED

Super SeaROVER

Type
Remotely Operated Vehicle (ROV).

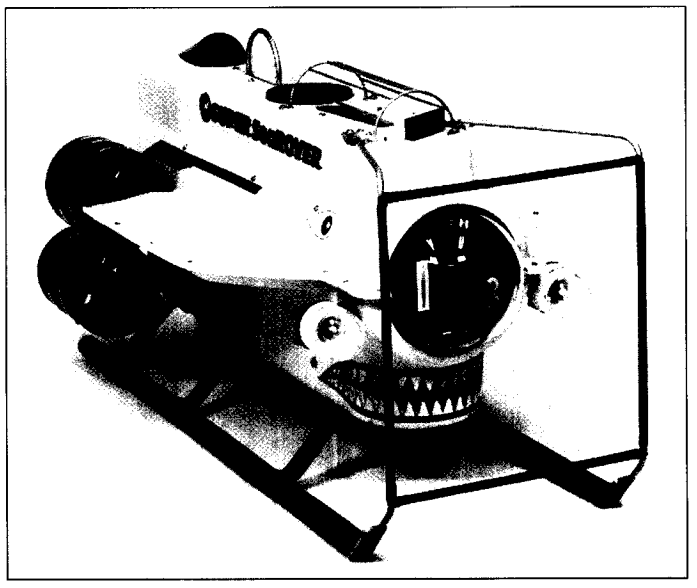
Description
The Super SeaROVER high-performance ROV can be customised to perform a variety of tasks including mine countermeasures, harbour security surveillance, inspections, surveys and so on.

The lightweight, compact ROV is fitted with 48 cm rack-mountable consoles, controlled via user-friendly controls, and with a sophisticated telemetry system with an RS-232 interface and a head-up video graphics overlay.

A number of special options can be fitted to the ROV including ultra-short baseline tracking system, high-resolution scanning sonar, altimeter, 1, 2 or 3 function manipulator arms, super thruster package or 35 mm cameras.

The vehicle is powered by two (optionally four) horizontal thrusters, and one vertical and one lateral powered by brushless DC drive motors. These give the vehicle a maximum speed of 5 kt and enable it to turn on its own axis, reverse, move laterally and vertically while maintaining heading, and hover motionless in light to moderate currents. The ROV is rated to a depth of 300 m.

Standard equipment carried by the Super SeaROVER includes a high-resolution colour video camera and two high-intensity underwater lights. The camera has a wide field of view (90°) and can pan and tilt on command from the operator. Video signals from the camera and navigational data from the vehicle's sensors are transmitted via an umbilical cable to surface TV monitors, allowing the pilot to simultaneously view the underwater scene and the on-screen video graphics overlay showing heading, depth and other data.



The Super SeaROVER ROV with video camera and lights forward and thrusters aft

A wide range of optional equipment can be fitted such as a positioning/navigation system, scanning sonar, manipulators, a low-light video camera and a tether management system.

Operational status

Originally ordered in 1988 by the US Navy as part of its effort to keep shipping lanes in the Gulf open during the Iran/Iraq war. Subsequently vehicles were used during Operation Desert Storm and later in the northern Gulf as part of the clean-up effort to identify and clear underwater mines laid by the Iraqis.

Specifications

Length: 1.42 m
Beam: 0.69 m
Height: 0.65 m
Weight: 91 kg
Speed: 5 kt (surfaced)
Operating depth: 304 m
Payload: 7-10 kg (in water)

Contractor

Benthos Inc, North Falmouth, Massachusetts.

UPDATED

UNDERWATER VEHICLE ANCILLARY EQUIPMENT

Denmark

DAMDIC Mk 1

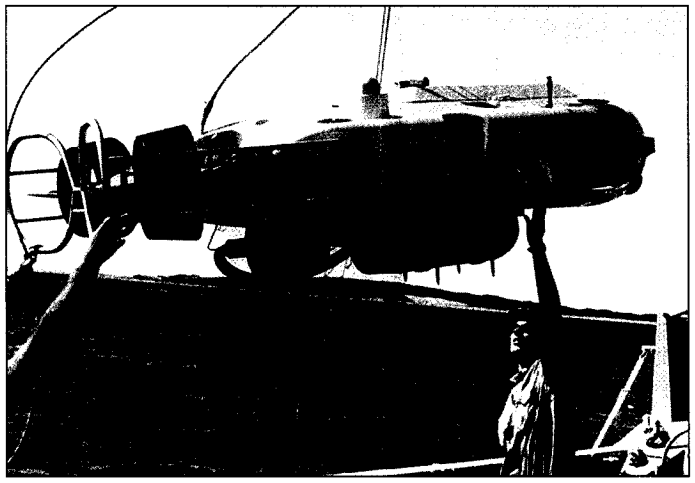
Type
Mine disposal charge.

Development
Nordic Defence Industries A/S and Naval Materiel Command Denmark jointly developed the DAMDIC system because of the need for a charge which would fulfil the Royal Danish Navy's rigorous safety demands. During the design phases the main objective was to achieve a very high degree of safety. Detonation via cable was preferred over acoustic signals as the latter often proved unreliable, especially in coastal waters with large variations in salinity.

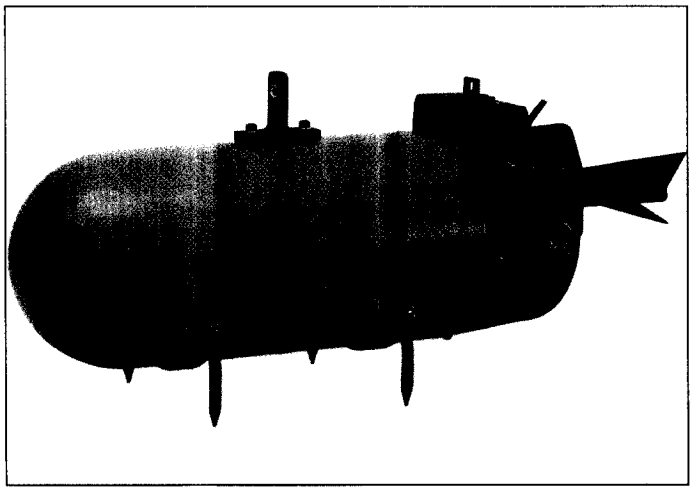
Description
The DAMDIC Mk 1 (DAnish Mine DIsposal Charge) is an explosive charge developed to neutralise mines and other ammunition detected on the seabed. The charge and cable spool are carried to the vicinity of the target by an ROV where, it is released to carry out a controlled descent to land alongside the mine after following a pre-calculated hydrodynamic glide trajectory. The ROV then returns to the parent MCMV and the charge is detonated by cable control. The cable spool houses a minimum of 1,000 m of cable, which allows the MCMV to remain outside the danger area of any mine at all times.

The charge itself is non-magnetic and does not contain any energy sources. It has two independent locking mechanisms and an additional transport locking mechanism.

The fuze mechanism is an out-of-line type with a pressure activated arming mechanism (it requires a depth greater than 6 m) that also requires release of the charge from the ROV to start the arming process. Thus, DAMDIC is never fully armed until it has been placed on the seabed and its cable attached to an energy source and, even at this late stage of deployment, it is still possible to disarm and recover the charge.



DAMDIC Mk 1 charge carried under Double Eagle ROV. Note the box holding the cable for spooling behind the charge (Nordic Defence Industries) 0097166



DAMDIC Mk I countermine charge (Nordic Defence Industries A/S) 0099448

Deployment procedures are straightforward. Software comprising a complete set of drop curves for the relevant current speeds and heights above the seabed are integrated into the ROVs camera system. Once the ROV with charge and spool hovers over the target, the operator carries out a video survey, and using the camera's aiming reticule (bomb sight), selects a suitable spot on the seabed for the charge. The command to release DAMDIC is given remotely from the ship, and as the charge glides to the selected position, the arming process begins, and the cable on the ROV is spooled out. The fins at the rear of the charge ensure a controlled descent while four short legs on the charge prevent it from rolling when it reaches the seabed. The ROV then returns to the ship for retrieval, while spooling out more cable. The cable is then connected to the exploder and the detonation initiated causing the charge to explode and the mine to sympathetically detonate.

DAMDIC can be easily interfaced and carried by any ROV. In combination with the Double Eagle ROV, the entire mine disposal system and console is containerised allowing it to be temporarily or permanently installed on any MCMV or COOP.

Operational status
Currently being supplied to the Royal Danish Navy for deployment from the Stanflex 300 Flyvefisken class. The Royal Australian Navy has ordered DAMDIC for deployment from Huon class MCMVs.

Specifications
Length: 816 mm (incl fins)
Diameter: 250 mm
Weight: 49 kg (in air) 21 kg (submerged)
Charge: 31 kg Comp B
Operating depth: 6-300 m

Contractor
Nordic Defence Industries A/S, Noerresundby.

VERIFIED

France

GIB-ROV

Type
ROV guidance and tracking system.

Description
The GIB-ROV is claimed to be an efficient and inexpensive system that uses a set of anchored buoys spread around the working area. The buoys continuously broadcast to a control station their D-GPS position together with the time of arrival of acoustic signals transmitted by the ROV's pinger. This results in all ROV positions being computed with a high repetition rate and an accuracy that allows them to be guided to a specific target.

GIB-ROV equipment can be easily operated from a support ship or a shore station to guide and track one or two ROVs. It offers a full mission overview at a glance. Position fixes are referred to in WGS-84 co-ordinates.

The system covers a wide spread of applications including:

- pipeline survey
- repair work
- SAR (submarine, black box, dummy mine recovery and so on)
- asset identification.

The portable system is easy to install onboard any non-dedicated vessel and can therefore be rapidly deployed anywhere in the world. The system requires no calibration and offers a much higher accuracy than traditional short baseline systems.

The system offers 3-D real time tracking in longitude and latitude with a metric accuracy in D-GOS mode. A typical work area covers a cylindrical volume 300 m in diameter and 150 m in height. The equipment is fully compatible with C-map digital charts and is operational in up to sea state 3-4.

The GPS element is a 12-channel receiver and the buoy is equipped with a 2-way 9,600 bps radio modem with a range of 800 m. The acoustic receiver covers the 30 kHz band. The control station is equipped with a Pentium 800 MHz laptop computer powered by rechargeable batteries and an external power supply. The ROV pinger operates in the 30 kHz frequency band with a 170 dB transmitting level.

Operational status
Available.

Contractor
ACSA Underwater GPS, Meyreuil.

NEW ENTRY

RECA

Type
Remotely piloted mine disposal charge.

Description
Developed by ECA, the Remotely Controlled Ammunition (RECA) is a new system designed to counter modern moored and ground mines that are extremely sensitive to both acoustic and magnetic signatures. Carried by Remotely Operated Vehicles (ROVs) such as the PAP, the RECA is a very small, self-propelled remote-controlled mine disposal charge which is able to navigate towards the mine-like object using its autonomous acoustic tracking system, identify the mine using its onboard video and steer to the target by a simple command transmitted via its wire tether.

Like other standard mine disposal charges, RECA is fitted underneath the ROV. Once in the target area (up to 500 m from the target) the operator releases RECA from the ROV using the standard control console. The ROV then returns to the ship. The RECA's propelled section then detaches from the mooring frame which remains on the seabed to provide stability.

RECA is then remotely piloted by wire from the ship's PAP console and can approach the target without endangering the ROV. Once the target is identified, RECA is piloted towards it and when contact is made the RECA explosive charge is remotely activated. If the target is identified as a non-mine, RECA is not released and thus recovered on the surface ready for the next mission.

RECA comprises two subsystems: the passive bottom mooring unit and the active unit comprising a power source, identification and tracking sensors (a 200 kHz sonar, two lights and a video camera - 625 lines CCIR standard) and control electronics, wire transmission line, horizontal propulsion thrusters and a shaped charge.

RECA can be carried by all PAP vehicles (Mk 3, Mk 5, PAP Plus) without any update or modification.

An exercise variant is available and training can be carried out using PAPSIM (see separate entry) which can integrate RECA operations if required.

Operational status
Sea trials carried out during 1995 and 1996. RECA has been tested by the French Navy. Industrialisation commenced in 1998-99. A qualified shaped charge is under integration. RECA became available on the market from the beginning of 2000.

Specifications
Length: 300 mm
Diameter: 135 mm
Weight (in air): 125 kg (vehicle 35 kg, anchoring frame 90 kg)
Charge: shaped charge type or other
Operating depth (max): 100-200 m
Standoff distance: 500 m
Speed: 3 kt (max)
Autonomy: 15-30 min (depending on operating conditions)

Contractor
ECA, Boulogne-Billancourt.

VERIFIED



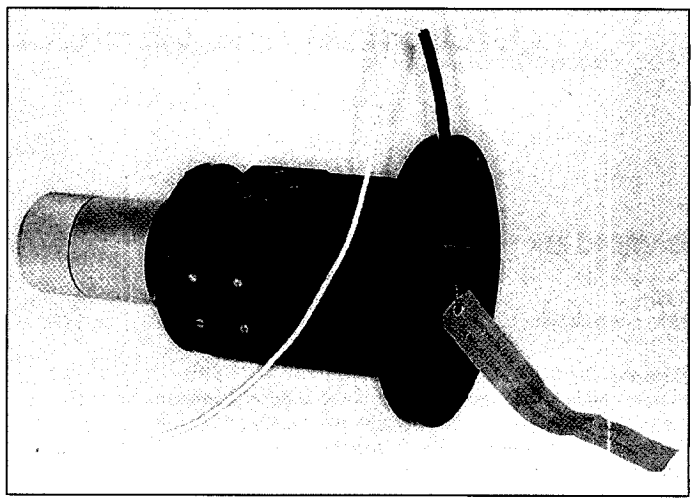
Remotely controlled ammunition RECA (ECA) 0064611

Germany

265 R

Type
Exercise fuze.

Description
The exercise fuze is functionally and dimensionally identical to the HE fuze DM 1002-3009 A1-A3 (see DM 1002-3009 entry), except for the explosive train.



Exercise fuze 158 R which is no longer in production

On receipt of the fuzing signal, the exercise fuze generates an electric impulse of 12 V and 1 A for a duration of 1 second. This impulse activates a relay or melts a wire which releases a buoy from an exercise charge.

Operational status
In production and use by the Royal Navy, Royal Australian Navy, Royal Saudi Navy and Singapore Navy. The 158R exercise fuze is no longer in production.

Specifications
Operating range: <=2,000 m
Operating depth: 5-300 m
Total weight: 8 kg
Battery: 12 V/1,000 mAh
Relay impulse: 12 V, 4 A, 3.5 s
Reusable with same battery: 20-40 times
Dimensions: 364.5 mm (max length); 200 mm (max diameter)

Contractor
Rheinmetall W & M GmbH, Unterluss.

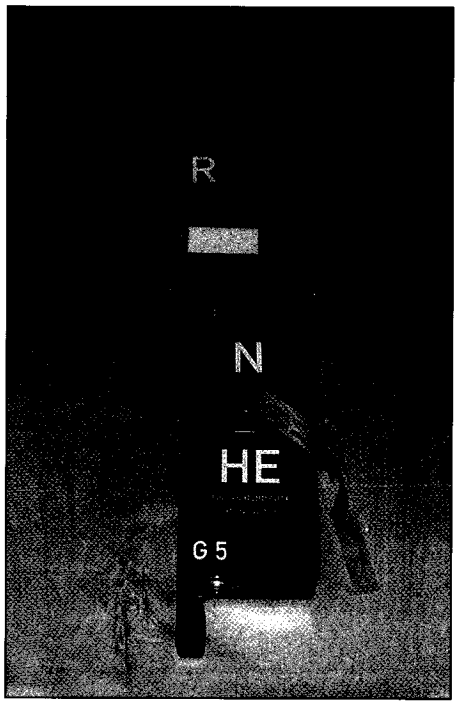
VERIFIED

DM 59/DM 69 to DM 119/DM 129

Type
Remote-Controlled Explosive Cutter (RCEC).

Description
Based in part on design features of the Rheinmetall explosive cutter for sweep wire attachment, this cutter is intended for use with underwater ROVs, such as the Société ECA PAP 104 system, STN ATLAS Elektronik Pinguin or Gayrobot Pluto.

The cutter's remote-control system is functionally identical to that used for detonating the mine disposal charge with the fuze DM 1002-3009 A1 to A3. With its hard foam housing, the RCEC is neutrally buoyant in water.



Remote-controlled explosive cutter DM 59/DM 69

Operational status
In production and in service with the Japanese Navy, Royal Navy, Singapore and Royal Saudi Naval Forces.

Specifications
Cutting capacity
Stud link chains: 16 mm
Steel wires: 20 mm
Synthetic ropes: 40 mm
Operating range: 300-2,000 m
Operating depth: 5 to <300 m
Weight in air: 6.4 kg
Weight in water: neutral buoyant
Dimensions: 865 × 195 × 121 mm

Contractor
Rheinmetall W & M GmbH, Unterluss. ***VERIFIED***

DM 1002-3009 A2-A3

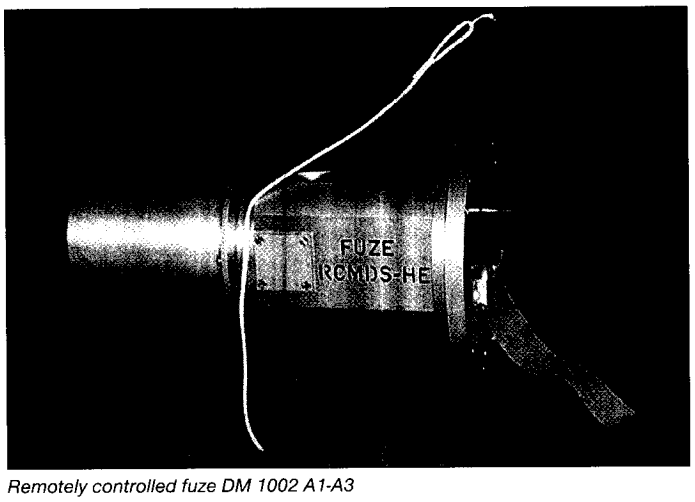
Type
Remote-controlled fuze.

Description
The fuze is ignited by a coded acoustic signal only and deactivates automatically if no such signal has been received within a certain time span. The fuze is impervious to shocks from detonations or similar occurrences above or below the water, as well as to any other acoustic noise or signal.

Operational status
In production and used by the German Navy as well as by the Australian, Belgian, Dutch, Indonesian, Japanese, Norwegian, Royal, Saudi and Singapore navies. The DM 1002-3009 A1 version is no longer in production.

Specifications
Length: 364.5 mm
Diameter: 200 mm
Operating range: ≤2,000 m
Operating depth: 5-300 m
Weight: 8.0 kg
Weight of explosives: 0.92 kg
Self-deactivation: 45 min (after laying - A3); 75 min (after laying - A2)

Contractor
Rheinmetall W & M GmbH, Unterluss. ***VERIFIED***



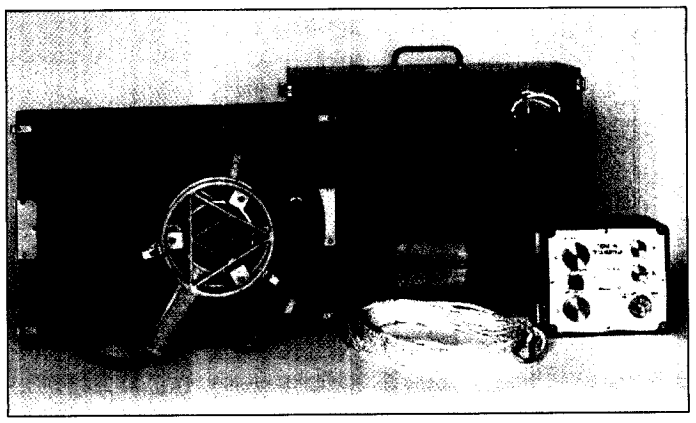
Remotely controlled fuze DM 1002 A1-A3

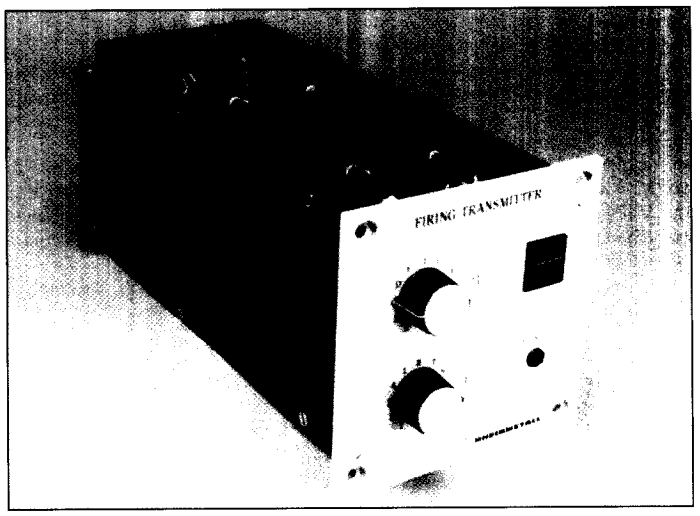
E 67/E 67 Mod 1

Type
Firing transmitter.

Description
The firing transmitter generates a coded acoustic signal which is led via cable to the transducer in the water. The coded signal sets off the mine disposal charge via its remotely controlled fuze at operating distances of up to 2,000 m.

The transmitter exists in two versions. One is supplied in its own carrying case for use on the quarter-deck, the other is for incorporation in a console below deck.


Firing transmitter E67 supplied in its own carrying case for use on the quarterdeck



Firing transmitter E67 Mod 1 for incorporation in a console below deck

Operational status
In production and used by the German Navy as well as the Australian, Belgian, Dutch, Indonesian, Japanese, Norwegian, Royal, Saudi and Singapore navies.

Specifications
Firing transmitter E 67 capacity
Output: 14 W
Supply voltage for battery charger: 110 V
Batteries: 2 × 12V/500 mAh
Code setting: by two rotary switches
Weight of transmitter: 6.5 kg
Weight of cable with transducer: 10.8 kg
Length of cable: 33 m
Weight of storage container: 11.7 kg
Dimensions of transmitter: 230 × 200 × 130 mm
Dimensions of transducer: 200 mm (max diameter)
Dimensions of storage container: 440 × 600 × 250 mm

Firing transmitter E 67 Mod 1 capacity
Output: 14 W
Power supply: 115 V AC
Code setting: by two rotary switches
Weight transmitter: 3.5 kg
Weight of cable with transducer and cable drum: 15 kg
Length of cable: 100 m
Dimensions of transmitter: 340 × 153 × 153 mm

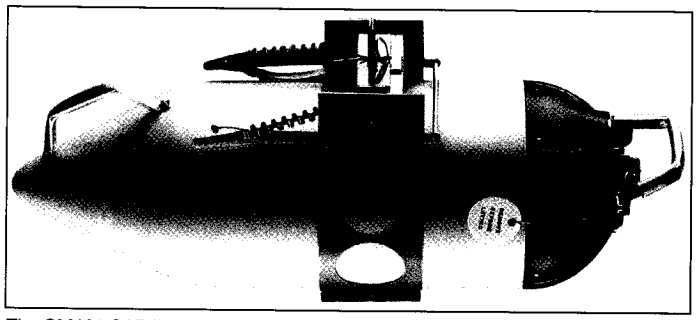
Contractor
Rheinmetall W & M GmbH, Unterluss. ***VERIFIED***

Italy

CM101-CAP

Type
Countermining charge.

Development
The CM101-CAP has been developed to the specific requirements of the Italian Navy to counter the threat posed by seabed mines.



The CM101-CAP live version with dedicated coupling hook (SEI SpA) 0097706

Description
The CM101-CAP countermining charge is designed to be carried by any ROV using a dedicated coupling system and released in the proximity of the mine to be destroyed. The charge is designed to neutralise the target mine by sympathetic detonation.

The device has a negligible magnetic signature.

Once the charge is deployed beside the mine to be neutralised and all safety devices removed (both mechanical and hydrostatic) an arming delay allows safe recovery of the ROV. After the arming delay time has elapsed the operator can initiate the charge from the MCMV, stationed at a safe distance.

The firing command is activated by means of a coded acoustic signal (a combination of different frequencies) generated by a dedicated transmitter located on board the MCMV. The transmitter can send a range of 24 possible codes contained in pulses in four different frequencies. The maximum activation range is about 2,000 m.

The weapon is also available in exercise and dummy variants suitable for training, simulation and sea trials.

Operational status
In production and service with the Italian and many other navies.

Specifications
Diameter: 250 mm
Length: 800 mm
Height: 367 mm
Weight: 44 kg (in air)
Main charge weight: 28 kg of C/B
Operational depth: 6-300 m

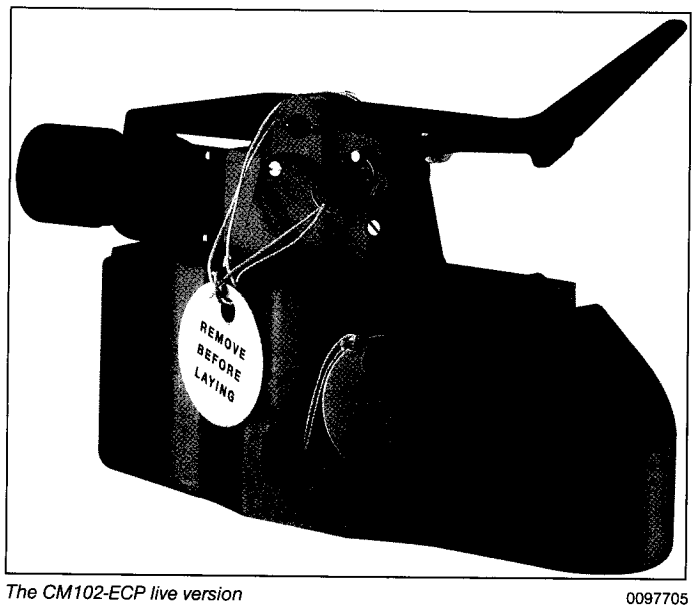
Contractor
SEI SpA, Ghedi.

VERIFIED

CM102-ECP

Type
Explosive cutter.

Development
The CM102-ECP has been developed to the specific requirements of the Italian Navy for countering the threat posed by hostile moored sea mines.



The CM102-ECP live version 0097705

Description
The CM102-ECP explosive cutter is designed for installation on the front part of any ROV using a dedicated mechanical interface. It is used to cut the chain or wire of moored mines up to a diameter of 30 mm.

The device has a negligible magnetic signature.

Two small guidance conveyors allow the device to be fitted on the chain. The pressure of the chain, felt by a mechanical sensor, operates a spring that clamps the cutter to the chain. After release by the ROV, and all safety devices (mechanical and hydrostatic) removed, a mechanical switch activates an electronic circuit that starts the countdown to the detonation. After a fixed arming delay time, to allow safe recovery of the ROV, the firing circuit closes and the shaped charge is activated to cut the wire or chain. A float provides positive buoyancy to ensure the maximum effect.

The cutter is also available in exercise and dummy variants suitable for training, simulation and sea trials.

Operational status
Proven in mine clearance operations and in production and service with the Italian and many other navies.

Specifications
Dimensions: 340 × 220 × 90 mm
Weight: 2 kg (in air)
Main charge weight: 110 g of C/B
Operational depth: 6-300 m

Contractor
SEI SpA, Ghedi.

VERIFIED

CM104-CAP

Type
Countermining charge.

Development
The CM101-CAP has been developed to the specific requirements of the Italian Navy to counter the threat posed by seabed mines.

Description
The CM104-CAP countermining charge is identical in most respects to the CM101-CAP, except for the quantity of explosive. It is designed to be carried by any ROV using a dedicated coupling system and released in the proximity of the mine to be destroyed. The charge is designed to neutralise the target mine by sympathetic detonation.

The device has a negligible magnetic signature.

Once the charge is deployed beside the mine to be neutralised and all safety devices removed (both mechanical and hydrostatic) an arming delay allows safe recovery of the ROV. After the arming delay time has elapsed the operator can initiate the charge from the MCMV, stationed at a safe distance.

The firing command is activated by means of a coded acoustic signal (a combination of different frequencies) generated by a dedicated transmitter located on board the MCMV. The transmitter can send a range of 24 possible codes contained in pulses in four different frequencies. The maximum activation range is about 2,000 m.

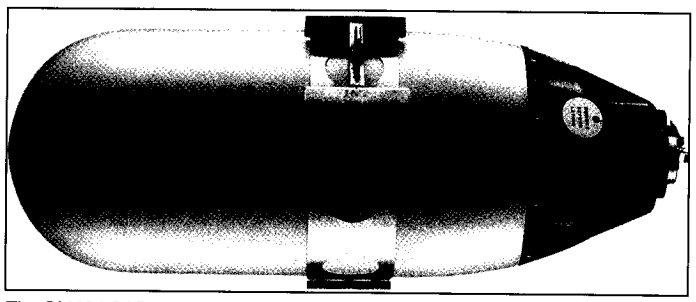
The weapon is also available in exercise and dummy variants suitable for training, simulation and sea trials.

Operational status
In production and service with the Italian and many other navies.

Specifications
Diameter: 350 mm
Length: 970 mm
Height: 455 mm
Weight: 100 kg (in air)
Main charge weight: 78 kg of C/B
Operational depth: 6-300 m

Contractor
SEI SpA, Ghedi.

VERIFIED



The CM104-CAP live version with dedicated coupling hook (SEI SpA) 0097707

CM106-ECMO

Type
Moored mine disposal charge.

Development
The CM106-ECMO is under development to meet specific requirements of the Italian Navy for countering the threat posed by enemy moored sea mines without the negative result of the mine drifting subsequent to the use of the standard cutter.

Description
Built of non-magnetic material, easy to store and safe for on board storage, the CM106-ECMO mine disposal charge is easy to transport and operate.

It can be installed on any ROV by means of a dedicated mechanical interface. When the device is clamped to the chain of the moored mine all safety devices (mechanical and hydrostatic) are removed and an arming delay ensures safe recovery of the ROV. The disposal charge is tied to the mooring rope/chain of the mine to be destroyed; the ballast is released and the charge is put in contact with the mine casing, using the mine mooring rope/chain as a guide and the positive buoyancy of the charge container as a contact force. The charge form, articulated and jointed so that it can conform to the shape of the mine casing, favours a good contact with the mine.

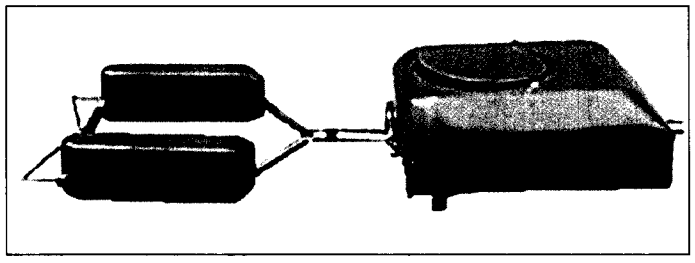
The explosive charge is constructed so that, at the limited distance allowed by the system's mechanics, it can obtain a blast effect that is sufficient to cause the mine to detonate.

Operational status
Under development for the Italian Navy.

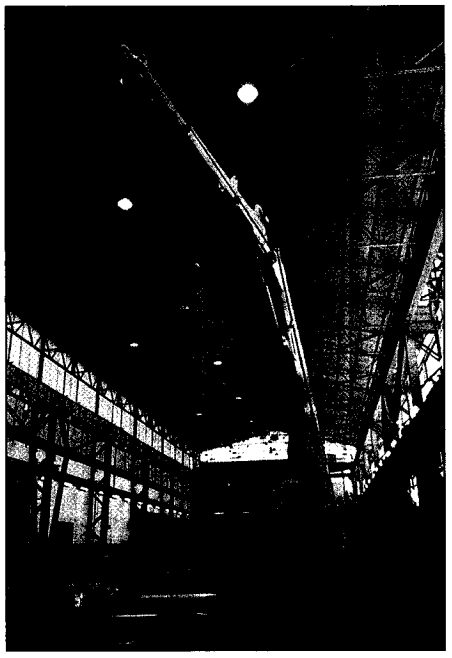
Specifications
Diameter: 430 mm
Length: 900 mm
Height: 190 mm
Weight: 27 kg (in air)
Charge: 8 kg
Operational depth: 150 m (max)

Contractor
SEI SpA, Ghedi.

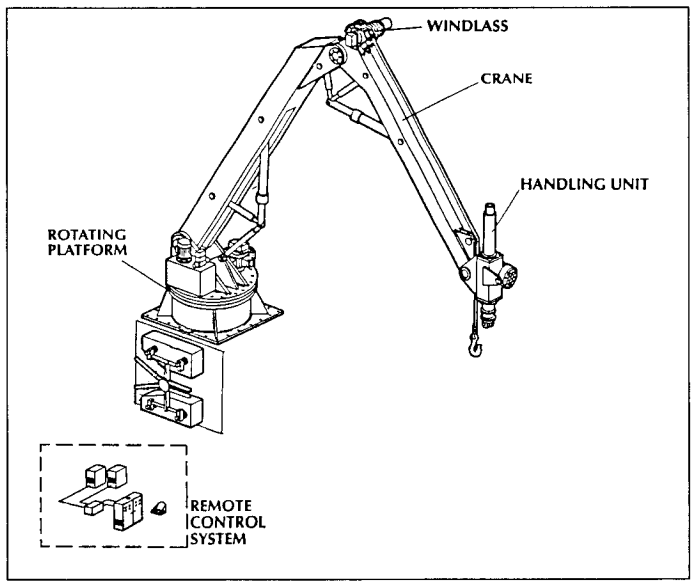
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Transport layout of the CM106-ECMO disposal charge (SEI SpA) 1020460



Prototype LARSC in the factory prior to sea trials

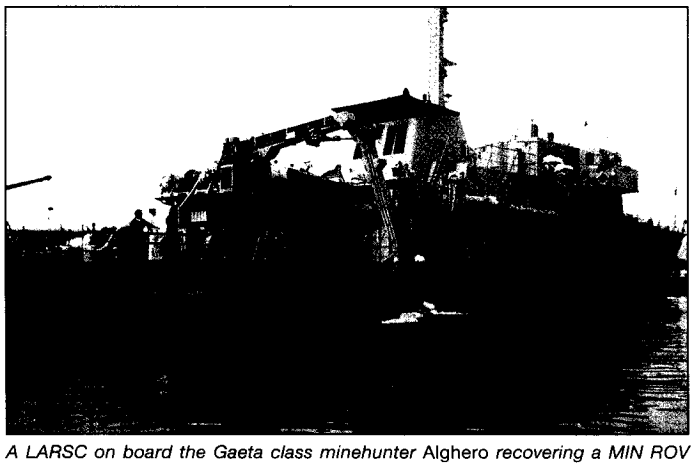


Launch and recovery system for ROV/AUVs

LARSC

Type
Launch And Recovery Smart Crane (LARSC).

Description
The LARSC has been specifically developed for the automatic launch and recovery of tethered or untethered underwater vehicles in high sea conditions. The system features reduced manpower requirements during the handling phase, improved safety and improved operational availability of vehicles.



A LARSC on board the Gaeta class minehunter Alghero *recovering a MIN ROV* 0009518

The system comprises the ROV/AUV interface, a handling unit, crane and electronic remote-control system. The portable console allows the operator to exercise full control over the handling of the crane and its payload, using push buttons and control joysticks.

The electronic control unit performs all the functions of command, control, warning and system safety. It receives signals from the sensors located on the crane and the set points derived from the portable console and transforms them into output signals to operate the crane's booms.

The crane has two knuckle-type booms which automatically compensate for the relative motion of the ship and the sea. The ROV handling unit, fitted to the end of the boom, is designed to capture the ROV as it surfaces by clutching the vehicle's probe which can be interfaced on different vehicles.

LARSC overcomes the need for weighty and cumbersome hardware on board a small ship. The vehicle interface requirements are simplified to allow the system to be fitted on almost all existing vehicles without impairing performance. Launch and recovery operations are carried out in semi-automatic remote mode in up to Sea State 4 in just a few minutes.

The crane can handle loads ranging from 500 to 2,000 kg in weight.

Operational status
The system underwent sea trials in 1989 and has been operational on Italian Navy Gaeta class minehunters since 1994. A number of navies have shown interest in the system and sea trials with different ROVs have been proposed.

Contractor
Calzoni Srl, Bologna.

UPDATED

Poland

Toczek

Type
Countermining charge.

Description
The Toczek family of underwater mine disposal charges has been developed by the Polish CTM (Centrum Techniki Morskiej) at the request of the Polish Navy. The family comprises three types of charge (Type A, B and C) with weights varying between 48 and 3 kg, the latter Type C being a hand-held charge to be delivered by a diver.

The charges are fitted with a universal acoustic fuze and a multilevel safety system.

The charges are detonated by a unique coded hydro-acoustic signal transmitted by the operator on the MCMV. Charges can be detonated at ranges up to 1,000 m from the parent vessel. In addition, the operator can command the time delay (up to 300 minutes) as well as presetting the time of detonation (40 to 480 minutes). Operating temperatures are between –10 and +40° C at water depths from 6 to 150 m.

Operational status
In service aboard the three upgraded Krogulec class MCMVs.

Specifications

	Type A	Type B	Type C
Length	480 mm	340 mm	270 mm
Diameter	250 mm	180 mm	120 mm
Weight	48 kg	10 kg	3 kg
Charge	40 kg	5 kg	1 kg
Operating depth	6-150 m	6-150 m	6-150 m

Contractor
CTM, Gliwice.

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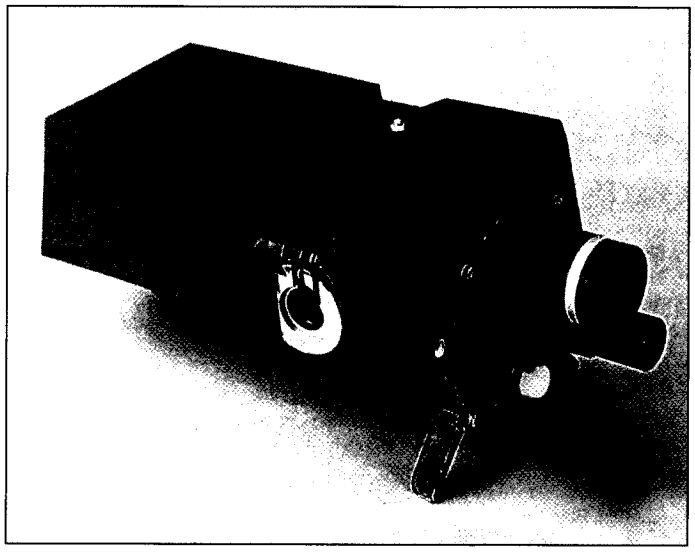
Sweden

MDC 605

Type
Mine disposal charge.

Description
The MDC 605 is designed primarily to detonate and destroy ground influence mines. It can also be placed on the sinker of a buoyant mine to sever its mooring, or be used for various underwater demolition tasks. The charge is normally deployed from an ROV, in particular the Double Eagle deployed from the Swedish Landsort class MCMV. The MDC 605 can also be carried and placed in position by a diver as it is small enough to be handled and can be made weight neutral in water by fixing a detachable float.

The charge is detonated by acoustic telecommand using a coded (8-bit frequency shift) signal. For safety, firing commands are ignored for a fixed time after laying. The MDC 605 incorporates a hydrostatic device which precludes the charge being armed until it has reached a set depth. The detonator is not fitted until immediately before deployment and the MDC 605 contains only low-sensitivity explosives during storage and transport.



Mine disposal charge MDC 605

Operational status
In service with the Swedish Navy.

Specifications
Length: 380-615 mm
Diameter: 170 mm
Weight: 4 kg (excl of charge)
Charge: 3-10 kg HE (optional)

Contractor
Saab Bofors Dynamics AB, Karlskoga.

VERIFIED

United Kingdom

3-AXIS MAGNETIC SENSORS

Type
General purpose and heading reference magnetic sensors.

Description
The TAM7, AMR1/2/3, TAG and HR3 3-axis magnetic sensors are designed for general purpose and heading reference applications. A wide range of high-performance, 3-axis fluxgate strapdown magnetometers are available.

Many of these magnetometers have been specifically designed and qualified for use in heading reference applications for Unmanned Aerial Vehicles (UAVs), Remotely Operated Vehicles (ROVs), and underwater weapons.

The sensors provide an analogue output voltage for measurements proportional to the magnetic field in each of the three axes. This information is then combined with roll and pitch information derived from the vehicle's vertical reference system where the host computer can calculate the resultant heading of the vehicle.

The TAM7 device is a true strapdown magnetometer designed to provide high-precision vector measurement of the ambient magnetic field. The fluxgate sensing elements and electronics are integrated into a small single lightweight package.

The HR3 second harmonic fluxgate magnetometer is a solid-state, 3-axis, strapdown unit designed for navigation requirements. It is a low-power unit with low drift, low-DC offset and low-noise electronics. The outputs are voltages directly proportional to the magnetic field affecting each of the three measurement axes with a common analogue signal reference (that is four-wire output). The heading is obtained by processing X, Y and Z outputs with roll and pitch data from attitude sensors using a trigonometrical algorithm.

To site the HR3 fluxgate head in the optimum location and to maximise accuracy, the sensing head is packaged separately from the processing electronics.

The AMR1/2 solid-state strapdown magnetometers provide high-precision vector measurement of the ambient magnetic field. The AMR1 is designed to operate directly from an aircraft 28 V supply.

The TAG is a high-performance, low-power, triaxial magnetometer developed for use in many anomaly detection and heading reference applications (roll and pitch data is required). It uses solid-state second harmonic fluxgate technology and incorporates magnetic feedback for improved accuracy and stability. The basic design is a single-card module comprising both the fluxgate sensors and electronics, all housed in a rugged aluminium enclosure. An alignment edge is incorporated for heading reference application. A sleep mode is also incorporated to enable the unit to be shut down when not required.

Operational status
All the sensors detailed above are in production and are supplied to a worldwide market.

Contractor
Ultra Electronics, PMES , Hednesford, Cannock, Staffordshire.

UPDATED

DME

Type
Acoustic depth measuring system.

Description
The DME (Depth Monitoring Equipment) system has been designed to precisely measure the depth of tow of minesweeping devices. The system comprises a small acoustic transponder fitted with a calibrated depth pressure sensor that is acoustically interrogated by a surface transceiver unit. The transceiver recognises and decodes these pings and communicates this data to the command computer.

Depth transponder

The transponder is an underwater acoustic beacon fitted with a depth pressure sensor. When acoustically interrogated by the transceiver, the transponder

computes the depth and returns this data using two acoustic pulses. The time interval between these pulses is proportional to the measured depth.

The transponder can be operated on two discrete channels (A or B) that can allow two vessels to operate in close proximity to each other without conflict between DME systems. This channel selection is implemented by arming plugs that are fitted to the transponder charging connector during operation. The transponder is powered using rechargeable battery packs that can be recharged using the DME battery charger.

Transceiver

The transceiver is an underwater acoustic interrogator that has been designed to operate as a control for the DME transponder. The transceiver acts on serial commands transmitted down the electrical tow cable. These commands are decoded and the correct operation executed.

The DME transceiver requests depth from the transponder by interrogating the transponder with a single transmit pulse of set frequency. The transponder replies with two pulses, again of known frequency which the transceiver decodes and transmits the depth result back through the serial interface.

The transceiver, like the transponder, can be operated on two discrete channels (A or B). This channel selection is implemented with a DIP switch located on a printed circuit board internal to the pressure housing.

V-fin depressor

The V-fin depressor is a towed underwater vehicle that is hydrodynamically designed to fly at a determined depth relative to the amount of cable paid out and the speed of the towing vehicle. The V-fin is highly stable, even in turbulent water, and has been designed to accept the DME transceiver and its payload.

Towfish

The towfish provides protection to the more delicate transponder during deployment, recovery and general handling. It also isolates the transponder from the vibration of the sweep line with the aim of improving the acoustic sphere of operation.

Operational status
Operational worldwide.

Contractor
Sonardyne International Ltd, Yately, Hampshire.

UPDATED

OE 1324

Type
Remotely Operated Vehicle (ROV) camera.

Description
The OE 1324 SIT low-light level image-intensified, monochrome camera is supplied as an upgrade for the PAP 104 Mk 3 camera in conjunction with other sensors supplied by CSIP/ECA. It provides higher resolution, longer viewing range and will operate at significant depths, even with ambient light levels. It is also fitted with a wide-angle lens thus providing the ROV pilot with greater vision enhancing obstacle avoidance and final positioning of the ROV-deployed mine disposal charge.

Operational status
In service with the Royal Navy.

Contractor
Kongsberg Maritime Ltd, Bridge of Don, Aberdeen.

UPDATED

OE 2700

Type
ROV cameras.

Description
The OE 2700 system comprises a monochrome and a colour TV camera which are fitted to the ECA PAP 104 Mk V vehicle assembly. The cameras are mounted on cover plates which in turn are fitted with watertight housings and attached to a common tilt mechanism. Each camera views the underwater scene through a port which makes corrections for the refractive index of water, while the iris of each camera lens is automatically adjusted to suit the prevailing level of scene luminance. The cameras have the capability to lock to an external signal source — genlock.

Operational status
In service with the Royal Navy and Royal Saudi Naval Forces Sandown class single-role minehunters.

Contractor
Kongsberg Maritime Ltd, Aberdeen.

UPDATED

ROV/Diver TRAK

Type
Tracking system for ROVs and divers.

Description
ROV/Diver TRAK is an acoustic positioning system that has been developed for tracking the position of small ROVs and divers. It can track one surface and one underwater mobile target.

A key feature of the system is its ability to mark way points which can be used to define arrays to represent sets of parallel search lines, tag underwater objects and features, mark transponder positions and tie-in known features like jetties, shore markers and so on. The system is particularly applicable in explosive ordnance clearance, monitoring diver operations, search and salvage, vessel ranging and so on.

The number of waypoints is limited only by hard disk space. Additional display markers indicate the surface vessel and underwater mobile target. A display option provides a 'snail' trail for each of these two mobile targets. All marker and track data is automatically logged to disk, together with related information such as position, depth, heading and time of day to provide a complete dive record that can be subsequently replayed.

The system incorporates the Sonardyne ROV-Homer target relocation system and low cost acoustic beacons.

Operational status
Operational worldwide.

Contractor
Sonardyne International Ltd, Yately, Hampshire.

UPDATED

ROV-Homer

Type
Relocation system for ROVs.

Description
The ROV-Homer is a miniature range and direction guidance system for small or large ROVs. It is specifically designed for fast, efficient relocation of underwater targets such as lost diving bells, divers, seabed equipment or small objects. The system is particularly suitable for use in the marking of exercise mines and in EOD clearance. It enables points of interest to be marked either temporarily or permanently so that an ROV can be guided straight back to the target by the pilot, even in zero visibility, which substantially reduces search time

The system operates with a range of miniature battery powered acoustic transponders, each being easily selectable by the ROV operator using the surface display unit. The transponders are small and lightweight so that they can be easily fitted to equipment and have a long life battery pack making them suitable for use as permanent markers. Each transponder is individually encoded enabling many transponders to be used on the same site to unambiguously mark multiple targets.

The system comprises an ROV-mounted range and direction unit, a surface display for the operator and small lightweight marker transponders. The ROVs unit is accurately aligned with reference to the ROVs heading sensor. The operator uses the keypad on the surface display unit to select the marker transponder they require the ROV to home on to. The unit then interrogates the specified transponder and, from the reply, determines both the range (distances up to 0.5 km are accurately measured) and direction of the marker transponder from the ROV. This data is relayed back to the surface via the ROVs umbilical and displayed on an LCD unit, indicating to the operator the range to the target and the direction in which to steer the ROV (left/right/ahead) towards the selected transponder. The system enables normal or emergency relocation of marked points of interest.

Operational status
Operational worldwide in water depths up to 12,000 m.

Contractor
Sonardyne International Ltd, Yately, Hampshire.

UPDATED

SAP

Type
One-shot mine disposal warhead system.

Description
The SAP (Semi-Armour Piercing) warhead system developed by QinetiQ (formerly DERA) in collaboration with the Norwegian Defence Research Establishment, BAE Systems Blackburn, Reynolds Industries and Kongsberg Defence and Aerospace, is specifically designed to be effective against all current tethered and bottom mines. The warhead, which is fired from an underwater gun, is fitted with an electro/mechanical fuze, which can be set either for instantaneous detonation or for a preprogrammed time delay. Tests have shown the warhead to be equally effective in achieving complete destruction of mine targets filled with either conventional or insensitive polymer bonded explosive (PBX) compositions. The

weapon firing platform is typically a small, expendable ROV such as the Norwegian Minesniper. To simplify vehicle integration, the warhead has been designed as a self-contained weapon requiring only four signal inputs from the ROV to communicate with the integral fire-control unit. The warhead is capable of either internal or external vehicle fitment. In the Minesniper, which is equipped with video camera, lights, laser aiming device and 360° panoramic sonar, the SAP charge is fired through the nose of the vehicle to penetrate the mine casing and into the explosive filling.

Operational status
The system has undergone successful trials.

Specifications
Length: 6,894 mm (internal fitment)
Diameter: 100 mm (breech); 53.5 mm (muzzle)
Weight (in air): c 5.6 kg
Operating depth: c 500 m

Contractor
BAE Systems, RO Defence, Blackburn Lancashire. ***VERIFIED***

Sea Sting

Type
Shaped charge mine disposal system.

Description
BAE Systems has developed a small shaped charge, Sea Sting capable of destroying all types of ground and moored mines. In the case of moored mines, this obviates the need for cable cutting techniques and subsequent destruction of surfaced mines.

The weapon is deployed using a Remotely Operated Vehicle (ROV) with a limited function manipulator for placement, attachment and simple sensors such as low-light/TV for identification and placement. The attachment process is fully automatic, thus minimising the need for sophisticated operator interaction. The attachment mechanism ensures attachment to any mine surface.

Sea Sting is compact and almost neutrally buoyant so that it does not impose significant demands in terms of ROV power and manoeuvrability.

The use of a small explosive charge ensures that the sonar environment remains undisturbed in the event of non-detonation of the target mine. A repeat engagement can be mounted quickly.

Operational status
In development.

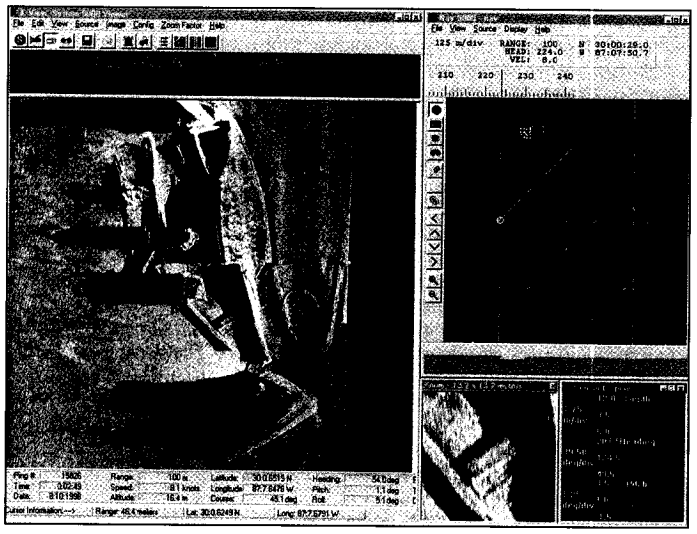
Specifications
Length: >400 mm
Diameter: >170 mm
Weight (in air): 10 kg

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire. ***VERIFIED***

United States

Series 5000 AUV

Type
Multibeam side scan sonar for AUVs.



Series 5000 system viewer details (Klein Associates) ***NEW***/0058808

Description
The Series 5000 high-speed, high-resolution side scan sonars use digital technology to form multiple, dynamically focused and collimated sonar beams on each side of the sonar. The Model 5500 five beam sonar system produces beams that have a 20 cm along-track resolution (normal resolution) and 10 cm along-track resolution (high-resolution mode).

The modular design allows easy application to several AUV platforms. Examples are the Bluefin Robotic and Maridan AUVs. Successful surveys were conducted in 2001 and 2002, and more applications and platforms are planned. On board controllers and expanded data storage devices were used. Data is downloaded via the Ethernet port.

The design of the Series 5000 sonar systems permits contiguous placement of the collimated sonar beam allowing gap-free, 100 per cent bottom coverage at speeds up to the maximum speed of the specific sonar model (the Model 5500 is 10 kt). This capability is achieved while maintaining the specified along-track resolution. As a consequence of the use of multiple beams the Series 5000 sonars can produce up to five times the data of an unfocused, single beam side scan sonar at significantly higher coverage rates.

At slower speeds the sonar beams are controlled to maintain equally spaced, contiguous beam placement, so that the sonar maintains 100 per cent bottom coverage. Five beams are continuously used and 'stacking' of overlapped beams at slower speed means there are multiple 'looks' at the same spot. This produces data that is useful in increasing the probability of detection of various targets. The use of multi-beam side scan sonar increases the image quality and enhances the detection of small details and contacts, while increasing area coverage rates over that available through the use of single beam side scan sonars and even multi-pulsed single-beam sonars.

The Series 5000 sonar systems have been designed to be deployed from a tow cable, permitting the towfish to be towed in the vicinity of the sea bottom for optimum resolution and for the avoidance of environmental interference. However, for shallow water operations, Series 5000 sonars can be hull-mounted and maintain operational capabilities in water depths as shallow as 2 m.

A series 5000 system consists of: a variable depth sonar transducer (the towfish); processing module; transceiver processor unit; and a shipboard unit consisting of the control module, typically an IBM type computer with a 17 in video monitor. All surface units are available in rack-mounted configuration.

Operational status
The Model 5500 AUV sonar system is currently in production and available for operations. Custom designs for AUV configuration are available.

Contractor
L-3 Communications Klein Associates, Inc, Salem, New Hampshire.

UPDATED

MINE CLEARANCE SYSTEMS

Australia

AMAS

Type
Minesweeping system.

Description
The Australian Minesweeping System (AMAS) emulates the magnetic, acoustic and electric signatures of target vessels in intensity, structure and spatial shape and presents as valid a ship target even to the most modern mines.

ADI's AMAS is a systems approach to minesweeping, consisting of combined influence sweeps (magnetic, acoustic, electric), programmable acoustic generators, mission planning software, an ECDIS Minesweeping Control System (MCS) and a Remote Controlled Minesweeping System (RCMS). The sweeps are self-contained, require no power from the towing vessel, and can be deployed from MCMVs, naval support craft, remote-controlled drones and COOP such as fishing vessels.

Multi Influence Sweep

Magnetic

Magnetic emulation is provided by a linear array of tow bodies called Dyads.

The modular nature of the sweep provides the capacity to emulate different ship classes. The magnetic signature is modified by varying the number of Dyads in the array, the polarity (positive or negative pole in the direction of tow) and the distance separating each Dyad.

The positively buoyant Dyads are mild steel cylinders driven into magnetic saturation by two permanent magnet disc stacks to form a large dipolar magnet.

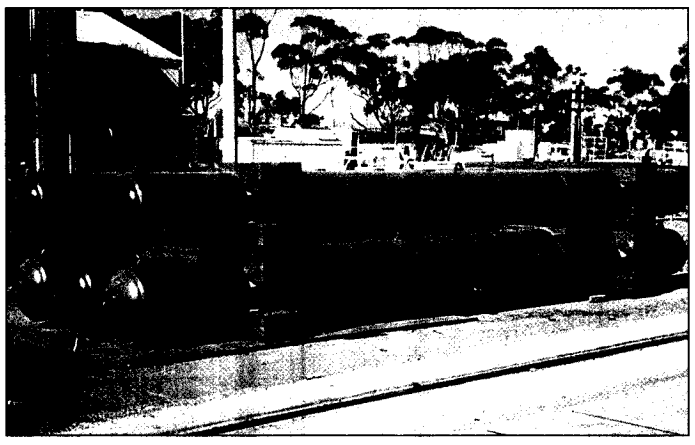
The ability to manipulate sweep signatures means that the system can be used in either a target setting mode (TSM) or a mine setting mode (MSM), and the resultant signature structure can be optimised to reflect the requirements of any geographic location.

Acoustic

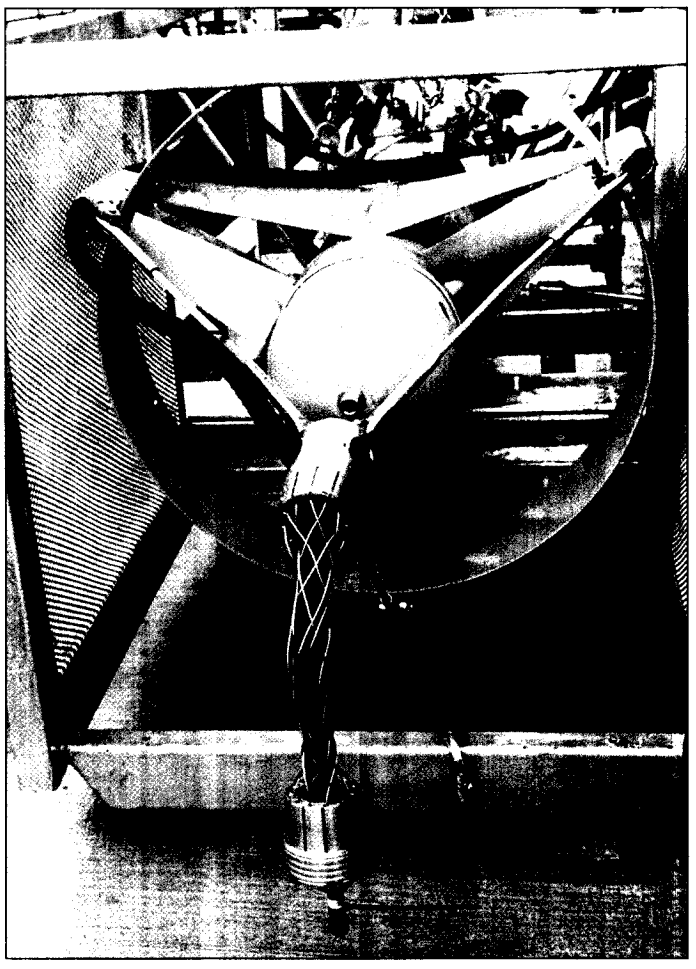
The baseline acoustic generator is a four tube Pipe Noise Maker (PNM) able to produce a ship-like acoustic coverage from low to ultrasonic frequency. The PNM is an inexpensive, consumable item with an operational life of approximately 60 hours.

Against the most modern mines, ADI's Australian Acoustic Generator (AAG) and Infrasonic AAG (IAAG) provide multiple stable line structure and programmable output spectrum. The generators are self-contained, programmable, electro-hydraulic acoustic piston noise sources powered by a water-driven turbine. The AAG (<5 Hz to > 30 kHz) emulates warships up to destroyer size and merchant ships below 50,000 tonnes. The IAAG (<5 Hz to > 3 kHz) is for sweeping in TSM for modern mines targeted against large warships and large merchant ships.

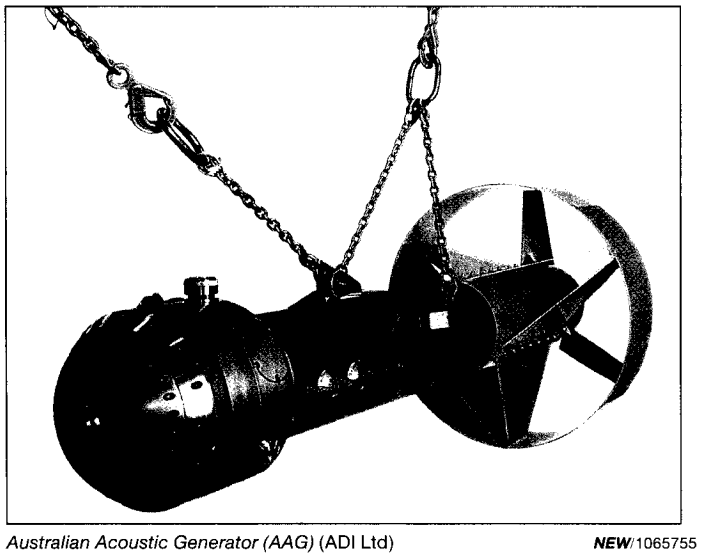
Algorithms loaded to an onboard processor enable the programming of multiple tonals and spectral shape and the generator is independent of external sources for either power or control. Consequently, the system can be easily deployed by vessels of all types, including remote control drones, without any need for modification to the deploying platform. The AAG is 2,000 mm long, and 350 mm in diameter at the acoustic head. The trailing variable pitch turbine has a blade diameter of 700 mm. The weight in air is 216 kg and the generator has a nominal



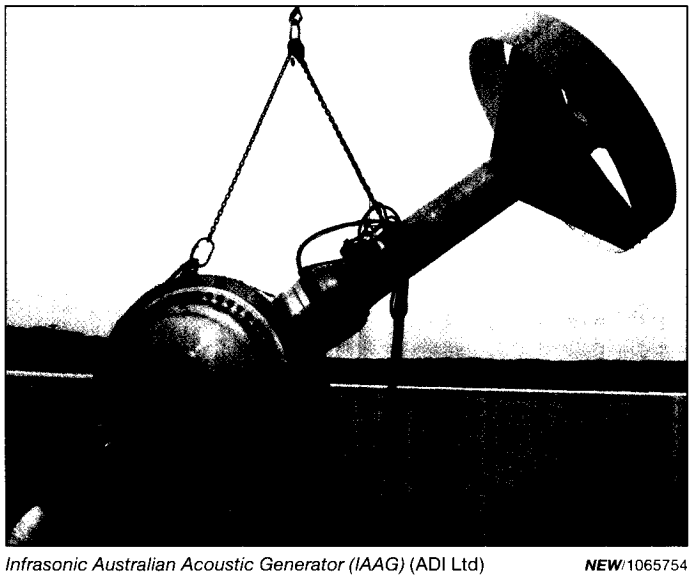
Mini Dyads (ADI Limited) 0536614



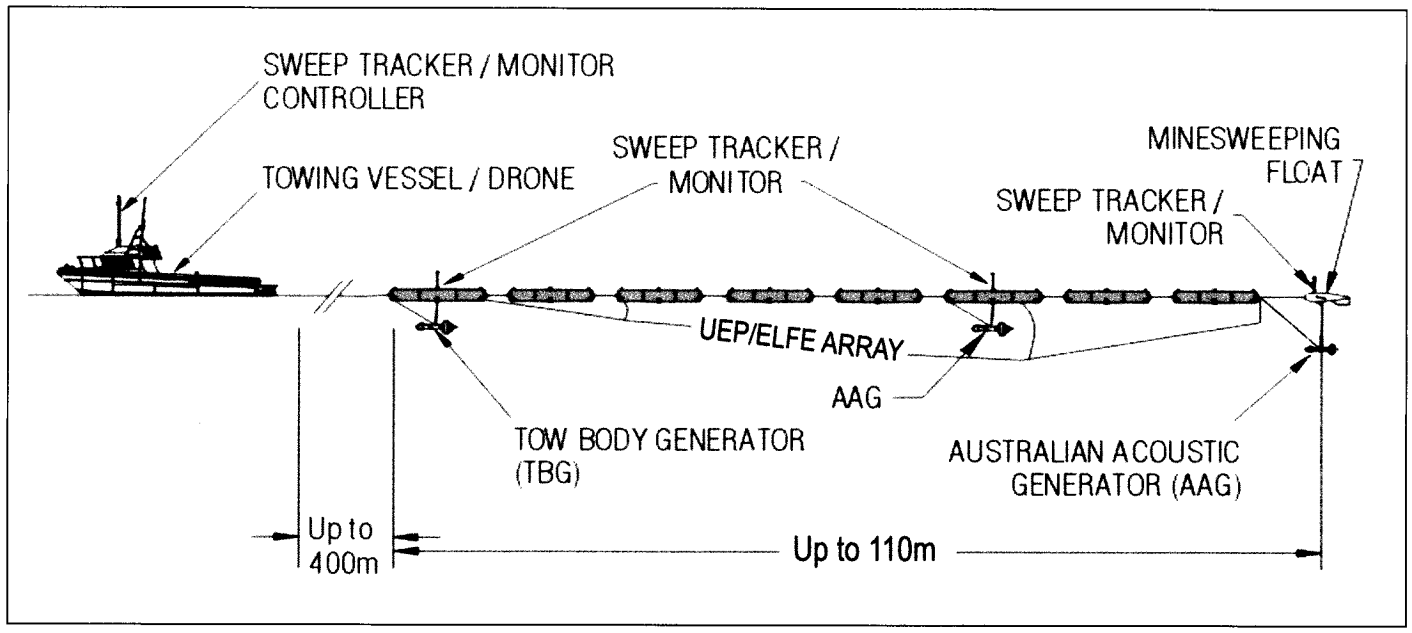
The UEP/ELFE tow body generator uses a turbine to power onboard electronic control to the array (ADI Limited) 0536616



Australian Acoustic Generator (AAG) (ADI Ltd) ***NEW***/1065755



Infrasonic Australian Acoustic Generator (IAAG) (ADI Ltd) ***NEW***/1065754



AMAS multi-influence sweep (ADI Ltd) ***NEW***/1065757



UEP/ELFE sweep array (ADI Ltd) ***NEW***/1065761

operating speed range of 6 to 15 kt. The maximum output (audio tonal) is 182 dB/1 $\mu Pa^2/H$, at 1 m.

Electric

AMAS is also able to counter mines with Underwater Electric Potential and Extra-Low Electromagnetic Frequency Emission (UEP/ELFE) sensors.

UEP emulation is achieved by providing programmable steady current to up to eight active electrodes along the sweep array in the same relative positions as the ship's emissions.

ELFE emulation is achieved by providing programmable alternating current to at least two pairs of active electrodes along the sweep array in the same relative positions as the ship's emissions. Each electrode can output either DC or AC or both AC and DC current simultaneously.

Mission Planning Support System

The complete minesweeping mission plan can be overlaid on electronic charts (vector or raster) from the integral MPSS Geographic Information System.

MPSS planning steps include:

- Magnetic sweep design
- Calculation of sweep effectiveness as an actuation probability profile for magnetic, acoustic and combined
- Calculation of track plan in each segment of a Q route
- Mission assessment

Minesweeping Control System

ADI's Minesweeping Control System (MCS) provides precise navigation of the tow platform and accurate positioning of the sweep along its runs. It incorporates ADI's ECDIS navigation software, VASCO-II for MCMVs.

The MCS is a modular portable system, which can be temporarily fitted to a COOP or installed on a dedicated MCMV. The system includes the Tactical Station, the Helmsman's Station, DGPS transceiver, Gyrocompass and associated navigation sensors, sweep tracking system and communications links.

Remote Control Minesweeping System

The RCMS incorporates the MCS and is used to control and monitor up to four Minesweeping Drones (MSD) via a single channel VHF data link. The RCMS control station may be installed onboard a control ship or ashore.

Operational status

Major AMAS system components are in service with the navies of Australia, Denmark, Indonesia, Japan, Poland, Thailand, the UAE and the US.

The UAE purchased a remote-control version of AMAS to include a GRP vessel to act as the remotely controlled tow vessel for the system, which includes a baseline AAG and mission planning and support software.

Mini Dyad sweeps and acoustic generators were hurriedly acquired by the UK Defence Procurement Agency in March 2003 for use by the Royal Navy MCMVs during the operation to clear the deep water port of Umm Qasr, during the war with Iraq in 2003. Referred to as SWIMS, the sweeps and generator were towed behind VT Halmatic Combat Support Boats, 12 of which were modified by QinetiQ for remote control from the Hunt class MCMVs *Brocklesby* and *Ledbury*. The Mini Dyads were hired for a 12-month period (reviewable after 6 months) while the acoustic generators have been fully purchased.

Contractor

ADI Limited, Sydney, New South Wales.

UPDATED

Finland

Magnetic Sweep

Type

Three-electrode magnetic sweep.

Description

In the three-electrode magnetic sweep the sweep current is conducted between the second and third electrode. Part of the current is carried in the first electrode in the opposite direction to generate an opposing magnetic field. This protective current reduces the magnetic field under and near the ship to ensure its safety against magnetic mines. The ratio between the protective current and the sweep current can be determined by adjusting the effective length of the first electrode.

The sweep incorporates a feeder cable, floating cable, three electrodes and four dual floats with a positioning prism on each float. The total length of the sweep is 650 m. The cable in this configuration can carry a maximum current of 1,000 A. If higher currents are required, the cross section of the conductors of the cable can be increased and the number of conductors increased.

Control, Deployment and recovery is carried out by four crew members: a sweep officer, winch operator and two equipment handlers. The time taken to deploy the

sweep is typically around half an hour. Typical towing speed is 6 to 8 kt with respective towing loads of 2.3 to 4.2 kN.

Operational status
In service aboard the six upgraded Kuha class MCMVs of the Finnish Navy.

Contractor
Elesco Oy, Espoo.

VERIFIED

MAINS

Type
Minesweeping And Integrated Navigation System (MAINS).

Description
MAINS is an integrated package consisting of all the components and functions necessary for sweeping modern influence mines, as well as for conventional minesweeping operations. The system integrates precision navigation and comprehensive sweep management with minesweeping signature generation/control implemented in a standard MS Windows NT environment.

MAINS is a complete turn-key solution for sweep management including mission planning, sweep monitoring, sweep gear control, post-mission analysis, reporting and simulation. It combines Target Emulation Mode (TEM) and Mine Setting Mode (MSM) sweep modes. The system supports both centralised mission planning for all MCM task units and the completely autonomous operation of a single sweeping ship.

To achieve reliable sweep results against unknown mine threats, an initial sweep is carried out in TEM. After this initial sweep for a certain target, the signature history of mine explosions can be analysed to enable precise mine parameters to be set. A final area sweep can then be conducted in MSM using the actual mine setting parameters.

MAINS is designed for use in small and medium size limited fleet navies. With lightweight hardware, it can be easily integrated into ships used primarily for another purpose, for instance mine hunting. The use of COTS technology keeps the solution cost-effective. Because of a light and modular hardware and software configuration, the sweep management system can be integrated into existing MCM systems. A completely automatic operation mode also makes it possible to use MAINS on remote controlled vessels.

The system is based on a LAN (Local Area Network) architecture with tasks distributed to several computers. The sweep management system takes navigation information in standard NMEA format which allows it to be interfaced with any navigation system. It can also be interfaced directly with the navigation sensors. The navigation system is interfaced with differential GPS (DGPS); radio navigation; Trisponder; Doppler and pulse log; echo-sounder; MAS; navigation radar; gyro; wind meter; and laser radar for accurate positioning of sweep gears. For mission reports, an A1 plotter and A4 laser printer are connected to the system. Sweep plans and the results of missions can be transferred safely between ships, and between ships and navy base or HQ, using high capacity removable disks.

System software is prepared with Microsoft Visual C++ compiler and software is held in modular form to enable the addition and assimilation of new sweep equipment and navigation hardware.

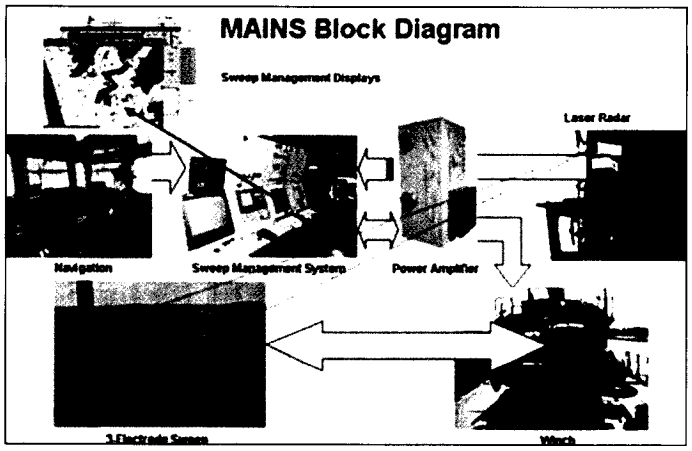
In mission planning the operator configures the system according to the existing mine threat. Tools are provided for detailed planning for an entire mine clearance operation. Navigation and route planning tools contain sweep lines with sweep turns at the ends of lines. The operation can be run automatically using the Propilot autopilot.

Sweep plans include acoustic and magnetic sweeps, and the shape and amplitude of the signature being defined. Signatures of different ship classes are stored in the signature library but new signatures can be created using signature library tools. Reshaping the existing signature creates the new signature; setting certain important points and smoothing the curve with the tools included or feeding the measured values from the ranging data from a floppy disc.

Results from different types of mechanical sweep can also be monitored.

The wet end units include a triple-electrode magnetic sweep cable assembly (MRK-960) with four floats, three of which are equipped with prisms for positioning, and an acoustic sweep (for instance SONAC AMS II). The diameter of the 650 m long buoyant sweep cable is 46 mm and its current capacity is 400 A DC continuous or 1,000 A repetitive peak. Its low tow resistance enables operation at speeds of up to 10 kt. The acoustic sweep is programmable and fully controllable. The maximum sea state for deployment and recovery of the gear is Sea State 3. The all-weather winch features a low magnetic signature and is controlled using either a hand held unit or by remote control.

The magnetic and acoustic sweep gears, enable the emulation of alternative overrun speeds independent from the MCMV's towing speed. The low towing load and light weight of the equipment enables its installation on small MCMVs. The equipment has been shock tested.



Block schematic of the MAINS system (Elesco Oy) 0134274

One of the key features of the system is the sweep coverage subsystem. This consists of a database of sweep coverage information organised in small geographical boxes or bins. For each bin, information is stored on various parameters, such as type of sweep, number of overruns and parameters of signatures. The Sweep Management System (SMS) controls the ship's navigation and the positioning of the sweep gear from an integrated unit. The display presents the operator with the sequence of lines to be swept, the bearing and depth of the swept line, the time to reach the end of the line and to complete the mission. The operator can pre-set safe distances, safe contour values of signatures and measurement limits. The information is designed to be viewed graphically, which quickly reveals the success of a sweep operation, or areas where further work is required. The laser radar is used for the positioning of the magnetic and acoustic sweeps. The maximum measurement range is >2,000 m and the maximum range accuracy is 10 to 20 cm. The angular resolution is better than 0.02°.

The combination of SMS and the navigation systems (subsystems of MAINS) gives all the tools required for a complete minesweeping operation, from initial mission planning to ship's navigation, positioning of sweeping gears, sweep control, real-time monitoring and reporting of sweep results, and post-mission effectiveness assessment using alternative sets of mine threat parameters when required. The system provides continuous monitoring and alarm facilities to ensure the safety of the towing vessel. The software package also includes a comprehensive training and simulation mode.

Operational status
Over 50 minesweeping systems in various configurations have been delivered since 1975. Six MAINS systems have been delivered since 1999. The MAINS system has been installed on all six upgraded Kuha class minesweepers of the Finnish Navy and all six MAINS systems have been in operational use since 2002.

Contractor
Elesco Oy, Espoo.

UPDATED

Sonac AMS

Type
Acoustic influence sweep.

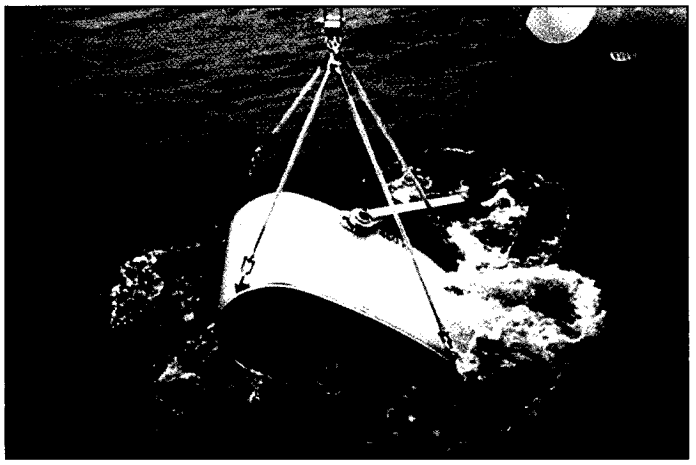
Description
Sonac AMS is a high-efficiency, fully controllable underwater sound source designed to sweep acoustic influence mines. It is specially designed for operation from small- and medium-sized vessels or drones.

The system comprises the Sonac AMS deck unit, wet end unit, 150 kg buoy and a buoyant towcable.

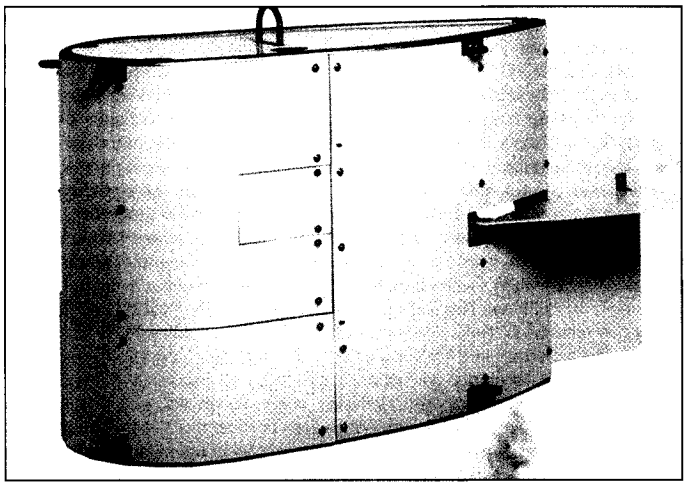
The deck unit consists of a control computer, signal generating unit, power amplifiers and matching transformers. The signal generating unit can create an unlimited number of broadband acoustic signatures simulating any known surface vessel. Real ship signatures can be recorded and stored in a signal library on a computer disk. Alternatively, user-defined signals can be created by modifying the noise spectrum envelope and adding the desired discrete frequencies and multiples. Changing the signature is simply accomplished using the specially designed Sonac AMS user interface using Windows®. The AMS system can be linked to external systems, for example multi-influence sweeps via a sweep management system.

The wet end unit consists of a low-frequency sound source (electrodynamic vibrator with pressure compensation unit) and several optional piezoceramic high-frequency transducers to cover the audible frequency band completely. The wet

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Launching the Sonac AMS towfish (Patria Finavitec Oy) 0097842



The Sonac AMS towfish (Patria Finavitec Oy) 0097843

end unit has been designed to achieve extremely high shock resistance and has been successfully tested against an underwater explosion to provide the shock resistance capability.

The buoy is designed to maintain the wet end unit at a constant operating depth. Wet end body shape enables cross line offset towing.

The buoyant towcable is specially designed to achieve high breaking strength, and the wet end unit end of the cable has an armoured section 30 m in length.

The sound source is towed several hundred metres behind the mine warfare vessel with a 50 to 100 m offset from the ship's course. The offset is necessary to keep the acoustic sweep away from the magnetic sweep cable during multi-influence sweeping.

Operational status
In service with the Finnish Navy on upgraded Kuha class minesweepers.

Specifications
Height: 900 mm
Width: 630 mm
Length: 1,330 mm
Weight: 500 kg wet end unit in air 150 kg (buoy unit in air)
Operating depth: 10 m
Towcable length: 500 m
Frequency range: 17 Hz-25 kHz
Output: 190 dB @ 20 Hz

Contractor
Patria Finavitec Oy, Tampere.

VERIFIED

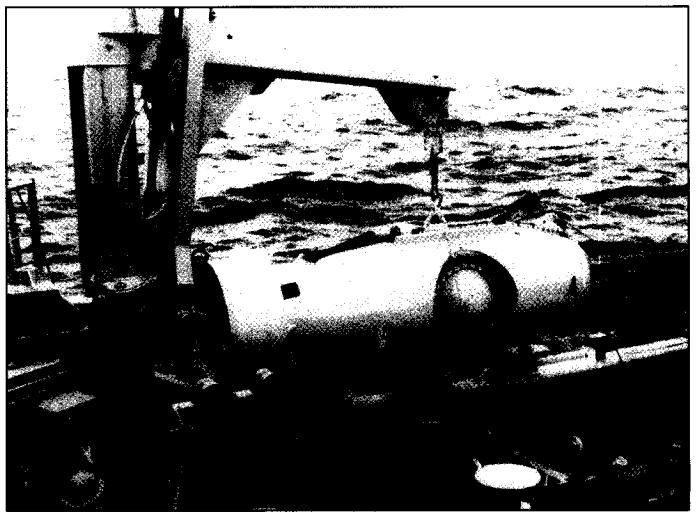
France

AP-4

Type
Acoustic minesweep.

Description
The AP-4 acoustic sweep comprises:

- a signal generator which can generate up to 192 acoustic signatures and spectra for various types of ships, signals being pre-programmed within a wide frequency band (in both spectrum and modulation);



AP4 acoustic minesweep

- a very high-powered low frequency amplifier with associated impedance matching circuit;
- an underwater vehicle which is towed by a combined power feed and towing cable and which is fitted with an underwater electro-dynamic loudspeaker with two symmetrical diaphragms;
- and an optional piezoelectric transducer for high frequencies.

The software programs are designed to meet operational requirements and can easily be developed or modified ashore, with the possibility of exchanging the pre-programmed electronics cards on board. These programs allow the generator to simulate acoustic signatures of various types of ship, to activate mines with known characteristics from a stand-off position, to activate unknown mines by scanning over their probable acoustic spectrum, to inhibit mine detonation devices within an extended area, and to transmit acoustic spectrum in synchronisation with the transmission of the current pulse of a magnetic sweep.

The magnetic signature of the shipborne equipment is very low, even when operating. A pre-programmed device enables the transmitted acoustic power to be adjusted according to acoustic propagation conditions over the swept path.

The transmission level can be adjusted within several tens of decibels. Minesweeping is performed at speeds between 3 and 12 kt (8 kt nominal) with a constant immersion of the transmitting vehicle between 8 and 10 m; this can be extended as an option. On a large ocean-going MCMV the towed acoustic generator can be launched in up to Sea State 4 and towed in up to Sea State 5. The towing force with the cable equipped with floats and towed at a speed of 8 kt ranges from between 0.7 to 2 tonnes, depending on the length of the tow cable. The system can be used without interruption over a period of 5 days with a normal operating rate of 48 h at 8 kt.

The vehicle has successfully passed the impact resistance qualification tests against an underwater explosion of 1 tonne of TNT at 80 m abeam. All frequency bands are covered by the sweep and electronically controlled by the computer.

Operational status
No longer in production. In service since 1985 with the French Navy aboard Eridan class MCMV. May also be in service aboard Tripartite MCMVs of the Pakistan Navy.

Specifications
Vehicle
Length: 3.9 m
Diameter: 1.1 m
Weight: 2,350 kg

Contractor
DCN, Paris.

VERIFIED

Germany

DM 19 A3

Type
Explosive minesweeping cutter.

Description
This explosive cutter for sweepwire attachment has been in naval service for many years. The DM 19 A3 is the latest version and is an upgrade of the DH 19. It uses a linear shaped charge and assures operational safety even at high sweep speeds and offers a high degree of handling safety. The equipment is lightweight and capable of operation at considerable depths. It is a one-shot system and can be mounted onto sweepwires of different diameters. Neither onboard maintenance nor preparation for use are required.



Explosive minesweeping cutter DM 19

No residual parts remain on the sweepwire after detonation. The sweepwire is sandwich-shield protected.

Operational status
In service with the German, Indonesian and Thai navies.

Specifications
(DM19 A3)
Cutting capacity
Stud link chains: 16 mm
Steel wires: 20 mm
Synthetic ropes: 40 mm
Operating depth: 3 to <200 m
Weight in air: 4.4 kg
Weight in water: 2.3 kg
Dimensions: 410 × 470 × 85 mm

Contractor
Rheinmetall W & M GmbH, Unterluss. ***VERIFIED***

Norway

Acoustic Antenna

Type
Mobile acoustic antenna system.

Description
Developed by FFI, the mobile LF acoustic antenna system is an easily deployable and remotely controlled vertical hydrophone array system.

The vertical antenna is free floating and data and control commands are relayed between the antenna and MCMV by secure radio link. Coverage is provided from 5 Hz to 15 kHz using 16 hydrophones with an omni hydrophone providing data between 4 Hz and 100 kHz.

Work is ongoing to develop similar MF and HF beam forming antenna system.

Operational status
Under development.

Contractor
FFI, Horten ***NEW ENTRY***

Agate

Type
Acoustic sweep.

Development
Development of the acoustic sweep began in 1990 in a joint venture between the Norwegian Naval Materiel Command and the former GECO Defence Company, now part of Kongsberg Aerospace and Defence. Extensive trials with a prototype were carried out by the Norwegian Navy between 1992 and 1994.

Description
Developed by the Norwegian Defence Research Establishment, Agate (Air gun and transducer equipment) is designed for deployment from the Royal Norwegian Navy's Alta class minesweepers. The system features a pneumatic air gun driven by high pressure trapped in a chamber. This results in a low-frequency sound suitable for use in minesweeping operations. Each acoustic impulse is created by the release of a controlled volume of air. The output level is a function of the quantity of air that is released and the air pressure. The air guns incorporate two different firing chamber volumes (1.67 in^3 and 0.84 in^3) and can be modulated to fire between one and six shots per second. The compressor for the air gun has a capacity of 350 m^3/hr and can be operated between 10 and 140 bar. They typically simulate propeller cavitation, blade rate and shaft rate of a ship which are low-frequency acoustic sources. Merchant ship propellers generate periodic noise components below 100 Hz. To react to mines set to detonate against such sound sources the acoustic sweep must generate significant acoustic energy at these very low frequencies in order to operate effectively in target mode. The air gun can achieve output levels in excess of 180 dB in the 5 to 50 Hz frequency range. Above 50 Hz high-performance transducers generate broadband noise and spectral lines.

In addition to the air gun, Agate also incorporates Terfenol-D, a magnetostrictive material with a particularly high level of magnetostriction, which converts electrical energy into mechanical energy. The SaabTech-developed Terfenol-D flextensional transducers develop a much higher power level than conventional piezoelectric transducers of about the same size and are well suited to the production of sound in the lowest seismic spectrum up to 100 kHz. The transducers can simultaneously generate both single tones and noise. Each transducer has an amplifier optimised for transducer type, bandwidth and power consumption requirements. The LF, MF and HF amplifiers are located in separate cabinets. In order to cover frequencies up to 100 kHz, three bandwidths are covered by one or two transducers: a MF (100 Hz) transducer with power input level of 10 to 20 kW; a MF (3 kHz) transducer with a power input level of 1 to 3 kW; and a HF transducer with 0.1 kW power input level. Agate also incorporates piezoelectric transducers for the generation of HF signals.

The outputs from Agate include both noise (digitally filtered white noise) and spectral lines. The entire system is controlled by a shipboard computer that contains a library providing data on a wide range of ship signatures. The digital signal processor is used to generate the desired waveform, which can be pre-set or manually adjusted. This is then fed to the transducers in analogue form.

The equipment is housed in a variable depth steerable towfish with a surface paravane reference. An umbilical connects the towfish to the sweeper and carries high-pressure air for the gun and electrical signals to the transducers. The steering system of the towfish enables it to intercept mines away from the sweeper's centreline, reducing the risk of the sweeper triggering a mine. The high-pressure air for the gun is supplied by a dedicated compressor.

Control of the system is exercised from a monitoring console, which allows the operator to define graphically the sweep signature using a rollerball or keyboard. The MMI is based on modern Windows-type graphical interface. The output of the acoustic sweep is continuously monitored by hydrophones mounted in a small towed array sited near the sweep. Data from the array is relayed to the vessel where spectra are continuously computed and monitored with reference to specific levels. The console can also simultaneously control a magnetic sweep.

Agate can operate in one of three modes: mine setting mode (the conventional approach to minesweeping); target sweeping mode (a technique used when mine intelligence is limited); and mine jamming mode (in which real vessel signatures are masked by a second signature). Agate also controls the Elma electromagnetic sweep system.

Operational status
The first unit is installed on the Norwegian minesweeper *Alta* and six are being delivered, two of which will be kept as spares. Agate is now in series production. The system is also being adapted for installation on remotely controlled drones for the Netherlands Navy.

Specifications
Frequency: 100 Hz, 3 kHz, 100 kHz
Input: 10-20 kW, 1-3 kW, 0.1-1 kW (respectively)

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.
UPDATED

ELMA

Type
Magnetic sweep.

Description
The ELMA magnetic sweep has been developed for the Alta class by the Norwegian Defence Research Establishment and the Norwegian Navy Materiel Command. The sweep is based on an improved 'straight tail' of the type that has traditionally formed the magnetic component of a multi-influence sweep but is not well suited to target simulation mode minesweeping where the ship signature in question must be simulated with the highest possible fidelity.

The ELMA sweep uses three electrodes rather than the normal two, arranged in a forked configuration using kites to simulate the magnetic field structure of the target vessel with a higher level of fidelity and producing a more shiplike signature. The forward electrode provides the protection field for the minesweeper, while the centre and aft electrodes carry the main current to produce the sweep field.

To ensure that the power supply for the sweep has a low magnetic signature, the Norwegian Materiel Command trialled an experimental power supply under a variety of different loading conditions at its magnetic silencing facility. The power supply for production versions of ELMA are manufactured by Siemens Norway under subcontract to Kongsberg Defence & Aerospace as overall prime contractor for the series production of the combined acoustic/magnetic sweep.

The sweep is designed to operate in two main modes. In the traditional influence sweep mode it is configured as a straight tail with current fed to the forward electrode to provide the protection field under the platform, while current supplied to the centre and aft electrodes provides the main sweep field. When operating as a target sweep, the two cables are configured in forked geometry, with the current in the two branches controlled individually in order to produce a magnetic field structure that is capable of emulating a target vessel.

ELMA performs well in mine setting mode but offers only reduced capability in target simulation mode owing to the lack of steering of the X, Y and Z components.

Operational status
In service with the Alta class minesweepers of the Norwegian Navy.

Contractor
Siemens, Norway.

NEW ENTRY

TASSEN

Type
Tactical sensor unit.

Description
Following a Norwegian Navy requirement for real-time feedback to MCMVs during minesweeping operations FFI developed the TASSEN tactical data buoy.

TASSEN is a low cost sensor buoy that is easily deployed from MCMVs and is used as an integral element in achieving improved performance in standard and target simulation mode influence sweeping operations. The buoy is designed to be used for the calibration of influence sweeps and the optimisation and control of sweep settings in preparation for sweeping operations.

The sensor unit is a lightweight acoustic and magnetic deployable buoy. It is deployed in the area of MCM operations and transmits data in real time back to a laptop computer on the MCMV. The feedback is then used to correct the acoustic and magnetic sweep settings in order to achieve optimum performance against a mine threat or to obtain maximum protection for own ship.

Operational status
Five sets are in service with the Norwegian Navy.

Contractor
Innova.

NEW ENTRY

Russian Federation

AT-2/3/5/6

Type
Acoustic sweeps.

Description
The AT-2 and AT-6 are both wideband systems, with the AT-3 appearing to have three transducers powered by a water turbine. The AT-2 can be towed at speeds up to 12 kt at a distance of 550 m behind the towing platform. The total system weighs 2.2 tonnes of which the generator weighs 370 kg. The acoustic generator is fed with 4.2 kW power input, producing a swept current of between 7.5 and 14 A.

Operational status
In service with Vanya and Yevgenya class (AT-2), Zhenya class (AT-3), Natya and Sonya class (AT-5) and Lida and Olya classes (AT-6).

UPDATED

GKT-2, GKT-3, GKT-3MP

Type
Mechanical sweeps.

Description
The GKT-2 mechanical sweep is a deep sweep system in service with both coastal and ocean minesweepers. The system can be used in a stand-alone mode to deal with moored mines, or in combination with a sound generator to counter acoustic mines. In the latter case the cutters and cartridges are supplemented by corner reflectors. Swept path is between 260 and 280 m with a maximum sweep depth of 200 m and a minimum depth of 10 m. The sweep can be towed at speeds up to 10.5 kt depending on sweep depth.

The GKT-3 system is a deep sweep contact system for deployment from a single ship. It incorporates integral sonars to monitor the sweep position.

The GKT-3MP is a deep team sweep system incorporating mechanical sensors for bottom following. Swept path is between 50 to 120 m at depths between 2 and 120 m. The sweep can be towed at up to 12 kt.

Operational status
In service aboard Natya class minesweepers around the world and Russian Navy Sonya class vessels. The GKT-3 variants are in service aboard Lida and Vanya class vessels.

VERIFIED

IU-2, IT-3

Type
Ground mine detector/destructor.

Description
The IU-2 is a detector/destructor designed to counter seabed magnetic influence mines in harbours and protected anchorages. It is a sophisticated system incorporating a mine detector towed 2 to 3 m above the seabed. When the magnetic field of the IU-2 is disturbed, it releases either a marker or mine destructor which is towed in a container behind the detecting elements. The markers/destructors can each mark up to four mines and are capable of destroying two mines at depths between 6 and 20 m. The system is capable of operating at depths down to 60 m with a swept path of 16 m at speeds up to 6 kt.

The IT-3 TV detector/destructor features a swept path of 20 to 30 m with a working depth of 10 to 60 m and a towing speed of between 3.5 and 6 kt. The device is deployed at a distance of 70 m behind the towing platform. It is designed to detect and mark ground mines. The equipment comprises an LVT3-2TM cable drum winch and a BBG-OT1 davit with a load capacity of 2.5 tonnes and a boom length of 1.37 to 4.73 m. The device is equipped with an LLLTV camera.

Operational status
In service aboard Sonya and Lida class MCMVs. IT-3 is in service with Yevgenya class minesweepers in the Indian Navy.

VERIFIED

PEMT-4

Type
Magnetic loop sweep.

Description
The PEMT-4 magnetic loop sweep consists of a 3-core cable 424 m in length with a 2-core feeder cable 227.5 m long attached. The 5.2 tonne sweep can be towed at speeds of 6 kt and depths between 7 and 60 m. The system develops 250 A current in the sweep with 50 kW power.

Operational status
Deployed on Sonya class vessels.

UPDATED

SEMT-1 & ST-2

Type
Magnetic solenoid sweep.

Description
The SEMT-1 magnetic solenoid coil sweep is designed for use in shallow water and harbour clearance operations. The system comprises one, two or three individual magnets each 18.2 m long which form a set, the entire system comprising two sets.

The magnets can be used in waters as shallow as 5 m with a towing speed of 4 to 8 kt.

The ST-2 magnetic solenoid sweep is designed for sweeping operations in coastal waters using a current of 200 A. The sweep comprises a single magnet 29.1 m long and weighing 2.24 tonnes which can be towed at speeds between 5 and 12 kt in water depths beyond 10 m at a distance of 300 m behind the towing platform.

Both sweep systems are powered and controlled from the operating platform and the total weight of the shipboard elements is 1 tonne.

Operational status
In service aboard Leniwka, Lida, Olya, Vanya and Yevgenya class minehunters (SEMT-1) and Sonya class (ST-2).

Specifications
Weight: 12 t (SEMT-1), 2.24 t (ST-2)
Magnetic moment: 800 kA/m²
Operating depth: 25-30 m
Towing speed: 4-8 kt (SEMT-1), 5-12 kt (ST-2)

VERIFIED

Sweden

MS 106

Type
Mechanical minesweep.

Description
Similar to the Swedish Navy's wire sweeps M/58, M/48, and MS 106 (double) oropesa sweep is compact, lightweight, of simple design and easy to handle. Its size means it is well suited for use as an ancillary sweep system for deployment from a minehunter. The sweep is armed with six explosive cutters.

Operational status
Delivered to various navies including Thailand for use on the Lat Ya class.

Specifications
Length of sweep wire: 300 m
Diameter of sweep wire: 13 mm
Swept path: 200 m
Swept depth: 10-30 m
Swept speed (nominal): 8 kt
Towing load at nominal speed: 30 kN
Explosive cutters: 2 × 8
Weight (total): 1.8 t

Contractor
Saab Bofors Dynamics AB Karlskoga.

VERIFIED

Pressure sweep

Type
Pressure sweep for MCM operations.

Description
The CETUS Systems have developed a new concept for sweeping pressure mines. The device consists of a high flow pump, which creates pressure in the form of a directed jet of water. The water flow is generated by flaps moving through a straight pump channel.

The design is being developed to be sufficiently flexible to enable it to be handled by small vessels – necessary if the towing vessel is not to detonate a pressure mine. The pressure sweep is active, velocity independent, modular, and incorporates a programmable sweep function. The sweep can be combined with magnetic and acoustic sweep equipment in a suitable form.

The exterior appearance of the pump shows a long, quadratic tube with a fluid inlet and outlet at the ends. Internally it is fitted with a number of flaps connected to a circulating chain, which creates the output fluid flow. The chain mechanism and flaps can rotate along one of the sides of the pump giving a virtually continuous piston motion in the interior. The play between the flaps and the interior sides of the pump is being so designed that any fluid leakage between the piston flaps and the pump channel during operation can be ignored. Two different flap arrangements are being evaluated – vertical and slanted. Tests showed that the slanted flap configuration exhibited better high-speed performance, while at low speeds the vertical configuration exhibited less friction.

Operational status
Under development, with a scale prototype generator having undergone tests both in a test tank and at sea from the quayside.

Contractors
CETUS Systems AB , Vasteras.
Defense Material Administration (FMV).

NEW ENTRY

T Mk 9 Mod

Type
Explosive minesweeping cutter.

Description
A successor to the cutter T Mk 9 the T Mk 9 Mod, introduced in 1997, features a shaped charge instead of the former 125 g bulk charge. The result is a considerably enhanced cutting capacity, in spite of a reduced charge weight. The port/starboard independent cutter is made of stainless steel. Firing – which is possible only as long as the cutter is under water – results in only the fin being left on the sweep wire.

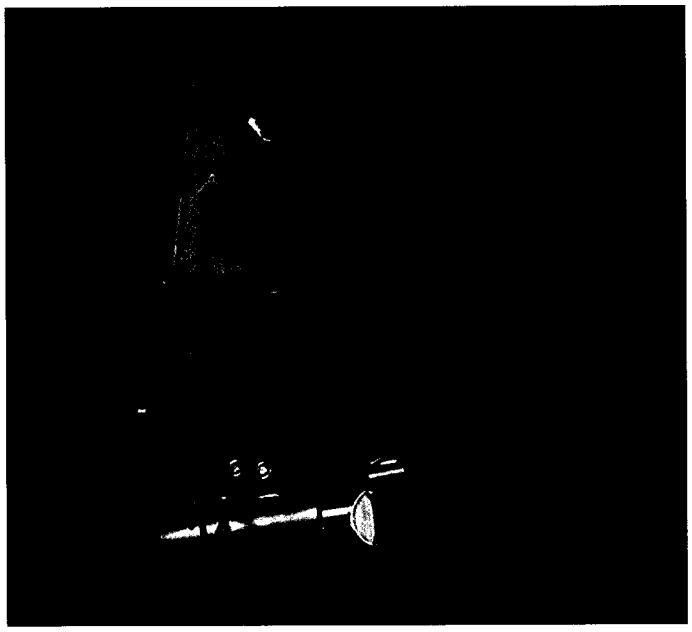
The uniquely shaped conical charge develops into a 'knife' form when fired. It can cut chains up to 16 mm and steel wire rope up to 30 mm. Sweeping speed is 4 to 12 kt.

Specifications
Length: 470 mm
Height: 370 mm
Width: 70 mm
Weight: 7 kg
Charge: 80 kg
Operating depth: 5-200 m

Operational status
The product is qualified and is in series production.

Contractor
Saab Bofors Dynamics AB Karlskoga.

VERIFIED



Explosive cutter T Mk 9 Mod 0009584

United Kingdom

CIS

Type
Combined Influence Minesweeping (CIS) system.

Description
By combining the MSSA Mk 1 towed acoustic generator (see MSSA Mk 1 entry) with a magnetic sweep (at present the single axis closed-loop system which is

virtually the same as the system used in World War II), BAE Systems has developed the CIS system. This system is capable of sweeping the most modern microprocessor-controlled mines. In the CIS both the acoustic and magnetic signatures are microprocessor controlled, giving complete and total control of the generated signature. Both target simulation mode and mine setting mode techniques may be employed readily with CIS.

The current magnetic sweep is due to be replaced by a tri-axis sweep under the RIMS Programme.

Operational status
In service with the Royal Navy aboard the Hunt class MCMVs and is being supplied to the Republic of Korea Navy.

Contractor
BAE Systems, Underwater Systems , Waterlooville, Hampshire.

VERIFIED

Limpet Mine Disposal Equipment (LMDE)

Type
Mine disposal equipment.

Description
The LMDE has been designed to destroy limpet mines which are difficult to remove from ships because of their powerful magnets and their anti-handling devices.

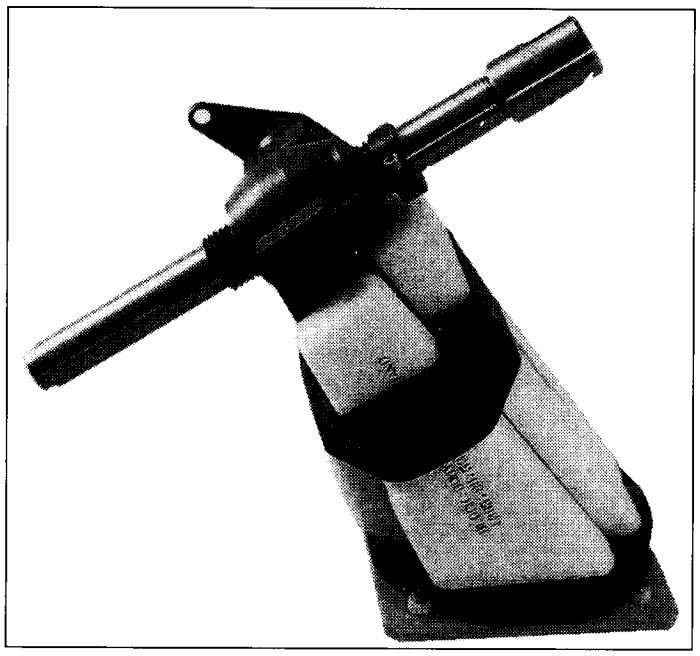
The system features a stainless steel barrel bomb disruption device similar to those used against terrorist bombs on land. The barrel is mounted in a movable sleeve and trunnion on a stand with flotation magnets to attach it to the ship's hull, and the whole device, which weighs less than 15 kg, has buoyancy blocks to reduce the effective weight in water.

When a limpet mine is discovered the diver assembles the LMDE out of the water, then takes it underwater and places it as close as possible to the mine. The barrel is carefully positioned so it faces the heart of the mine, then the diver returns to the surface from where he/she remotely fires a bridgewire cap cartridge. This propels a powerful slug of water at the mine, smashing open the thin casing and dispersing the main explosive charge.

Operational status
The system is operational with five customers.

Contractor
AB Precision (Poole) Ltd, Poole, Dorset

UPDATED



Limpet Mine Disposal Equipment (LMDE)

MSSA Mk 1

Type
Acoustic minesweeping system.

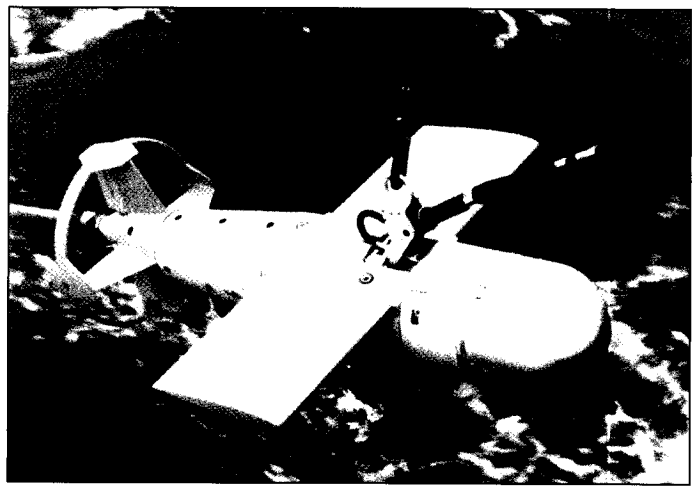
Description
MSSA Mk 1 is an advanced acoustic minesweeping system which can generate a wide range of target-like acoustic signatures. Its acoustic output is continually monitored and controlled to ensure that the required amplitude at seabed level is maintained regardless of variations in acoustic propagation conditions. It provides a versatile sweeping system capable of very high power output. It is used to activate all acoustic mines, including those with frequency selective triggering characteristics which are designed to be actuated only by certain types or classes of vessels.

The system comprises a towed acoustic generator (TAG) towed behind a towed acoustic monitor (TAM) with a towed hydrophone array, and an onboard control console.

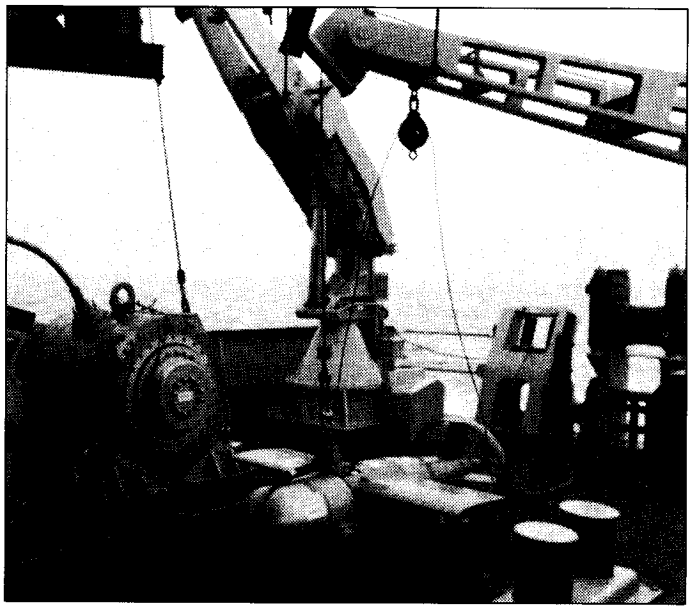
The TAG is powered by an electric motor and propagates an acoustic signal over a wide frequency band. The acoustic signal is generated by multiple diaphragms that are hydraulically actuated. Power output and frequency is selectable from the control console. The system can be deployed at any preselected depth.

The system has been specially designed to withstand the repeated levels of explosive shock likely to be experienced in operation, and is normally deployed in association with a magnetic sweep to provide a very effective method of sweeping combined influence mines.

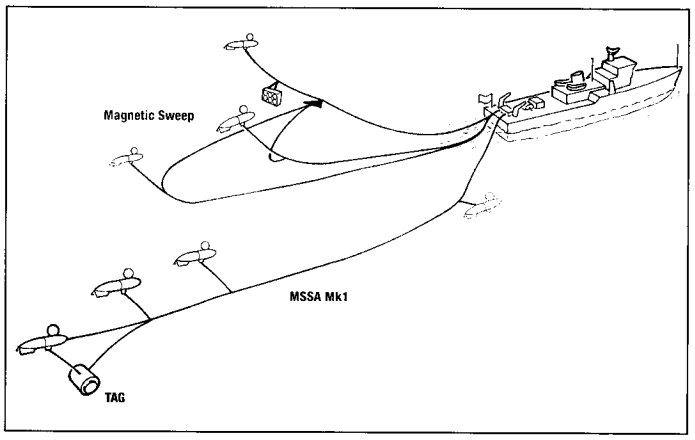
The cable for the TAG consists of a series of load bearing, insulating and protective layers and conducting cores. The cable is armoured with two opposing



Towed acoustic monitor of MSSA Mk 1 minesweeping system



Towed acoustic monitor (centre) and towed acoustic generator (left)



MSSA Mk 1 (TAM not shown)

layers of stainless steel strain wires, which are so laid as to negate any torque and so prevent the cable from twisting when towing the TAG. The system was extensively upgraded during the 1990s.

Operational status
MSSA Mk 1 is in service with the Royal Navy on the Hunt class MCMV, and has undergone evaluation trials with the US Navy. The system has also been sold to the Republic of Korea Navy.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

VERIFIED

Wire sweep Mk 8

Type
Low-magnetic signature wire sweep system.

Description
The Mk 8 wire sweep system is a development of the wire sweep Mk 3 mod 2 used on the Ton class minesweepers. It has been designed to have a low magnetic signature in order to be compatible with the overall low-magnetic characteristics of modern mine countermeasure vessels.

The Mk 8 is designed to sweep most types of buoyant mines that are moored to the seabed with sinkers by severing the mine mooring chain or wires with explosive cutters fitted to the sweep wires. The Mk 8 may be deployed in the following configurations: single oropesa, double oropesa and armed team sweep (the latter gives a very wide swept path).

Operational status
The Mk 8 system is in service on the Royal Navy Hunt class mine countermeasure vessels.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

VERIFIED

Wire sweep Mk 9

Type
Controlled, deep wire sweep system.

Development
With the advent of buoyant moored mines which can be laid in much deeper water and with shorter mooring wires, BAE Systems began to work, together with the Admiralty Underwater Weapons Establishment (AUWE), in 1974 on the development of a sweep system that could be worked much closer to the seabed and at far greater depths. To operate such a system efficiently the minesweeper would have to be able to control both the height of the sweep wire above the seabed and its flatness, so that it does not drag along the seabed and break or prematurely explode the wire cutters connected to it.

It was decided to adapt the existing UK Mk 3 wire sweep system but use a single wire with the sweep wire attached directly to the end of the kite wire. The kite would then only have to depress one wire instead of two, and allow the sweep to go much deeper with greater control.

Extensive use of computer modelling was followed by lengthy trials, which enabled tables to be drawn up comparing swept depth against length of kite wire and, when used in conjunction with Wire Sweep Monitoring Equipment (WSME), it proved possible to heave or veer the kite wire to the exact amount required for the sweep wire to follow the contour of the seabed.

Following extensive trials the system was accepted into Royal Navy service in the early 1980s.

Description
The sweep's primary operational mode is team sweeping but it can also be deployed as a double or single oropesa sweep. It is designed to be deployed from either purpose-designed minesweeping vessels or ships taken up from trade - usually stern trawlers. Although usually operated with two ships, several ships have been linked together to form a multiship team sweep providing greater swept paths and allowing an odd number of vessels to be used.

Each vessel carries three lengths of wire on a winch. The outer barrels carry a sweep wire connected to a kite wire and the centre barrel carries a kite wire for oropesa sweeping.

Using WSME in conjunction with the ship's echo-sounder, the sweep can be adjusted to follow the seabed at a constant clearance by heaving or veering kite wire from the winch.

Operational status
Wire sweep Mk 9 entered service with the Royal Navy in the early 1980s on the River class vessels, but is no longer operational in the Royal Navy since the River class vessels were withdrawn from service. This system has also been delivered to Canada for the Canadian government Naval Reserves Mine Countermeasures Project and is now operational. A version of this system has also been sold to the Republic of Korea Navy.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

VERIFIED

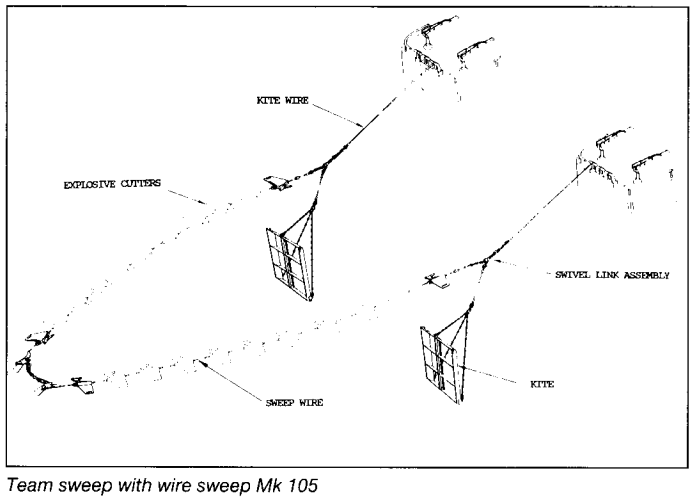


Wire sweep Mk 9

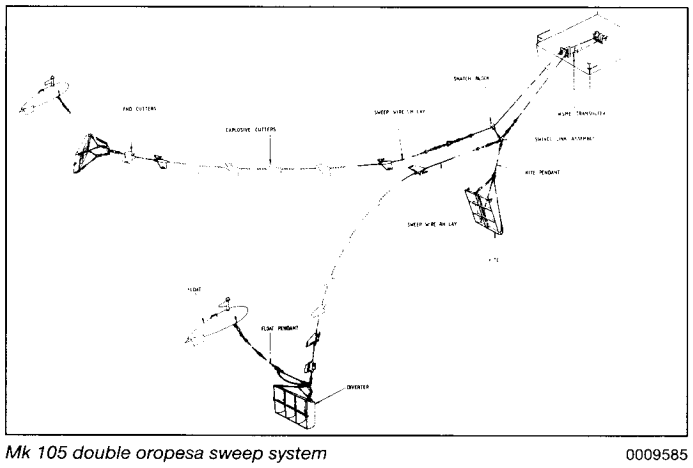
Wire sweep Mk 105

Type
Compact, low-magnetic wire sweep system.

Description
The Mk 105 sweep configuration is a development of several Royal Navy wire sweep systems and is available in a range of sizes (including US size 1, 4 and 5) to enable a range of naval vessels to undertake minesweeping operations. The smaller variants of the sweeps may be fitted to small patrol craft or minehunting vessels to provide a dual-role mine countermeasures capability. The larger variants



Team sweep with wire sweep Mk 105



Mk 105 double oropesa sweep system 0009585

are generally fitted to dedicated minesweepers or larger Craft of Opportunity (COOP) where the space and power available is sufficient for the larger equipment.

The design uses a simplified wire configuration enabling relatively small winches to be used to save deck space and in smaller sizes to reduce towing loads. The Mk 105 system may be deployed as either team, double or single oropesa sweeps and includes all items of minesweeping equipment necessary to fit out a vessel for minesweeping including the wires, winch, floats, cutters, kites and marker buoys. The complete systems are available in either low-magnetic or ferromagnetic materials. The system is used in conjunction with the WSME system to achieve good bottom-following. The size 5 equipment incorporates a new float design which enables greater depths to be achieved in oropesa sweeping (25 m) together with a team sweep which is able to reach 120 m depth.

The Mk 105 sweep configuration is a very flexible system that has already been configured to suit several ship designs including minehunters, fast patrol craft, minesweepers and COOP.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire. ***VERIFIED***

Wire Sweep Monitoring Equipment (WSME)

Type
Wire sweep monitoring equipment.

Description
WSME was developed primarily for use as part of the UK wire sweep Mk 9 to improve its accuracy of sweeping. WSME is fitted to purpose-built MCM vessels and vessels taken up from trade to allow effective minesweeping operations. The purpose of WSME is to provide a flat sweep profile at a steady seabed clearance.

For effective operations against all types of moored mines, it is important to tow the sweep wires just above the surface of the seabed otherwise mines on short moorings will not be swept. To achieve this position the sweep wire must be flat; if the wire sags the sweep will contact the bottom and damage the sweep, and if the wire hogs it may miss some mines.

Previous methods of minesweeping used vessel speed to indicate sweep flatness but the errors due to ships' logs, tidal flows and current profiles often lead to sweeps with significant hog or sag.

Sea trials have established that most of the tension measured as the wire passed through the fairlead on the ship to the water could be attributed to the drag of the sweep in the water and the forces acting on the kite. From measurement of this tension the speed of the sweep could therefore be calculated, and hence its flatness. This led to the development of the WSME which displays digital readings of average and peak load on the Sweep Monitor Console. The ship speed is then either manually or automatically adjusted to obtain the correct tow tension.

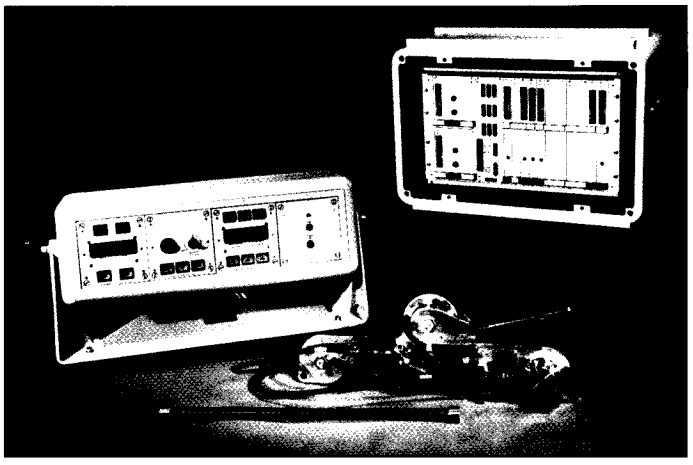
The WSME measures depth. Two options are available to the user. Firstly a direct measurement using an acoustic link to a depth sensor or, secondly, electronic measurement of the length of kite wire passed through the tension meter to determine the depth of the sweep wire and displaying a depth reading which can be directly compared with the digital output of the ship's echo-sounder. The winch is then either manually or automatically heaved or veered to maintain the required seabed clearance.

The WSME is also available with sweep location equipment for monitoring actual ground covered by the sweep. Links to the ship's command and control system are also provided.

Operational status
The WSME was introduced into service in the Royal Navy River class minesweepers in the mid-1980s. In 1989 systems were ordered for the Canadian government's Naval Reserve Mine Countermeasures Project and the systems are now operational. It has also been sold to the Republic of Korea Navy.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED



Wire Sweep Monitoring Equipment (WSME)

United States

ALISS

Type
Advanced Lightweight Influence Sweep System (ALISS).

Development
The ALISS was developed as an advanced technology demonstrator to meet the US Navy's need for a lightweight acoustic and magnetic minesweeping system that can emulate landing craft acoustic and magnetic signatures to clear a beach assault area in significantly less time than is currently possible. The acoustic subsystem uses plasma discharge, pulse power technology to generate high-power, low-frequency sound waves to detonate acoustic influence mines. It will replace fixed-frequency mechanical noisemakers used in the past with one system which is software configurable to the required frequency band. The acoustic system will be integrated with the magnetic system. Following an 18 month technology demonstrator programme, the US Navy is planning an engineering and manufacturing development programme to build an integrated acoustic and magnetic sweeping system.

Raytheon Systems Company (formerly Alliant Techsystems Marine Systems, subsequently part of Hughes Aircraft Naval and Maritime Systems), was awarded a US$4.6 million contract by the Coastal Systems Station, Dahlgren Division of the US Naval Surface Warfare Center to build and test the acoustic subsystem for ALISS.

The Coastal Systems Station will develop and test the spark gap acoustic transducers. Hughes Aircraft will integrate the entire acoustic subsystem of ALISS.

ALISS will be mounted in a QST-35A target drone craft. A super conducting dipole magnet will be used to generate ship-like magnetic signatures while a spark gap generator will generate LF acoustic signatures.

Description
The ALISS features two influence sweeps (acoustic and magnetic) designed to emulate the signatures of assault craft in shallow water and the near surf zone. It is intended that the system will be deployed from either a small surface craft or a helicopter. The sweep system uses advanced spark gap transducer arrays, which provide the frequency agility necessary for spectral shaping of the acoustic output in both broad and narrowband. The demonstrator also used a pulse-powered plasma discharge as the acoustic subsystem.

The magnetic sweep uses lightweight, high field, conductively cooled superconducting dipole magnets housed in a low heat leak, vacuum insulated cryostat. The coils are conductively cooled using a specially developed, closed-cycle cryogenic refrigeration system capable of cooling the magnet down to a temperature of 4.0 K. The magnet is based on a solenoid wound with a niobium titanium (NbTi) superconductor, and is capable of withstanding 100 g shock loads from any direction.

The magnetic subsystem consists of a lightweight, high field, conductively cooled superconducting magnet The magnet and operates at temperatures below 10K. This technology was chosen because landing craft are magnetically emulated by a dipole moment. Super conductivity magnets offer the highest dipole magnetic field for the lightest weight, in the field strengths of interest for influence sweeping. In addition closed-cycle conductive cooling overcomes the need for liquid helium and its associated handling problems.

Unlike electrode sweeps, superconducting magnets do not rely on placing hardware in the water, and the resultant field is not affected by sea water.

Operational status
The ALISS concept demonstrator was completed in 1998. ALISS technologies may be employed in operational systems, and the super-conducting magnet and spark gap generator technologies are being considered for the OASIS programme.

Contractor
Raytheon Company, Electronic Systems, El Segundo, California.

VERIFIED

AN/37U-1 (AN/SLQ-53)

Type
Mechanical sweep system.

Description
The AN/37U-1 lightweight mechanical sweep system is a single ship/helicopter deep sweep system, which is capable of being deployed in less than 45 minutes and recovered by a single operator. It does not require any davits for deployment and no cumbersome floats are used in streaming the sweep.

The sweep is a diverted catenary system using four otters, a self-contained depressor and up to three auxiliary depressors which are used to sink and spread the sweep wires at the required depth.

The system incorporates an acoustic depth monitoring system that provides real-time depth monitoring and ensures that the wires maintain a flat sweep. The sweep wires are manufactured from 7.1 mm diameter CRES wire rope streamed behind a 305 m long 12.7 mm Kevlar tow. The port sweep uses a left hand lay, and the starboard sweep a right hand lay, these assist in the creation of lift to maintain a

flat sweep at the operating speed. The otters and depressors are self-contained and a water-powered alternator provides all electrical power. An electronics bottle on the forward part of the otters and depressor contains the circuits required to control the depth and acoustically transmit depth data to the towing ship.

A calibrator is used prior to deployment to conduct a go-no-go test on the electronics and to store the operational depth for the mission.

The sweep wire is fitted with Swedish TMk 9 explosive cutters to cut mine moorings that are engaged during the sweep operation.

The system can operate at depths down to 300 m.

The system has been adapted for deployment from surface ships as the AN/SLQ-53 Single Ship Deep Sweep (SSDS). It is deployed from a three-drum winch carrying up to 1,524 m of cable on the main drum and 595 m on each of the side drums.

Operational status

In service with the US Navy for airborne MCM. Scheduled for deployment from the 'Osprey' class MCMVs as the AN/SLQ-53. Ten systems have also been ordered by the Royal Danish Navy for whom they will be modified for operation from the MSF remote controlled vessels.

Contractors

Anteon Corporation, Panama City, Florida. ***UPDATED***

AN/ALQ-219 (SWIMS)

Type

Shallow Water Influence Minesweep System (SWIMS).

Development

SWIMS is a US Navy shallow water magnetic/acoustic minesweeping system used to support amphibious operations, port breakout and riverine/brackish water operations. It is a small, high-speed, influence sweeping system for all operating environments, deployable from helicopter or surface craft. The requirement for the system resulted from naval operations during the Gulf War.

Description

SWIMS has been conceived as a dual-influence (acoustic/magnetic) mine clearance system for use in littoral waters. It is currently operated from the MH-53E Sea Dragon helicopter, and is intended to support future organic MCM from smaller CH-60S helicopters and selected surface vessels. It is totally contained within the helicopter during transit to and from the area of operation, thus providing the capability for high-speed transit from over the horizon. It will be towed at speeds up to 40 kt in water depths of 60 m.

The magnetic subsystem of SWIMS contains an electronically controlled iron-core dipole solenoid within a torpedo-shaped body. The magnetic output of SWIMS is preprogrammed to provide the operator with a variety of waveshapes to trigger the perceived threats. Demagnetisation is provided to allow for the magnetic body to be brought back aboard the helicopter upon mission completion.

The acoustic subsystem being developed by Thales Underwater Systems uses an electrodynamic transducer to produce a speed-independent broadband output controllable in both frequency and amplitude. The subsystem will be mounted in a floodable nose with wings which will allow the towfish depth to be varied. The wings may be fixed or of variable attitude depending on the optimum configuration, ease of operation and so on.

Operational status

SWIMS is in production with five magnetic systems delivered. Under separate contracts, EDO incorporated the acoustic element into SWIMS for delivery in 2001-2002. The H-60 is currently conducting tow tests with SWIMS. SWIMS has also been offered as fitment to the EH 101 helicopter.

Specifications

(including acoustic subsystem)
Length: 3.2 m
Diameter: 46 cm
Weight: 544 kg
Input power: 7.5 kW
Towing speed: up to 40 kt

Contractor

EDO Marine and Aircraft Systems, North Amityville, New York. ***UPDATED***

AN/ALQ-220 (OASIS)

Type

Organic Airborne and Surface Influence Sweep (OASIS).

Description

The AN/ALQ-220 OASIS is a towed minesweeping system that will be carried by specially configured MH-60S helicopters of the USN. These helicopters will deploy from surface combatants (principally carriers) and possibly large deck amphibious vessels or from shore locations. The system will provide a rapid response sweeping capability against seabed and moored acoustic and magnetic or combined acoustic/magnetic influence mines. OASIS will also provide the ability for warfare commanders to effectively and expeditiously address the mine threat with resources available in theatre.

The system comprises a towed body designed to interface with the MHS-60S helicopter. The carriage, stream, tow and recovery system, provide the mechanical interfaces for OASIS hardware and the host helicopter.

OASIS is subdivided into six sub-elements consisting of: towed body, magnetic influence subsystem, acoustic influence subsystem, control/monitoring and power subsystem, control console OASIS software, and tow cable/control console interface. The towed body, which is hydrodynamically stable in all control modes while being towed in a straight line and, when the aircraft is conducting turns, houses the magnetic and acoustic subsystems and mechanical assemblies. The towed body measures its height above the seabed using a transducer, and its depth using a pressure sensor in order to provide guidance and control signals to the towed body control surfaces to maintain the correct position in the water column as commanded by the control console. The tow cable carries the power distribution for all the towed body components and provides communication between the towed body and the control console. Should the towed body be lost or jettisoned during a mission it can be relocated and recovered using an on-board pinger system.

The system is designed to detonate influence (magnetic and/or acoustic) mines in waters as shallow as 25 m.

Operational status

In 2002 EDO Marine and Aircraft Systems were awarded a contract for system development and demonstration of OASIS. The contract covers all analysis, systems engineering, design, development, fabrication, assembly, testing, qualification, operator and maintenance training documentation, planning and management required to support the effort, as well as all the logistics necessary to ensure successful demonstration for production. AN/ALQ-220 OASIS will meet the US Navy's requirement for a rapid, wide area coverage, mine clearance capability. Work is due to be completed by October 2005.

Contractor

EDO Marine and Aircraft Systems, North Amityville, New York.

UPDATED

AN/AQS-232 (AMNS)

Type

Airborne Mine Neutralising System (AMNS).

Description

Raytheon Integrated Defense Systems (prime contractor), teamed with BAE Systems in the UK, is adapting the British Archerfish (see entry on Archerfish) mine neutralisation weapon to meet the US Navy requirement for a helicopter-deployed remotely operated one-shot expendable device for the rapid destruction of previously located moored or seabed mines by day or night. The system will exploit the complementary technologies of the Archerfish with MCM ROV control expertise from Raytheon. The vehicle is armed with an insensitive directed energy warhead developed by SNPE in France.

The AMNS will be integrated into the US Navy MH-60 helicopter maximising the capability of the existing MH-60 helicopter MCM system.

Lockheed Martin, teamed with ATLAS Elektronik, is based around the Seafox one-shot mine disposal system, is the other contender for the AMNS Programme. Seven Seafox units are on order and will be delivered during 2004 to equip the US Marine Corps MH-53E helicopters.

Operational status

The demonstration and development programme for AMNS will run until September 2006.

Contractors

Lockheed Martin Naval Electronics & Surveillance Systems, Manassas, Virginia, US.
ATLAS Elektronik, Bremen, Germany.
Raytheon Company, Integrated Defense Systems, Portsmouth, Rhode Island, US.
BAE Systems, Waterlooville, Hampshire, UK.

UPDATED

Focused Pressure Wave Mine Neutralisation

Type

Mine neutralisation system.

Description

The focused pressure wave mine neutralisation system is being developed by United Defense (responsible for pulse forming) and Tetra (responsible for pressure wave generation) for rapid and reliable mine neutralisation tasks.

This approach concentrates pulse power-based energy against mines from a safe standoff distance. It will enable forces to carry out rapid mine clearance operations without the need for detection, classification or explosive expendables.

The technology uses intense pressure waves created by pulsed electrical energy discharged into water. The pressure waves generated from arc plasmas will neutralise the mine by rupturing its casing, rendering the sensing and fuzing systems useless, or causing the detonation of the mine.

The system comprises a phased array of transducers that focus the high-energy pressure waves at pulses of 0.5 Hz on the mine. The array generates high peak pressure at a focal point approximately 200 m from the array, with sufficient impulse to neutralise or detonate the mine. The array will be capable of sweeping an access lane some 25 m wide by 8 m deep at a speed of 16 kt.

The concept is based on technology that has already been proven in underwater commercial applications used to drill and crush rock. Developments to efficiently load energy into underwater plasma sources and its conversion to pressure wave energy have significantly improved the effectiveness of these commercially-based processes.

Such a system could be integrated in air-cushioned vehicles, surface vessels or helicopter-deployed sleds for mine clearance operations in shallow and very shallow water and surf zone regions.

Operational status
A prototype model has been built and the concept proven.

Contractor
United Defense, Armament Systems Division, Minneapolis, Minnesota

NEW ENTRY

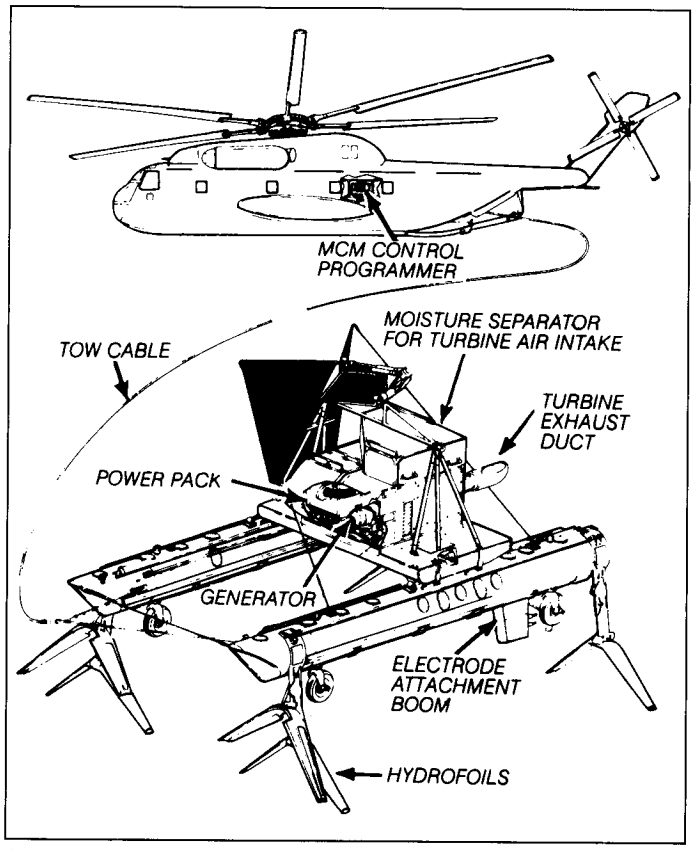
Mk 105 airborne minesweeping system

Type
Magnetic/acoustic influence minesweeping system.

Development
EDO Corporation has developed a highly mobile, helicopter-towed, unmanned MCM system that provides high-speed magnetic mine clearance and reduces the risks to personnel inherent in minesweeping operations. The Mk 105 is designed to be towed by the US Navy's MH-53E Sea Dragon helicopter and other heavy-lift helicopters of similar performance and size. Minesweeping operations may be either land-based or launched from various amphibious assault ships such as an LPH or LHA.

Description
The Mk 105 airborne minesweeping system is a helicopter-towed system carried on a hydrofoil that uses a gas-turbine engine generator set (power pack) to provide electrical power to an array of buoyant sweep cables. The electrical power is programmed and remotely controlled from the helicopter to simulate the magnetic signature of various ships. Magnetic influence mines are detonated by the magnetic field generated by the system. The Mk 105 is composed of a hydrofoil sled, a control programmer that is mounted in the towing helicopter, a towcable and an array of sweep cables.

The sled consists of a seaborne equipment platform and a generator set. The platform includes two tubular floats of light, metal-alloy construction, connected by an aerofoil wing assembly. Cavitating hydrofoils are attached to the forward and aft sections of each float. The surface piercing tandem foil configuration features two inverted V-shaped foils forward and two aft for balance. High-riding pitch control subfoils of similar configuration are located ahead of the two bow foils. For landing and ground manoeuvres, the foils may be rotated up and parallel to the floats by a self-contained hydraulic system. Wheels are attached to the underside of the floats to facilitate ground or deck handling, and a retrieval system is mounted on the platform for helicopter recovery operations. Fuel for the turbine is carried in two centrally located tanks, one in each float. The vehicle can be refuelled by the helicopter while under tow. Towcable attaching points are provided on the forward inward faces of each float. Once launched, the sled is towed at about 25 kt some 140 m behind the helicopter by a 1,237.16 m towcable that is capable of carrying both electronic signals and fuel to the gas-turbine engine generator set.



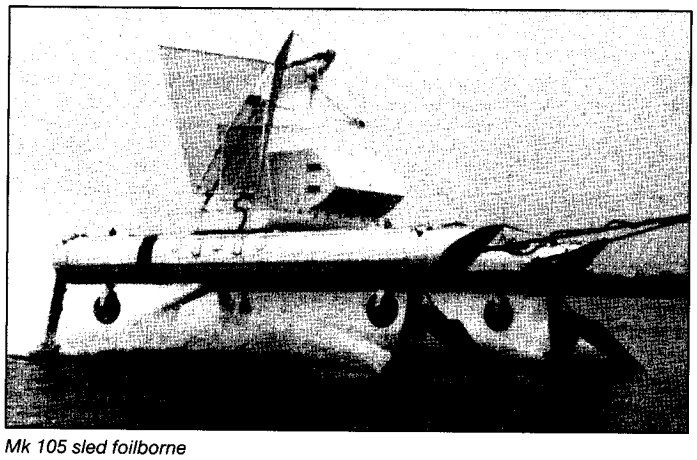
Schematic of Mk 105 system

Mounted on the wing assembly of the platform is the 350 kW, 2,000 A generator set that includes a gas turbine-driven AC generator, a rectifier, a controller containing the waterborne electronics and batteries to power the electronic system. The generator set provides energy for the generation of the magnetic field. The two 183 m long open electrode sweep wires are attached to the aft end of the sweep boom, which is located on the centreline of the sled, aft of and below the wing assembly. The sweep boom comprises an upper electrode attached to the end of a trailing cable and a lower electrode fitted to the boom fin. Using the water as a conductor, the potential between the electrodes produces a magnetic field that simulates the magnetic signature of a ship.

The control programmer, located in the helicopter, is the only occupied station employed in the system. It contains the airborne electronics and all the controls and instrumentation necessary for operating the Mk 105. The control programmer console contains the fuel transfer control panel, turbine indicators, hydrofoil and boom actuators and the generator controls and indicators. From the control programmer, the operator can start and stop the turbine, raise and lower the foils and control the magnetic influences generated through the sweep cables trailing behind the sled.

The Mk 105 has been upgraded to the Mod 4 variant with a new gas turbine generator offering improved reliability and endurance. Under the upgrade the more reliable powerpack features a positively pressurised nacelle to prevent the ingress of seawater leading to corrosion. The generator will create an electro-magnetic field that replicates the magnetic field of a ship.

The Mk 106 configuration, also towed by the MH-53E, incorporates the Mk 105 magnetic influence sweep and the Mk 104 acoustic influence sweep which is attached to the end of one of the electrode tails. The Mk 104 comprises a venturi tube and a water-activated turbine that rotates a disc to reproduce a ship's acoustic signature. It measures 1.24 m in length and is 889 mm high and 660 mm wide.


Mk 105 sled foilborne

Operational status
First used by the US Navy in 1973 during Operation End Sweep, the mine clearance operation in Haiphong Harbour, Vietnam. In continuous use since then by the US Navy. Most recently used in the Persian Gulf during Operation Desert Shield/Storm. The system is currently undergoing a major upgrade. The Mod 4 upgrade was rolled out on 24 August 1999. Delivery of upgrade kits commenced in 2000 with the system entering service in 2001. Also in service with the Japanese Maritime Self Defence Force (JMSDF).

Specifications
Length overall: 8.3 m
Beam
Catamaran structure only: 3.5 m
Across foils: 6.5 m
Height, foils extended
To top of retrieval rig: 5.25 m
To top of nacelle: 4 m
Height, foils retracted, to base of wheels: 3.5 m

Weight
Gross: 3,800 kg (Mod 4 – 4,081 kg)
Fuel: 590 kg
Power: 350 kW (max)
Operational speed: 25 kt
Operational sea state: Sea state 4

Contractor
EDO Marine and Aircraft Systems, North Amityville, New York, USA.

VERIFIED

MMS

Type
Marine Mammal System (MMS)

Development
In 1959 the US Navy acquired a Pacific white-sided dolphin for hydrodynamic studies. The dolphin was to be studied to determine whether it had any special hydrodynamic characteristics that could be applicable to torpedo, ship and submarine design. The studies were designed to determine whether the dolphin possessed a highly developed capability to reduce drag underwater. Because of the technical limitations of the time, the data gathered was considered to be inconclusive. Technology has now advanced to the stage where research work has been resumed with studies concentrating on such diverse but synergistic features as: skin compliance; boundary layer heating and biopolymers.

Apart from the work associated with torpedo development, studies were also carried out to investigate the specially developed senses and capabilities of dolphins and sea lions, for example their biological sonar (biosonar) and deep diving physiology. The studies were designed to ascertain whether dolphins and sea lions could be trained to perform useful tasks. This was subsequently successfully demonstrated in 1965 when a US Navy dolphin successfully performed a number of tasks such as carrying messages tools and equipment between the surface and aquanauts living aboard the submerged SeaLab II project.

Studies into dolphins and their unique capabilities are continuing and currently include: diagnosis and treatment of health problems; neurological studies; attempting to understand how the animal's brain functions; the audio range of the dolphin and how they produce their characteristic sounds. The results of these studies will be used to develop new technologies for the Fleet such as new transducers and new sonar technologies in which not only audio transmission and reception are integrated, but also search modes and classification capabilities.

The object of the studies is to ascertain whether marine mammals can perform certain tasks more effectively, safely and cost effectively than divers or submersibles. Dolphin biosonar is unmatched by hardware sonar in detecting objects in the water column and on the seabed. Likewise sea lions have exceptional low light level vision and sensitive underwater directional hearing.

Description
Dolphins and sea lions are used by the US Navy to carry out underwater surveillance with the aim of detecting non-natural objects underwater. Under the supervision of their handlers the mammals survey a specific area using, in the case of sea lions, their extremely sensitive and directional audio channel, and in the case of dolphins, their biosonar. When a target is detected and located the animal reports back to the handler who then determines the necessary response based on the tactical situation. This may involve sending the mammal back to mark or recover the object, or using human divers to deal with the target object.

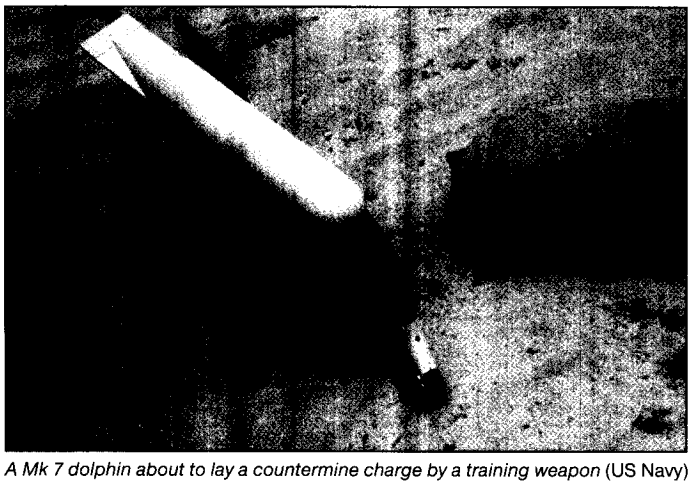
Among the roles defined for the dolphins and sea lions are swimmer/diver detection, MCM (both of seabed and moored mines), and ordnance recovery.

In the case of unarmed ordnance recovery, sea lions have proved particularly valuable as unlike divers they are not limited in their working time underwater or on the seabed, nor are they, within certain natural limits, depth restricted. Neither are they affected by poor turbidity, currents and the need for extensive medical back up in the form of recompression chambers and so on. The ordnance recovery system comprises an inflatable dinghy, a sea lion and two or three handlers. The sea lion is trained to detect sound from a transponder on the ordnance. On locating the signal from the ordnance, the sea lion returns to the surface where it is given a bite plate with a device for attaching to the ordnance, which in turn is connected to a strong line paid out from the inflatable. The sea lion then returns to the ordnance and attaches the device to the ordnance and releases the bite plate. The sea lion then returns to the inflatable where it is duly rewarded with fish – the line then being used to retrieve the ordnance from the seabed.

The US Navy's Fleet MMS are organised into four distinct functions; MMS being assigned to the Navy's Explosive Ordnance Disposal Mobile Units (EODMU). Each MMS comprises four to eight mammals with an officer and a number of handlers/trainers. The MMS are rapidly transportable to the area of operations by air, sea or land, together with all their essential equipment.

The Mk 4 MMS uses dolphins trained to detect and mark the location of moored mines; the Mk 5 uses sea lions for ordnance recovery down to 305 m; the Mk 6 uses dolphins trained in swimmer and diver detection; and the Mk 7 uses dolphins trained to locate and mark mines on the seabed.

All mammals used by the US Navy are very well cared for, every dive being rewarded with fish. There is no punishment for failing to perform a task. The mammals are housed in their natural environment in open mesh enclosures. The mammals undergo almost daily training and are always allowed complete freedom of movement. During the past 30 years of operation only seven mammals have gone AWOL.



A Mk 7 dolphin about to lay a countermine charge by a training weapon (US Navy)
0543462

Operational status
The US Navy has extensively used the mammal unit. Ordnance recovery using sea lions has been operational since 1975. In the swimmer defence role, the mammal unit was deployed to Vietnam in 1970-71 and to the Persian Gulf in 1987-88. In 2002 two dolphins were used in Exercise Blue Game for a major minesweeping exercise. The first known combat use of the dolphin in the MCM role was in the 1993 Gulf War. There two dolphins were used to hunt for mines, underwater ordnance and assist other MCM forces to clear a route up to Umm Qasr for the RFA *Sir Galahad* carrying humanitarian aid, where submersibles and divers had been hampered in their work by the highly turbid conditions.

Contractor
Space and Naval Warfare Systems Center, San Diego, California.

VERIFIED

MOLS

Type
Modular Open-Loop Sweep (MOLS) system.

Description
The MOLS system is based on a power pack technology that has been proven in service in the US Navy on the Mk 105 Mod 4 airborne magnetic sweep system for over 25 years. It is designed to provide high power open loop magnetic and acoustic influence sweep capabilities to any surface platform.

The power pack incorporates a gas-turbine generating set using a Pratt & Whitney PT-6 turbine derivative as the primary power source. This set, when coupled with a generator and rectifier, can generate an output current of 3,200 A and an output power of 3.5 kVA. Because it generates its own output power, no external power source is required for this application and only an external fuel connection is required. The MOLS provides high output in constant current or controllable waveform or pulse modes. This offers additional minesweeping effectiveness against most threats. The configuration and capability of the MOLS system permits operation in deep water and offers a large swept path performance. The speed range of the system is dictated only by the operational limits of the surface tow platform.

A modular winch assembly and sweep cable are provided with the power pack that is packaged to meet shipboard requirements for noise, EMI, magnetic signature, and salt-water ingestion. It is palletised for ease of installation and removal. A MOLS system can be installed in a modular configuration on almost any platform that can accommodate a 2,275 kg payload. It is thus suitable for use in COOP role as well as platforms dedicated to mine countermeasures.

Operational status
Available.

Specifications
Length: 3 m
Width: 1.8 m
Weight: 1.45 t

Contractor
EDO Marine and Aircraft Systems, North Amityville, New York.

VERIFIED

MUDSS

Type
Mobile Underwater Debris Survey System.

Description
MUDSS (Mobile Underwater Debris Survey System) is a joint US Navy-NASA project executed by the Naval Surface Warfare Center (NSWC) and the Jet Propulsion Laboratory and funded by the Strategic Environmental Research and Development Program (SERDP). The work is being carried out in partnership with the Naval Coastal System Station, Naval Surface Warfare Center in Florida.

The aim of the MUDSS programme is to demonstrate various technologies that can be used in economical, rapid survey of former defence sites to assist in the identification of underwater unexploded mines and ordnance for unexploded waste. These technologies used include:

- acoustic, magnetic and electro-optic minehunting sensors and signal and image processing technologies under development at the NSWC for the Office of Naval Research (ONR) and
- sensor fusion and visualisation technologies and trace chemical detection technologies under development at Jet Propulsion Laboratories for NASA and the Federal Aviation Authority respectively.

Typical of the sensors used are those that were involved with the search for the Swissair Flight 111 that crashed off the Canadian coast in 1998. These included a Synthetic Aperture Sonar (SAS) and an advanced Electro-optic Identification Sensor (EIS).

MUDSS works by combining sonar and EIS technologies in a single, torpedo-shaped submersible that feeds high-speed data to a parent vessel via a fibre optic cable. This enables the US Navy to use sonar to locate objects on the seabed and then to use the EIS to zoom in and identify those objects at closer range.

MUDSS comprises a custom-designed portable catamaran that tows underwater vehicles which house the sensor suite. This typically consists of:

- a superconducting magnetic field gradiometer used to locate and magnetically classify metal ferrous targets
- LF synthetic aperture sonar operating on a frequency of 20 kHz for high-resolution images for bottom and shallow buried targets
- an HF SAS operating at 180 kHz providing high resolution for seabed targets
- laser linescanner to image targets at ranges up to three to five times as great as conventional electro-optical systems and
- a SeaBat sonar operating at 455 kHz for target re-acquisition.

MUDSS also uses a small Unmanned Underwater Vehicle (UUV) with a chemical sensor that can be deployed to collect sea bottom samples near suspected targets for the detection of trace amounts of explosives.

A radio transmitter in the cabin on the catamaran forwards all the processed sensor data back to a shore-based van housing data acquisition equipment, sensor operators and survey directors.

A mass spectrometer laboratory analyser is used in the shore base to test bottom sediment samples obtained near targets for trace elements of explosives.

Once the US Navy finds debris, the results are turned over to the US Army which has the responsibility for disposing of all unexploded military waste.

Operational status
The first phase of the data analysis programme has been handed over to the US Navy following its first year's feasibility demonstration at St Andrews Bay, Panama City, Florida, the location of the US Navy's Coastal Systems Station's test site. MUDSS has completed a three-year programme under contract to the US DoD. The work was carried out in partnership with the Naval Coastal System Station, Naval Surface Warfare Center in Florida.

The capabilities of MUDSS were proved during the search for the crashed Swissair Flight 111 aircraft in 1998.

Contractor
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California.
VERIFIED

RAMICS

Type
Mine clearance gun system.

Description
Currently under development, RAMICS (Rapid Airborne MIne Clearance System) is designed to rapidly reacquire, target and neutralise floating and near surface moored sea mines in the upper water column (40 to 300 ft) that have been detected, classified and localised by a separate minehunting system. The system is based on a Light Detection and Ranging System (LIDAR) and a Mk 44 M-197 Gatling gun with modified muzzle clamp firing 600 rounds per minute. The cannon fires a Mk 258 Mod 1 armour-piercing, spin-stabilised 30 mm supercavitating discarding sabot projectile at a speed of about 1,000 to 1,300 m/s specially developed by C-Tech Defense. The tungsten sub-projectile can detonate surface or subsurface mines, penetrating the casing down to depths in excess of 30 m providing a mine-free path in shallow water and surf zones. The projectile enters the water at an angle of 45°. On entering the water a small protrusion on the nose of the projectile together with its speed produce a cavitation envelope in which the projectile travels in a straight low-drag trajectory. When the projectile strikes the mine it releases a highly reactive non-explosive lithium perchlorate oxidiser into the mine's explosive core causing the mine explosive to burn rapidly and destroy the casing. The gun is aimed using a blue-green laser which penetrates the water column with an 8° field of view to survey the target from a number of directions to overcome any false alarms and provide a positive mine identification.

Targets to be engaged by RAMICS are re-acquired by the LIDAR system using a GPS reference extracted from a separate system and confirmed by the weapon's officer as the correct target. The helicopter then transits back to a safe engagement distance and height while the LIDAR remains locked on to the target. At the safe engagement range the helicopter either hovers or circles round the target area and engages the target at a nominal slant range of about 300 m and a depression of 45°. When correctly positioned the gun is fired using a burst of around 20 to 25 rounds. The fire-control system uses complex algorithms to correct for the shell's ballistics in air and water, the refraction at the air-sea-surface boundary, and any image distortion of the target cased by reverberation and so on.

Operational status
An Advanced Technology Demonstrator (ATD) began testing in FY98, and was completed early in 2001. These trials included testing a modified M197 20 mm Gatling gun installed in an AN-1 Cobra helicopter. The trials included firing trials from a static test platform, and two series of airborne firing trials, firstly at the Aberdeen Test Facility in August 2000, and secondly at the CSS in Panama City in September 2000. The trials successfully demonstrated the ability of the gun and ammunition to cause mine-like explosive to catch fire at extended range and to penetrate mine-like casings at water depths to 6 m. Northrop Grumman was awarded a demonstration and development contract for RAMICS in Summer 2002 with completion scheduled for August 2005. A production contract is scheduled to be issued in 2006. The system will be deployed from MH-60S helicopters to provide organic airborne mine defence for carrier battle groups and amphibious ready groups.

Contractor
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.
UPDATED

DIVERS' EQUIPMENT

Introduction

This section covers many types of equipment associated with divers and their operations. Diving covers a vast field of activity ranging from sabotage, beach reconnaissance, disarming and removal of unexploded ordnance, to salvage and the inspection of underwater defences, hull inspection and so on. To support these varied underwater operations, a wide range of equipment including diving suits, breathing apparatus, hand-held sonars, underwater telephones, communications equipment and cameras, has been developed, some of which are described here. More of the equipment and systems used in these underwater operations will be covered in future editions of this book.

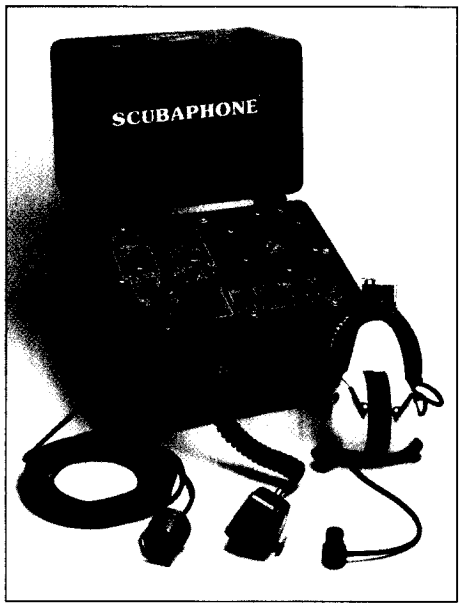
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Canada

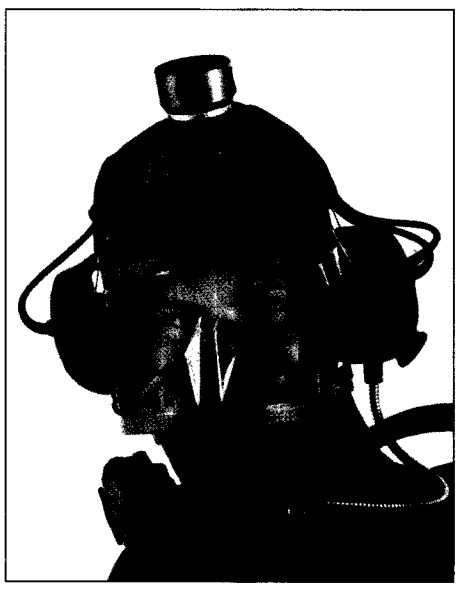
Scubaphone

Type
Diver underwater communications set.

Description
The Scubaphone wireless underwater communication system is designed for both military and commercial use. The Scubaphone products enable diver-to-diver and diver-to-surface intercommunication. It employs a crystal controlled single sideband (SSB), suppressed-carrier transmission technique to achieve maximum power output and effective range. Special filters in the system process the incoming signal to provide optimum speech clarity under adverse conditions by removing background sounds and reducing extraneous noises, such as the bubble noise caused by the exhalation of the diver. The SSB technology provides distortion free transmissions and extended battery life, allowing diving teams to enjoy clear communications even in strong currents or waters crowded with ships, wharf pilings, or debris.



Scubaphone diver communications set



Diver unit of the Scubaphone

To optimise the field of communications, the Scubaphone diver unit features an integrated head-mounted communications transceiver consisting of two high-output speaker enclosures housing all electronic circuitry, 12 V rechargeable Ni/Cad battery pack, a transducer attached to the top of the headband, and a push-to-talk activated microphone which fits into any full-face diving mask.

The entire unit is water and pressure proof to 100 m. This unique design provides a lightweight (only 750 grams in water), comfortable, easy-to-use system with proven reliability and ruggedness.

With the Scubaphone, diver-to-diver communication is independent of the surface unit. Communication from the diver can be performed over ranges up to 1,200 m in saltwater, while that from the surface ranges up to 3,600 m.

An optional video camera attachment allows a diver's voice to be recorded while video filming.

Operational status
In service.

Specifications
Frequency: 30 kHz standard; others optional
Diver Unit:
Weight: 1.25 kg (in air), 0.75 kg (in water)
Acoustic power output: 1 W
Audio output: 1 W RMS
Surface phone:
Weight: 10 kg
Acoustic power output: 5 W
Audio output: 2 W RMS

Contractor
Orcatron Communications Ltd, Port Coquitlam, British Columbia.

VERIFIED

Scubaphone Vox

Type
Voice-activated diver unit.

Description
The Scubaphone Vox (voice-activated) diver unit can either be belt-mounted or mounted on the air bottle. The unit uses the same SSB ultrasonic techniques as other Orcatron products and offers hands free operation but can also, with a switch, be converted to push-to-talk mode to ensure 'silence' when needed. This system is fully compatible with the Scubaphone 2000D and 2000S series and



The Scubaphone Vox Model 1080 showing the unit mounted on a diver's air bottle

operates in the 30 kHz frequency band. The system consists of the transducer, electronic circuitry and 12 V lead-acid battery pack, and a headset containing two high output speakers and a waterproof microphone. The equipment features a replaceable lead-acid battery pack.

The Scubaphone Vox has a diver-diver range in excess of 3 km and is rated to operate at up to 100 m depth.

Operational status
In service.

Contractor
Orcatron Communications Ltd, Port Coquitlam, British Columbia.

VERIFIED

SIVA S-10

Type
Oxygen rebreather diving apparatus.

Description
The SIVA S-10 is a chest-mounted rebreather diving set designed specifically for special forces and shallow water MCM operations. It is a closed-circuit pure oxygen re-breather for use to depths of 8 m. Specific user rules and regulations on oxygen swimming operations may permit the use of the S-10, for brief intervals, to greater depths.

The S-10 may (optionally) be fitted with an adjustable flow metering valve, which allows the diver to alter the flowrate between 0 litres/min and approximately 2.5 litres/min via an adjustable valve having four detent positions which locate the intermediate flows. In addition, the set has a manually operated bypass valve. The set incorporates a cartridge style scrubber with a four hour duration at 0°C.

The S-10 may also optionally be fitted with an automatic demand valve, located in the counterlung. This valve will operate and supply oxygen to the counterlung whenever the counterlung is breathed down to an empty, collapsed state.

Either the demand valve or the adjustable flow metering valve, or both, can be fitted in the S-10, depending on user preference.

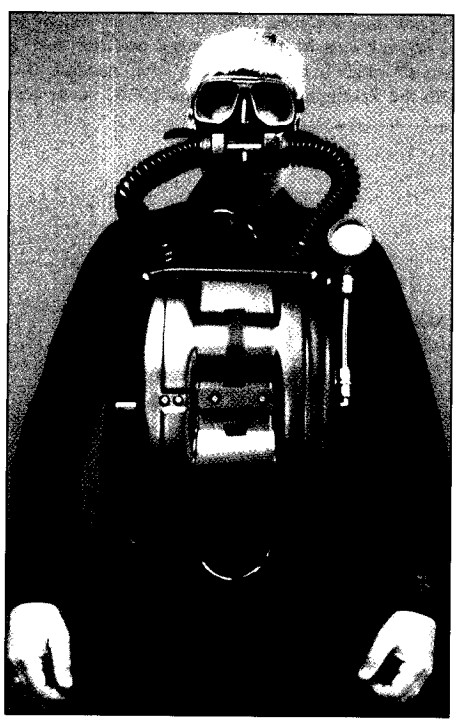
The apparatus can be upgraded to the SIVA S-24 semi-closed mixed gas configuration allowing operations down to depths of 24 m.

The equipment is capable of being certified non-magnetic and acoustically safe in accordance with NATO requirements for shallow water MCM and EOD (Explosive Ordnance Disposal) operations.

Specifications
Length: 43 cm
Width: 32 cm
Depth: 20 cm
Weight: <13 kg (in air)
Oxygen flask volume: 1.5 or 2.2 litres
Breathing bag capacity: 5.5 litres
Endurance: 4 h (dependant on flask configuration)
Charging pressure: 206 bar

Contractor
Carleton Life Support Technologies Ltd Mississauga, Ontario.

UPDATED



The Siva S-10 rebreather apparatus (Carleton Technologies)
NEW/1066877

SIVA Systems

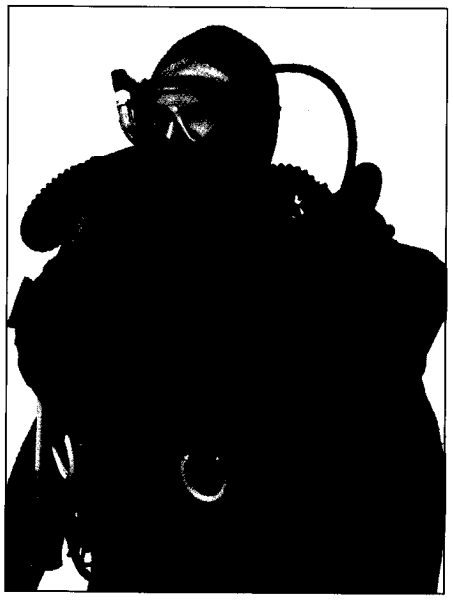
Type
Diver rebreather apparatus.

Development
The SIVA rebreather apparatus has been developed to provide divers with both shallow water oxygen and deep water mixed-gas capability.

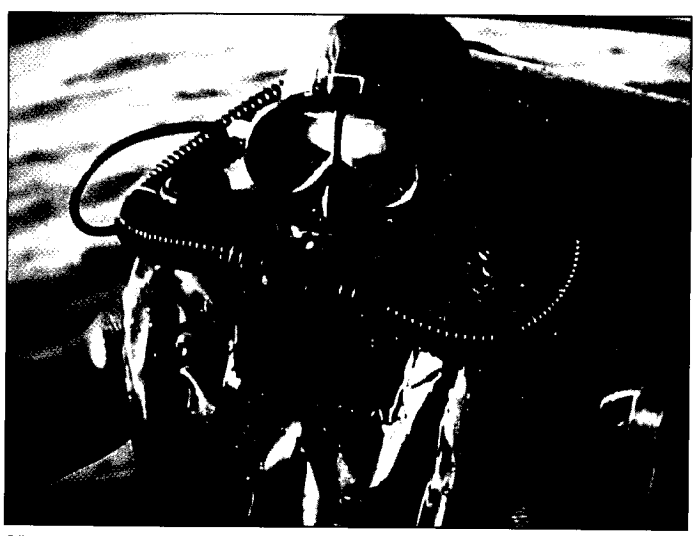
Description
The SIVA unit features a low-acoustic signature and, with a non-magnetic form available, the system is suitable for mine countermeasures duties as well as weapon recovery and other military tasks where minimal signature is important.



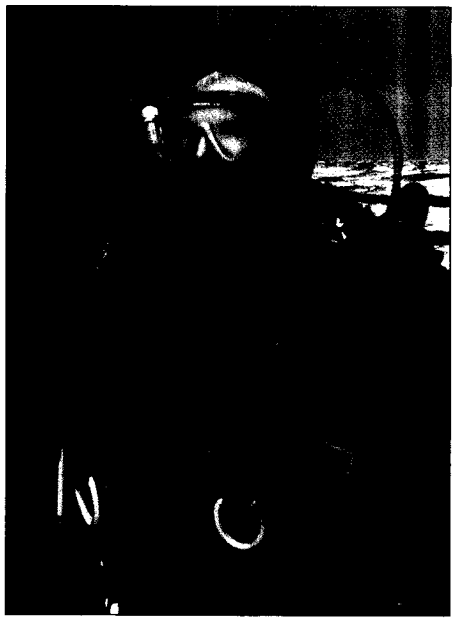
SIVA 55 dual mode rebreather (Carleton Technologies)
NEW/1066879



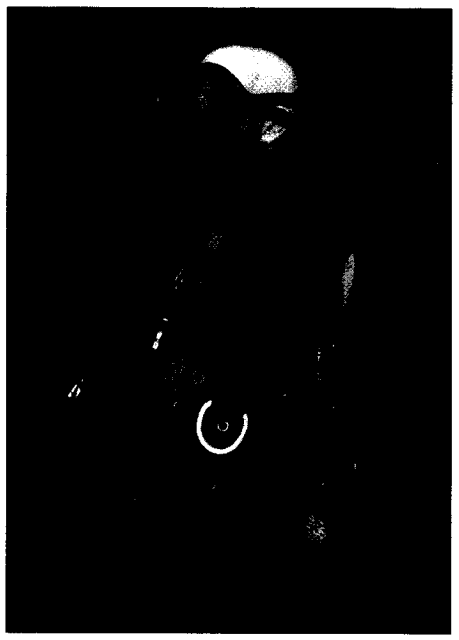
SIVA Viper-E UBA (Carleton Technologies)
NEW/1066881



SIVA+ self-contained rebreather (Carleton Technologies)
NEW/1066880



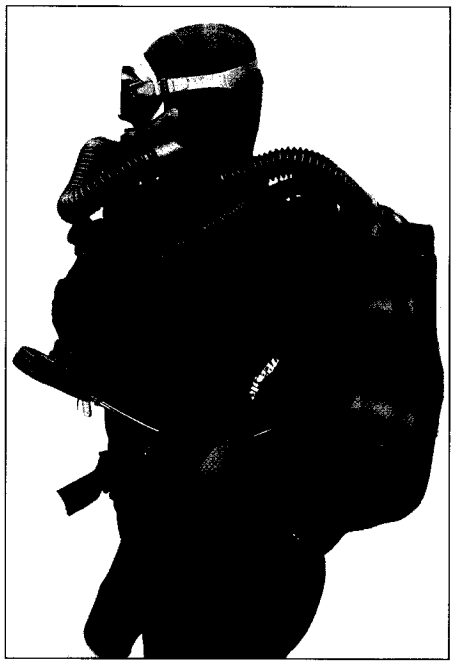
SIVA Viper-E mixed gas UBA
(Carleton Technologies)
NEW/1066882



SIVA Viper Plus UBA
(Carleton Technologies)
NEW/1066883



SIVA VIPER-SC self-contained rebreather
(Carleton Technologies)
NEW/1066884



SIVA VIPER-SC self-contained rebreather
(Carleton Technologies)
NEW/1066885

The modular dual-mode SIVA system accommodates two interchangeable gas control modules which offer the diver depth adaptability. The SIVA 55 gas control module permits the semi-closed circuit to be used with nitrox to a depth of 55 m. These are metered to the breathing circuit by a unique mass flow selector and control mechanism. The circuit for the control of premixed gases features four adjustable jets which can be calibrated by the user or supplied factory-set to suit the mixtures required for various depths down to 55 m (fully closed oxygen to 8 m for covert operations). In the closed circuit mode and when fitted with the optional counterlung demand valve, oxygen is automatically injected. Once set, the user has the freedom to switch mixtures between dives without recalibrating the unit. In the self-contained mode, Siva-55 has an endurance of up to 4 hours.

The dual mode SIVA+ semi-closed circuit gas control module delivers either 100 per cent oxygen (for covert operations down to 8 m) or the dynamic mixing of oxygen and diluent gas using a pneumatic control system for constant PPO_2 for dives to 95 m in depth. These depths are made possible by significant gas conservation achieved through the control of the oxygen partial pressure. In the self-contained mode, SIVA+ provides enough gas and CO_2 removal capacity in 0°C water to support a working diver to a depth of 95 m. This includes a 20 minute bottom time and allows for in-water decompression. A supplementary gas flask assembly is available for extended operations or bailout. The maximum depth attainable is limited only by the quantity of stored gases.

The Siva Viper-E is a closed circuit mixed gas system rated to 100 MSW depth and featuring low magnetic and acoustic signature. The apparatus is electronically controlled and designed for use in MCM and covert operations. The fully closed breathing loop offers the most efficient use of gas allowing a 4 h dive duration at 0°C. A manual bypass system allows for completely manual operation if required and an optional full face mask is available. Two completely independent monitoring systems are provided while the bubbleless operation and long dive duration are suitable for use by Special Operations Forces.

The SIVA VIPER PLUS is a self-contained rebreathing apparatus developed specifically for underwater MCM and covert closed circuit O_2 operations. It incorporates the proven SIVA+ technology into the lower profile VIPER series configuration. The dual mode semi-closed or closed circuit set is rated to 95 m and features pneumatic gas mixing for constant PPO_2, with no electronic controls. In the fully closed circuit O_2 mode the set can be operated down to 8 m. The gas control uses a constant mass flow of oxygen mixed with a variable flow of diluent proportional to depth. A manual bypass valve is incorporated.

The SIVA VIPER-SC is very similar to the VIPER PLUS, but is smaller at 50 cm length and weighs slightly less at 22 kg. Operational depth can be increased to 100 m with an optional electronic controlled closed circuit.

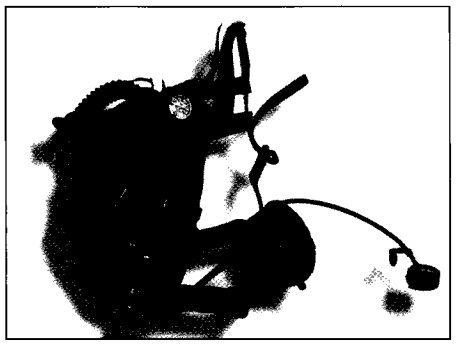
The Siva S-24 is a multirole shallow water/MCM closed/semi-closed circuit self-contained chest mounted apparatus. It can be used in closed circuit mode using 100 per cent oxygen to 8 m and in a semi-closed circuit mixed gas mode to 24 m in normal conditions. This can be extended to 55 m when calibrated and charged with the correct mixture for the maximum depth of dive. Gas control is managed via an automatic counterlung demand valve and inline mass flow control valve adjusted before the dive to suit the gas mixture being used. Alternatively a fixed mass flow is provided with no demand valve.

The use of surface-supplied gases from an optional umbilical permits extended bottom time by employing SIVA as a lightweight surface-supplied apparatus or by providing gas for in-water decompression following a free swimming dive. The design and the options extend depth and dive time to expand SIVA's operational capabilities.

The ergonomically designed counterlung and breathing loop minimises flow resistance and provides for more comfortable breathing. The counterlung is positioned on the diver to reduce hydrostatic effects while optimising swimming actions. A diver-adjustable valve is employed to establish the best breathing characteristics in all positions. The lung is made of a tough, abrasive-resistant, reinforced polyurethane that will not mildew or rot and is unaffected by ultraviolet light. It comes fitted with integral and jettisonable weights and functions as a flotation device, maintaining a diver face up on the surface.

Operational status

The SIVA-55 and Siva+ are in service with the Canadian Navy (as the CCDA and CUMA) and separately with the Belgian, Netherlands, New Zealand, Norwegian and South African Navies. The SIVA Viper-E is used by the Australian, UK and US navies.



SIVA S-24 self-contained rebreather
(Carleton Technologies)
NEW/1066878

Specifications

	SIVA 55	SIVA+	VIPER- E	VIPER PLUS	SIVA S-24
Length:	61 cm	61 cm	52 cm	52 cm	43 cm
Width:	37 cm	37 cm	40 cm (max)	40 cm	32 cm
Depth:	19 cm	19 cm	19 cm	19 cm	19 cm
Weight (in air):	<29 kg	<32 kg	24 kg	29 kg	<14 kg
Gas storage volume:	1,177 l	1,177 l	1,177 l	1,177 l	1,177 l
Breathing bag capacity:	8.0 l	8.0 l	8.0 l	8.0 l	8.0 l
Endurance (max):	4 h	4 h	4 h	4 h	4 h
Charging pressure:	297 bar	297 bar	200 bar	200 bar	297 bar

Contractor
Carleton Life Support Technologies Ltd, Mississauga, Ontario.

UPDATED

Special Diver Unit (SDU)

Type
Long-range diver underwater communication set.

Description
The SDU is a single- or dual-frequency, single-sideband, selectable power, through-water communication system specially designed for long-range communications of up to 10 km for intrusive or anti-terrorist missions. The SDU is available in two configurations: the 10 kHz band Mk I for use on a backpack by divers equipped with chest-mounted closed circuit rebreather apparatus; and the lighter 18 kHz band Mk II with a range in excess of 7 km designed as a twin-tube, lower profile system which can be customised from the Mk I. The maximum operating depth of the Mk I is 70 m and of the Mk II 60 m. Power is provided by a 24 V Ni/Cad battery pack. Numerous customised features are available.

Low power allows diver-to-diver communication. High power using low carrier frequencies with transmitter powers increased to 50 W allow up to 10 km communication between the divers and a submarine or surface ship equipped with a Subphone communication system. Divers can easily switch to low power (0.5 W) for shorter range communications with reduced chance of detection. The system can also be used for dry/wet swimmer delivery vehicles.



SDU communications set

Operational status
In service.

Specifications
Frequency: crystal controlled, user specified: 10 kHz USB standard
Transmitter power: 50 W (0.5 W selectable)
Voice: Tx/Rx
Morse: Rx
Nominal range: 10 km @ 10 kHz

Contractor
Orcatron Communications Ltd, Port Coquitlam, British Columbia.

VERIFIED

Subphone

Type
Submarine/submersible and surface vessel communications system.

Description
The Subphone is a single- or dual-frequency, crystal controlled single-sideband, selectable power, through-water communications system. It is a rack-mounted equipment for use in 1 atm submarines/submersibles or on surface vessels and can be mounted in a carrying case for surface support use.

The Subphone provides dual-frequency operation for two-voice frequencies and an internal pinger. It is intended to provide high-quality communications through saltwater at nominal ranges up to 10 km.

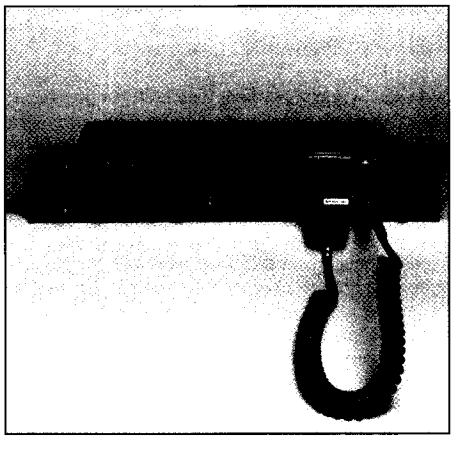
Subphone is also used as the surface station for the SDU (Special Diver's Unit) which allows clear communications between divers at nominal ranges of 10 km in saltwater.

Operational status
In service.

Specifications
Frequencies: user specified: 10 and 30 kHz USB standard
Transmitter power: 50 W (0.5 W selectable)
Pinger: 15 ms
Nominal range: 6 km @ 30 kHz; 10 km @ 10 kHz at maximum power

Contractor
Orcatron Communications Ltd, Port Coquitlam, British Columbia.

VERIFIED



Subphone diver communications set

Subphone Model 2190

Type
Submarine/submersible and surface vessel communications system.

Description
Model 2190 is a waterproof version of Subphone offering through-water, long-range communications designed for use in a rubber dinghy for intrusive launch and recovery of commandos under rugged conditions. The portable crystal-controlled single sideband (SSB) system features propriety electronic circuitry and filtering enhance speech clarity and reduces extraneous noises, thereby providing optimum clarity even under adverse conditions.

The Subphone Model 2190 has user selectable high and low power transmitter capabilities enabling the user to conserve battery life and provide a smaller acoustic footprint under conditions of short-range communications. The option of

dual-frequency also offers the operator the capability of choosing the best frequency for communicating under various ocean conditions.

Operational status
Available.

Contractor
Orcatron Communications Ltd , Port Coquitlam, British Columbia.

VERIFIED

France

DC 55 UBA

Type
Underwater breathing apparatus.

Description
The DC 55 is a self-contained semi-closed circuit Underwater Breathing Apparatus (UBA). It comes in the form of a set comprising a soda-lime scrubber unit, two aluminium alloy mixture cylinders and a breathing bag protected by a cover. The diver breathes into the apparatus through a mouthpiece, maintained by a strap and connected to two corrugated hoses which lead to the inhalation and exhalation pipes containing the corresponding non-return valves.

The composition of the mixture breathed at different depths is practically independent of the diver and the work performed. It is obtained by the release from the circuit of a certain volume of gas proportional to the breathing amplitude. In this manner, the mixture breathed is very stable. It is of demand type, comprising neither by-pass nor continuous flow. The reduction of the volume of gas in flow, due to gas release, oxygen consumption and carbon dioxide absorption, is automatically compensated by an addition to the mixture coming from the admission valve. The circulation of gases is ensured by the action of two non-return valves. The whole of the exhaled mixture passes through the absorber unit and there is complete absorption of the carbon dioxide.

Operational status
In service with the French Navy and in many foreign navies.

Specifications
Weight: 24 kg
Length: 0.68 m
Width: 0.39 m
Thickness: 0.17 m

Diving performance

	Without injector	With injector	With injector
Operating depth	0.25 m	20-40 m	30-55 m
Gas mixture	60% O_2/40% N_2	40% O_2/60% N_2	32.5% O_2/67.5% N_2
Duration of dive	180 m	90 m	75 m

Contractor
La Spirotechnique I C, Carros.

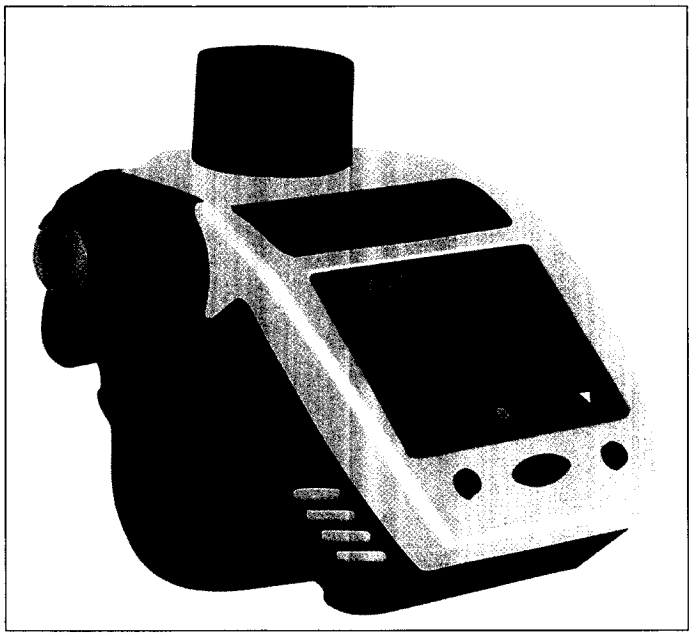
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ERUS MIL.COM

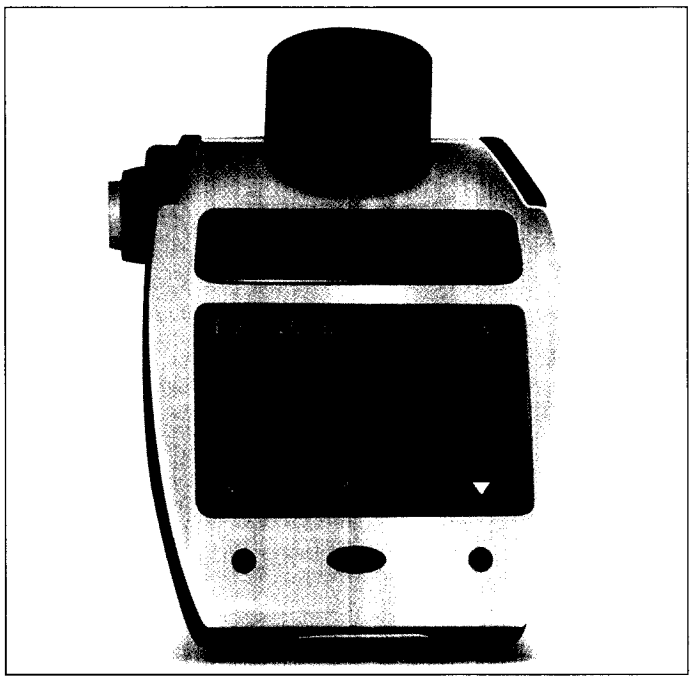
Type
Diver communication system.

Description
The ERUS MIL.COM is designed to provide wireless communication between divers, divers and surface ships, and divers and submarines. The equipment is designed to meet requirements for underwater communications, offering reduced weight and size, digital signal processing, increased autonomy and high level of intelligibility. The new design is housed in a high-impact and non-magnetic casing offering scrambled transmission for secure communication.

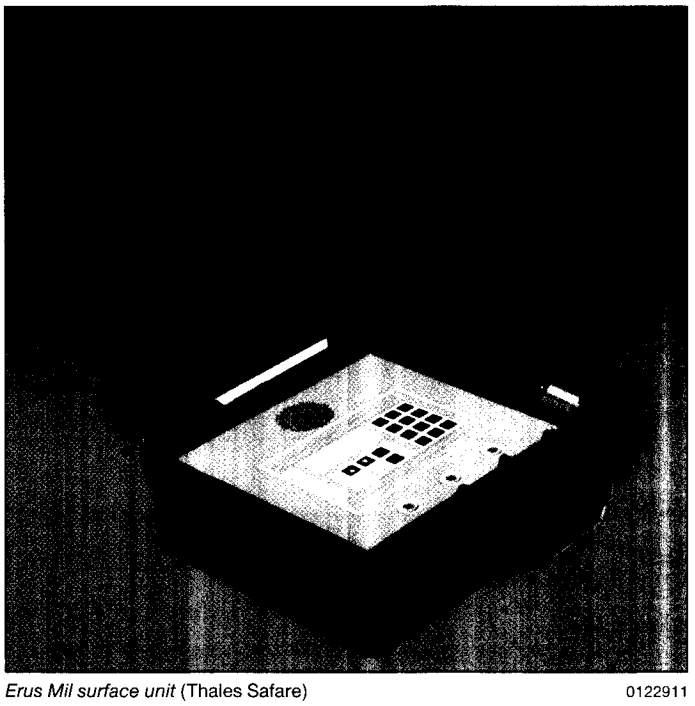
The system is compatible with all face masks currently in use and with a mouthpiece and silicone mouth mask. It can be operated in hands free mode (VOX), push-to-talk mode (transmit and receive) and emergency mode. The ERUS MIL.COM provides access to internal and external communication systems used on board submarines and surface ships allowing divers to stay in constant touch with mission tactical support. The four available channels make it possible for several groups of divers to operate simultaneously in the same area without any interference. The system is compatible with modern acoustic communication equipment such as ship and submarine underwater telephones, emergency telephones and diver communication systems. Its emergency channel of 37.5 kHz makes it compatible with the emergency operations (DISSUB) in conformity with STANAG 1074, 1296 and 1382. Its modular architecture allows it to be adapted to navigation functions.



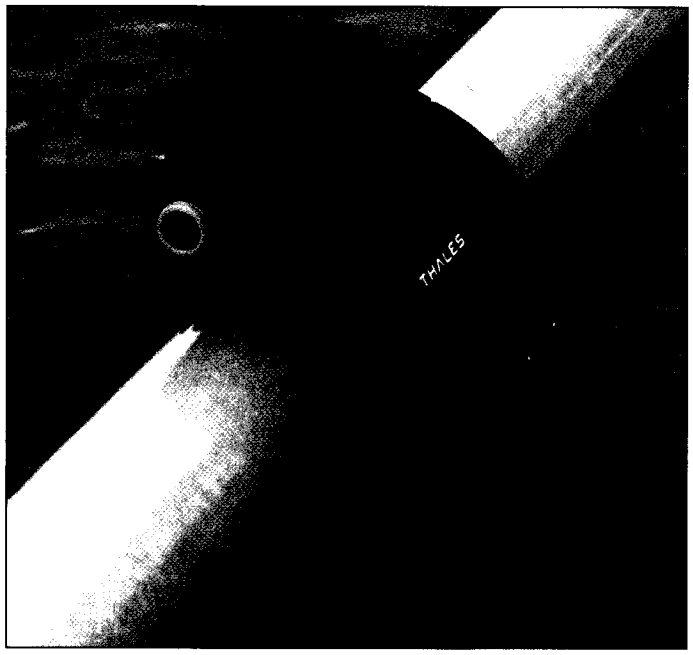
Erus Mil diver's wrist unit (Thales Safare) 0593012



Erus Mil diver unit (Thales Safare) 0593011



Erus Mil surface unit (Thales Safare) 0122911



Erus Mil diver unit (Thales Safare) 0122910

The equipment uses a unique type of single side band (SSB) modulation and operates on four channels between 30 and 40 kHz.

The diving unit is powered by a lithium ion storage cell, which provides more than 20 hours autonomy in reception mode. Communications can be conducted either in plain or scrambled mode and the unit is able to be tuned under water with on/off and volume controls.

The surface equipment provides two modes of operation: hands free and transmit/receive. Communication is presented either through a loudspeaker or headphones. The portable unit provides simultaneous monitoring of two channels.

The modular, digital design allows ERUS MIL.COM to be achieve full interoperability with other communication systems in use and also allows the integration of new features such as navigation and localisation functions.

Specifications

	Diver Unit	Surface Station Unit
Frequency band (multichannels)	4 channels, 30 to 40 kHz (Ch 1 = 32,768 kHz USB)	4 channels, 30 to 40 kHz (Ch 1 = 32,768 kHz USB)
Range	Sea State 1 = 1,000 m; Sea State 3 = 400 m	Sea State 1 = 2,000 m, Sea State 3 = 1,000 m
Output power	2 W (nominal)	5 W (nominal)
Communication	Microphone and earphone (full face mask) or mouthpiece (face mask and second-stage regulator)	Headset
Battery type	Reloadable Li-ion battery	Reloadable Pb battery
Autonomy	>20 h in reception, 2 h in transmission and 4 h in pinger mode	>20 h in reception, 4 h in transmission
Battery charge time	2 h and automatic switch to maintenance mode	<4 h
Dimensions (L × W × D)	120 × 95 × 50 mm	405 × 330 × 180 mm
Weight	0.7 kg in air	6 kg in air
Buoyancy	Slight negative	Positive
Operational depth	<80 m	
Magnetic signature	STANAG 2897 compliant	
Watertight	IP 68/12 bars	IP 67 closed
Receiver sensitivity	10 µv	10 µv
Housing material	High impact, ABS composite and polyurethane	High impact, composite material

Contractor
Thales Safare, Sophia Antipolis.

UPDATED

GIB-DPS

Type
Diver positioning and safety system.

Description
The GIB-DPS (Diver Positioning and Safety system) is claimed to be an efficient and inexpensive system that uses a set of anchored or drifting buoys spread over the mission area. The system is based on the GPS Intelligent Buoy principle using a set of three to five anchored or drifting buoys in the mission area. The buoys continuously broadcast to a control station their GPS position together with the time of arrival of acoustic signals transmitted by the divers. This results in all divers' positions being computed with a high repetition rate and an accuracy that allows them to be individually tracked.

GIB-DPS equipment can be easily operated from a surface ship or a shore station to supervise the activity of a diving team. It offers a full mission overview at a glance. Safety is achieved through the diver's individual distress call or automatically generated alert functions.

The system covers a wide spread of applications including:
- Combat and EOD divers training and exercise monitoring
- Trainee post exercises debriefing
- SAR (submarine, black box, dummy mine recovery and so on)
- Accurate mapping of amphibious force landing zones.

A typical volume coverage measures 300 m in diameter and 100 m in depth.

Operational status
In service with the US Navy diving and salvage branch. Available.

Contractor
ACSA Underwater GPS, Meyreuil.

UPDATED

Germany

DSE 1

Type
Diver sonar.

Description
Mounted in a rugged, non-corrosive housing, the DSE 1 diver sonar integrates all sensors, electronics, controls and display in one common unit. The batteries are housed in a separate battery pack underneath the unit, which is easy to replace. The unit is nearly neutrally buoyant, which allows it to float up slowly to the surface if released. Different water densities are compensated for by means of trim weights.

The sonar is controlled by two buttons – one each on the left and right hand side. The equipment is easily controlled by the diver's thumbs, even when wearing diving gloves. All functions are menu controlled.

The sonar operates in active mode with a horizontal search sector of 64° and a vertical search sector of 12°. The search sector is divided into 32 beams for scanning, each of 2°. The active sonar returns are presented in an easily interpreted display. An audio channel enables acoustic observation over a frequency range from 1 to 50 kHz. When using this mode the active sonar display is faded out. In addition to the sonar return, diving depth and a north reference enable the diver to determine position and obtain mission guidance.

The equipment is powered by replaceable batteries or with rechargeable Ni/Cd accumulators. An alarm signal appears on the screen when the battery is close to discharge.

For special applications the DSE 1 can be split into two sub-units by means of two adaptor plates and a connecting cable (available as an option). This version allows for the separate operation of the sonar head under water while the monitor with display is carried on board an escorting vessel.

Specifications
Length: 732 mm
Width: 392 mm
Height: 396 mm



DSE 1 diver sonar 0009569

Weight: 31 kg
Source level: 190 dB/μ/m
Field of view: active 64° (horizontal), 12° (vertical); passive 15° (horizontal), 30° (vertical)
Scale ranges: 12/25/50/100/200 m
Operating depth: 60 m

Contractor
L-3 Communications ELAC Nautik GmbH, Kiel.

UPDATED

Flying Bell

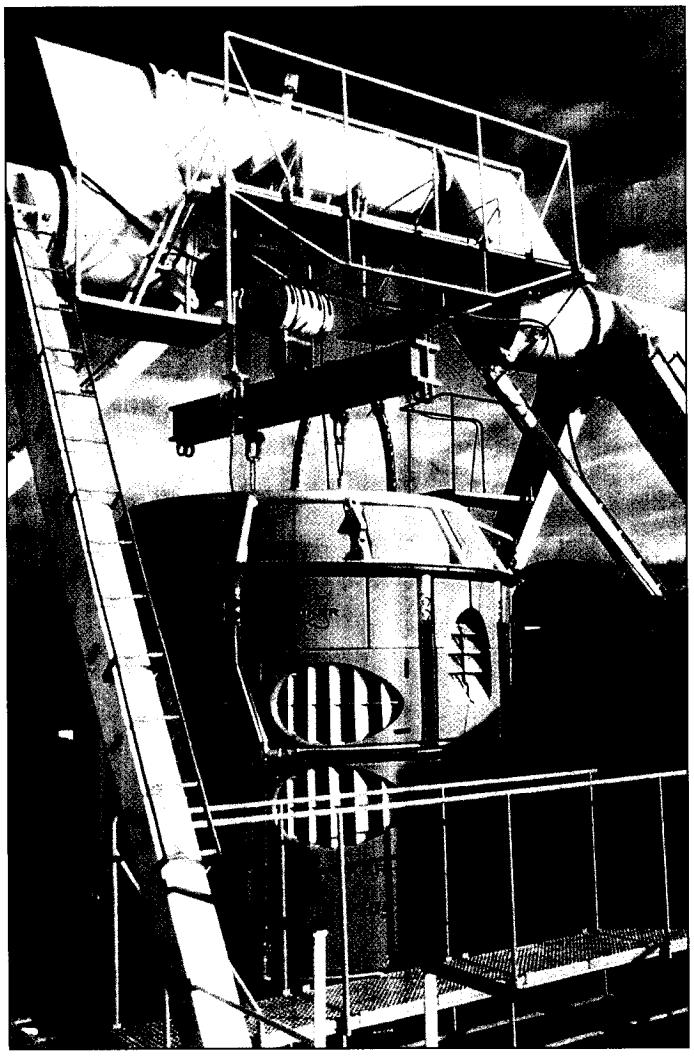
Type
Mobile diving, salvage or rescue bell.

Description
Mobile diving bells have been designed to combine the advantages of freely swimming diver lockout submersibles with those of conventional, surface supplied diving bells.

The Flying Bell concept, as delivered and commissioned for saturation diving purposes, eliminates the limitations of the first with regard to energy and gas supply autonomy by provision of a connection to the surface via a specially designed umbilical. Due to its variable buoyancy, propulsion and navigation systems the mobile bell achieves full three-dimensional manoeuvrability within a range only limited by the length of the supply cable. Furthermore, when launched and recovered through a moon pool a mobile diving bell may be less weather dependant than a rescue submersible handled over the ship's stern.

The pressure resistant body consists of a vertical cylindrical section with hemispherical caps on top and at the bottom. The cylindrical lockout trunk with double sealing hatch is inserted into the lower hemisphere. In the standard configuration the chamber accommodates up to three fully equipped saturation divers. The maximum operating depth of the system is 450 m (a rescue bell would be of spherical shape to typically accommodate nine rescuees plus one operator, the mating skirt with bayonet door inserted into the lower part of the sphere. The rated depth could be extended to 600 m and more).

The chamber is fitted out with a number of flat acrylic viewports looking in almost all directions for optimum observation of the surroundings.



Flying Bell 0009570

The vehicle's ballast system consists of two pressure resistant Hard Ballast Tanks (HBT) arranged on either side of the bell, plus a number of soft tanks on top. The HBTs can be emptied by means of compressed air or the HP drain pumps. The soft ballast tanks mainly serve for emergency surfacing and are blown by compressed air only.

Six large spherical, high-pressure gas containers are used for storage of air and breathing gas. This is a safety precaution in case the connection to the surface should fail. Should the umbilical become entangled it can be mechanically released from the connector installed on top of the bell. The umbilical contains electrical power and control cables, gas and hot water supply lines, gas control lines plus an integrated aramid fibre stress member. The latter is capable of carrying the weight in air of the fully equipped bell. The power cables end in a pressure resistant electrical power distribution module fitted out with terminals, circuit breakers, transformer and so on. The control cables are connected to a similar electronic module containing the bell units of the control computer and related interfaces. The mobile diving bell's propulsion system consists of six hydraulic thrusters, two located either side in a fore-aft direction plus two inclined vertical thrusters installed on top of the bell in a transverse position. The thrusters are fitted out with variable speed control. The two electrically driven hydraulic pumping aggregates feed into the hydraulic circuits either individually (at reduced overall power output) or in parallel. The hydraulic circuit and the hydraulic equipment installed on the bell are pressure compensated. The mobile diving bell is also equipped with north-looking gyro compass, autopilot, echo-sounder, hard wire and through-water communication systems, searchlights, underwater TV cameras plus sonar system.

Most of the functions of the bell, including manoeuvring, operation of ballast systems, claw, extendable pedestal, unlocking from the depressor and so on, can be controlled by the operator from within the bell. However, under normal operating conditions the system is remotely operated from a control console installed on board the surface support vessel, which also contains the sonar, TV, echo-sounder and DP-system monitors, the manoeuvring controls with auto-pilot unit, the handling system controls and the electric power distribution instrumentation. The bell and related systems are protected by a tubular outer frame basically cylindrical in shape with integrated fairings made of glass fibre.

The mobile diving bell is preferably handled through a moon pool situated in the ship's centerline. A typical handling system consists of a two-wire main lifting winch, umbilical winch, trolley for moving the bell horizontally between moon pool and decompression chamber, cursor to guide the bell through the moon pool plus depressor to push the system through the air/water interface when launching and for lifting the bell out of the water. The depressor, which can be lowered by 100 m or more below surface, is preferably fitted out with a mechanically driven power sheave for the umbilical.

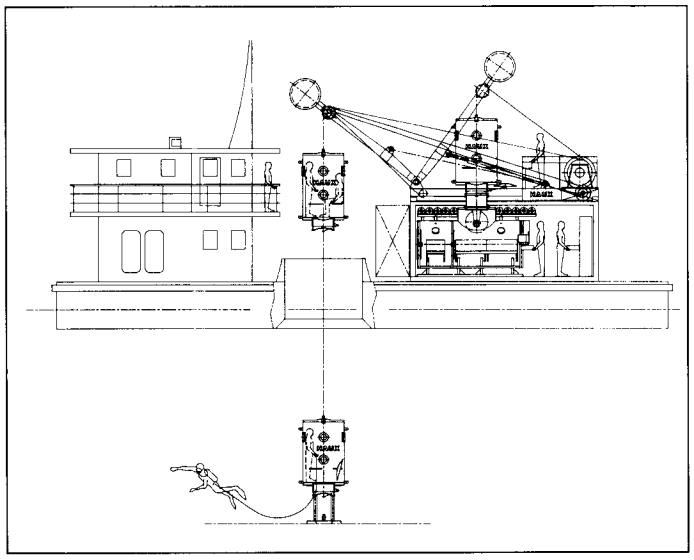
Contractor
Haux-Life-Support GmbH, Karlsbad.

VERIFIED

Haux-Deepstar 80/C

Type
Containerised self-contained diving system.

Description
The Haux-Deepstar 80/C containerised diving system consists of: the Haux-Modulstar 1500/6 Dome, a four-man deck-decompression chamber with two compartments and top transfer coupling system for the diving bell; the Haux-Deepstar 1300/80 diving bell for top transfer; the Haux-Divecontroller control panel



Haux-Deepstar 80 containerised diving system for the Indonesian Navy

for the diving bell; a handling system with two-guidewire bottom anchor; and a gas supply. The complete system is housed in two 20 ft containers. All containers are fully self-contained and operational except for the power supply which is fed from the ship's system or a generator.

The containers can be installed on a pontoon, a ship's deck or other suitable vessel. The containers are easy to transport and offer considerable flexibility for multipurpose diving operations. The Haux-Modulstar 1500/6 Dome decompression chamber consists of a main chamber with an integrated dome to enable a man to stand upright inside and an entrance lock. On top of the main chamber is a mating flange which enables divers to transfer from the diving bell to the chamber without interrupting decompression.

The decompression chamber incorporates a wide range of safety devices and equipment including a CO_2 scrubber and external life support system.

The diving bell is designed to carry up to three divers for bounce or heliox diving operations at a maximum depth of 80 m.

The bell is controlled from a separate control panel and incorporates various communications systems. Control and observation of divers can be effected from the bell or from the surface control station via TV and telephone.

Operational status
In service with the Indonesian Navy.

Contractor
Haux-Life-Support GmbH, Karlsbad. ***VERIFIED***

Haux-Medistar 1250/5.5

Type
Two-person diver recompression chamber.

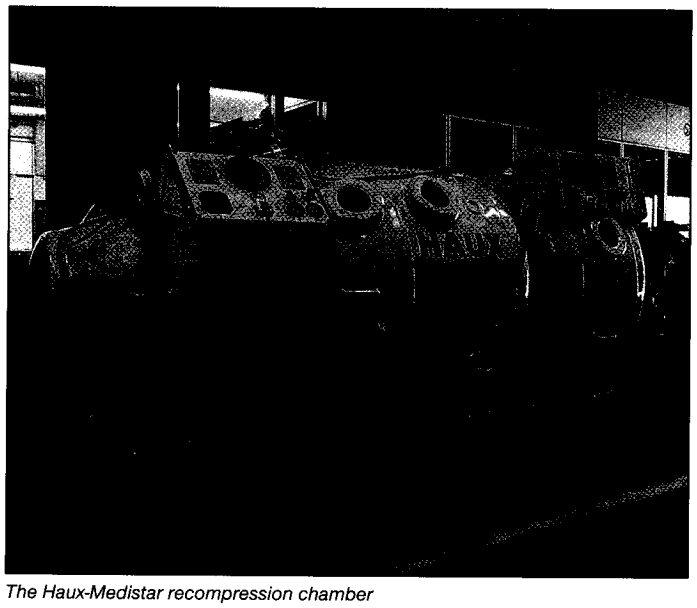
Description
The Medistar is a newly developed modern transportable recompression chamber with a maximum working pressure of 5.5 bar (optionally 7 bar). The frusto-conical shell of the Medistar is constructed of saltwater-resistant aluminium alloy and is provided with several handgrips and three pad-eyes for handling by crane. Accommodation is provided for one lying injured diver and a seated attendant.

Maximum space has been provided for the diver and assistant, the assistant being supported in a seated position on a padded seat which enables him/her to provide adequate support for the injured diver who is supported on a wide, upholstered stretcher. Free access to the patient makes full medical treatment possible.

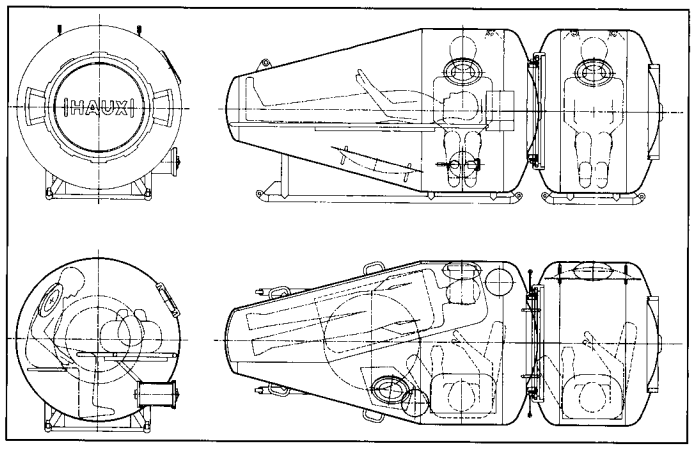
The low weight and small dimensions of the chamber enable it and its occupants to be transported in lorries, ships, aircraft or helicopters. It is easy to handle, and can be mated with any treatment chamber of any diameter which is equipped with a DIN/STANAG (NATO) flange.

The mating of the Medistar with the locking chamber Medilock offers a diver treatment chamber of considerable value. Injured personnel can be treated on site with minimum delay.

For short transit times between the site of the accident and a full medical centre for example, or for mating to another treatment chamber, the Medistar is able to use its own limited supply of gas. For long-duration transits or treatments, gas processing systems such as the Haux-Miniscrubber or other compatible systems ensure operation for hours even with limited gas storage (breathing air and particularly oxygen). The control desk is compact and clearly laid out in an ergonomic design with self-explanatory pictograms ensuring a higher degree of safety. The operator at the control console is able to maintain a constant watch on the chamber's occupants through observation windows in the chamber body. This constant visual contact of chamber occupants is particularly important for the



The Haux-Medistar recompression chamber



The Haux-Medistar with NATO flange/lock

psychological condition of the patient. Communication is available with a battery-powered intercom with volume control and headset microphone. Two oxygen breathing units are supplied as standard, with optional remote control of the chamber and for communication with the occupants via a control cable. Computer control is also available as an option, together with patient monitoring.

The Haux-Medilock is a one-lock chamber which is able to mate with the Medistar to enable the attendant to lock in and out of the chamber, and could enable a specialist doctor to replace the attendant while treatment continues.

Depending on the loading capacity of a helicopter, it is possible to transport the Medistar or even the whole chamber system complete with lock to the nearest shore-based treatment chamber.

Contractor
Haux-Life-Support GmbH, Karlsbad. ***VERIFIED***

Haux-Profi-Medicom

Type
Two-man diver recompression chamber.

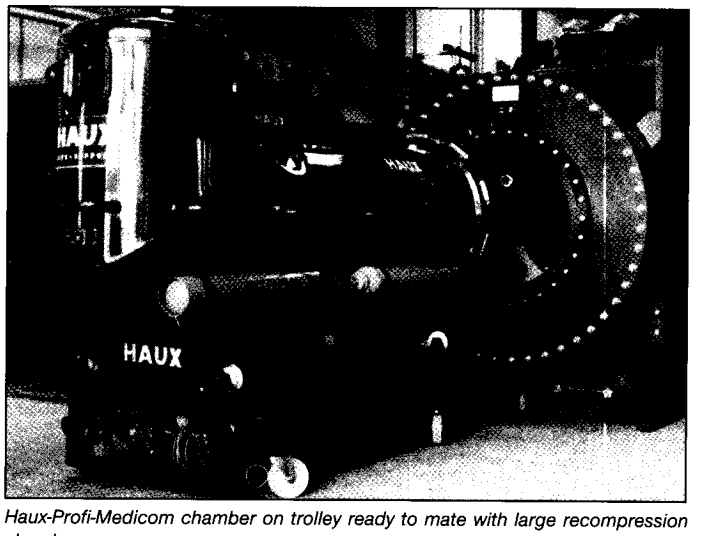
Description
This unit is designed for diver rescue operations by, for example, navy, police, or diving companies. With its two occupants the chamber can be carried by six to eight people and is easily transportable. The newly developed structural shape allows the chamber to mate with any treatment chamber of any diameter equipped with a DIN/STANAG flange.

For short periods of operation the chamber is fitted with its own gas supply. The inside of the chamber provides the optimum amount of space for the injured diver who lies on a wide, comfortable stretcher which is covered with a hard-wearing canvas cloth. The assistant sits upright in the dome of the chamber.

The compact control panel and observation window are sited by each other enabling the operator to view the occupants. The chamber is equipped with a precision manometer, semi-automatic fresh air ventilation and communication system, which includes a battery-powered talkback speaker with volume control. The Medicom is supplied with a newly developed trolley which is easily manoeuvred into position by two people to mate with a treatment chamber.

Contractor
Haux-Life-Support GmbH, Karlsbad.

VERIFIED



Haux-Profi-Medicom chamber on trolley ready to mate with large recompression chamber
0518682

Haux-Spacestar 1300/5.5 dome

Type
Amagnetic recompression chamber for MCMVs.

Description
The Haux-Spacestar recompression chamber is constructed of amagnetic stainless steel for the first-aid and treatment of divers on board MCMVs. The unit can also be used as a test and training facility.

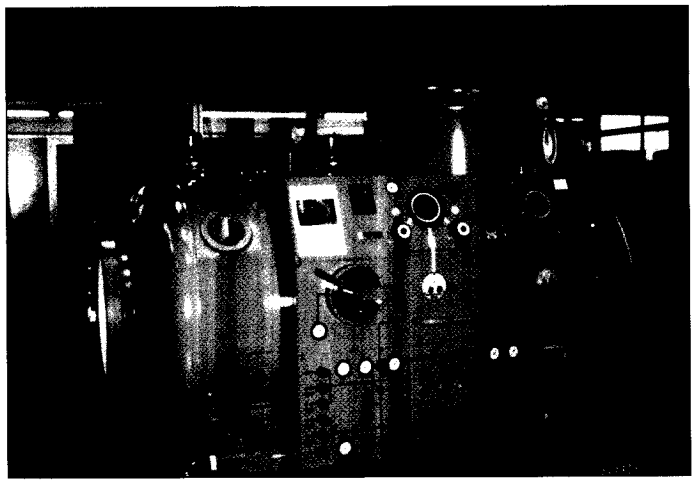
The design features a dome mounted on the cylindrical pressure vessel which allows an occupant to stand upright inside the chamber without the need for increased floor space. This feature greatly improves the treatment which medical assistants can provide for injured divers. With neurological problems it is absolutely imperative that the injured diver can stand upright for diagnostic treatment. Increased freedom to move is desirable for the medical assistant and for the practice of a number of life-saving methods. For long-lasting treatment the ability to stand upright improves the physical and psychological condition of the chamber's occupants. Finally, examination of eyes and ears is much easier if the patient and medical assistant are able to face each other.

The Haux-Spacestar consists of a main chamber and an antechamber. Under normal conditions accommodation is provided for two sitting and one lying occupant in the main chamber and one or two occupants in the antechamber. Pressurisation and fresh air ventilation are achieved using atmospheric air. The diagonal air flow in the chamber provides fresh air for the dome as well as the rest of the chamber. In order to improve decompression treatment, up to three oxygen breathing masks can be connected to a central point of attachment. Should pressurised gas storage begin to run low in long-lasting decompression treatments, safe operation can be assured for a number of days in the closed-circuit operation with the Haux-Scrubmaster CO_2 absorption unit and the addition of a small amount of oxygen from the supply.

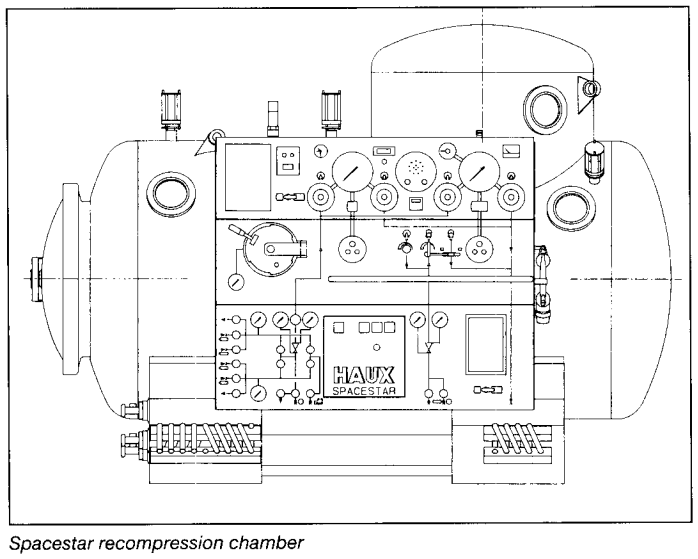
The unit is equipped with an intercom system enabling communication between the main chamber, antechamber and control station. Three windows are fitted in the dome and the cylindrical part of the chamber enabling continual observation of the occupants.

A Masterlock supply lock welded into the main chamber enables the occupants to be supplied with medication, food and drink without disturbing decompression in the main chamber.

For installation on MCMVs, recompression chambers have to meet stringent requirements and the Haux flat bottom design offering maximum economy of space and compact design with laterally sited operation centre, enables the unit to meet these requirements.



The Haux-Spacestar 1300/5.5 DOME decompression chamber for the 'MJ 332' minehunters of the German Navy



Spacestar recompression chamber

Operational status
A total of 10 of these chambers are being built to equip the MJ 332 class minehunters of the German Navy.

Contractor
Haux-Life-Support GmbH, Karlsbad.

VERIFIED

Haux-Starcom

Type
Recompression chambers.

Description
This is a series of compact, modular diver recompression chambers for the treatment of divers, surface decompression and the training of divers. By incorporating the flat bottom principle and front-mounted control panel, chambers can be constructed in varying diameters. Complete utilisation of the entire inner length of the cylinder wall with optimum space can therefore be achieved. With minimised outer measurements the chambers can be easily transported and with front-mounted control panels they are especially suited for installation in containers, ships or trucks. The front panel houses all the instruments required for control and, with an adjacent observation window, supervision of the chamber occupants can be effected from a single point.

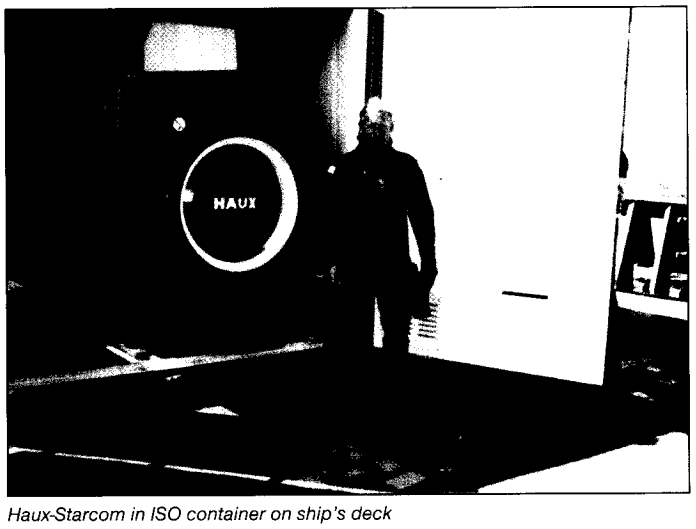
The aluminium alloy double-hinged doors are of pancake design and because of their symmetrical design can be operated from both sides.

The use of new Haux-Starvalve and Haux-Ventmaster valves and the integrated electronic Haux-Variomaster for the supervision of pressure changes offers a completely new way of supervising pressure changes enabling precise control over the build-up and maintenance of correct pressures.

With the use of the Haux-Scrubmaster IIIS CO_2 absorber, maximum operating time and gas consumption can be achieved. The system is low noise in every phase of the operation and Haux-Phonkillers (inside and out) ensure minimal A-sound level. Newly developed Haux-Luxmaster/85D cold-light lamps provide the chamber with anti-dazzle illumination which can be gradually dimmed.

Contractor
Haux-Life-Support GmbH, Karlsbad.

VERIFIED



Haux-Starcom in ISO container on ship's deck

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

Haux-Super-Transstar

Type
Transportable one-man diver recompression chamber.

Description
The Haux-Super-Transstar pressure chamber is designed for emergency rescue operations by navy, police, rescue organisations, diving companies and so on. Due to its compact design and low weight, the chamber is easily transportable on trucks, ships and helicopters and can be carried by four people to the site of an emergency.

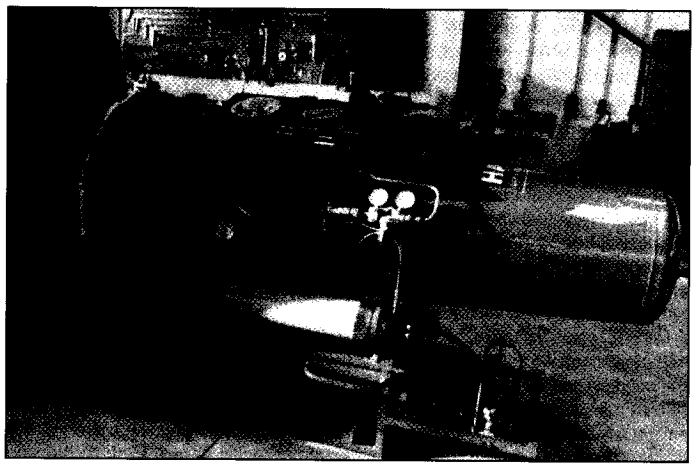
The pressure chamber is fitted with a standard bayonet flange enabling it to be connected to a treatment chamber.

For short-term operations, for example transfer of a patient to another transport system, mating with a treatment chamber and so on, the Haux-Super-Transstar is supplied with its own gas storage and supply systems. The cylindrical design of the pressure chamber in the region of the diver's trunk, and conical design in the leg region provides the occupant with the maximum amount of space. In the chamber the diver lies on a wide, comfortable stretcher with fabric covering and head rest.

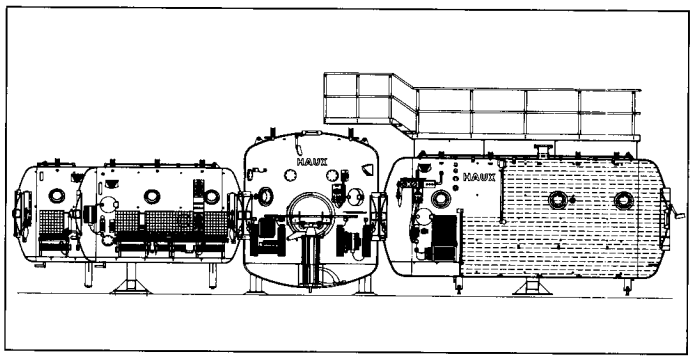
The compact control panel is arranged with the observation window adjacent, enabling the operator to maintain permanent visual contact with the occupant. A precision manometer, semi-automatic fresh air ventilation, inlet and outlet valves for pressure control and an intercom system ensure a very high safety level during chamber operation.

Contractor
Haux-Life-Support GmbH, Karlsbad.

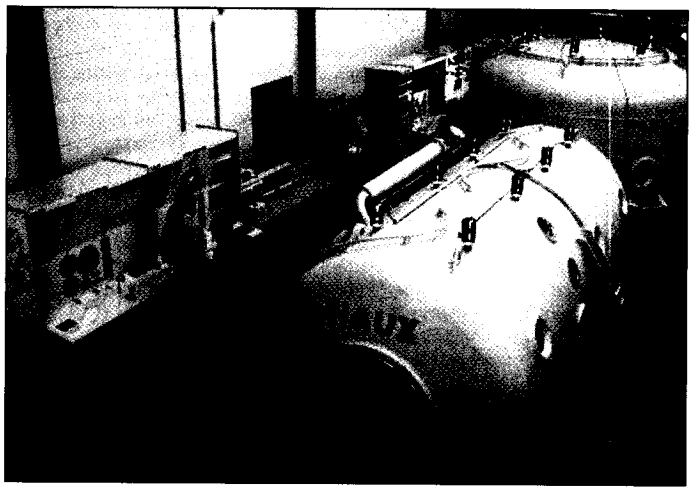
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Haux-Super-Transstar. Note control panel with observation window to left



Hydra 2000 diving simulator for the German Navy



Hydra 2000 diving simulator showing therapy chamber/simulation chamber/ diagnostic chamber

Hydra 2000

Type
Diving simulator.

Description
The Haux-Divestar Hydra 2000 is the first diving simulator to be built for the German Navy. The modular system comprises: a three-chamber complex of a simulation chamber, diagnostic chamber and therapy chamber operating at 20/10 bar; four separate control stations for each part of the decompression chamber; two control boxes which can also be used as fully operational emergency control stations; a Haux-Mixmaster computer-controlled mixer for breathing gases with preselectable but constant partial pressure; a supervision system for the operator under training which measures simultaneously under pressure such parameters as ECG, EEG, blood pressure, breathing frequency, transcutan PO_2 and PCO_2 on a separate observation stand; a colour TV monitoring system; gas supply with air, helium, oxygen and gas mixtures; and a water conditioner which automatically maintains water levels.

The diving and pressure simulator reproduces pressures that correspond to a diving depth of some hundred metres and can be simulated under secure conditions.

The horizontally mounted cylindrical diagnostic chamber is the largest. This can be almost completely filled with water and is divided into a wet and dry compartment by so-called buffalo walls. It is mainly used for the training of divers under realistic conditions, for testing diving and underwater equipment, diving methods, and underwater working procedures and for diver aptitude tests with several aspirants at the same time.

The simulation chamber is similar to the diagnostic chamber but can be pressurised only with breathing gas. It is mainly used for medical examinations of test persons, recompression of divers, and Hyperbaric Oxygen (HBO) treatments. The chamber consists of a main and an antechamber with room for up to 10 divers at a time.

The cylindrical pressurised therapy chamber is mounted vertically between the diagnostic chamber and the simulation chamber. It contains a complete operating theatre's equipment and is used for the intensive medical treatment of sick divers under pressure. The chamber is also fitted with a flange system that can interface with transportable chambers. This enables sick divers to be transferred from the portable chamber to the therapy chamber in a very short time and without suffering any further changes in pressure.

Operational status
In service with the German Navy.

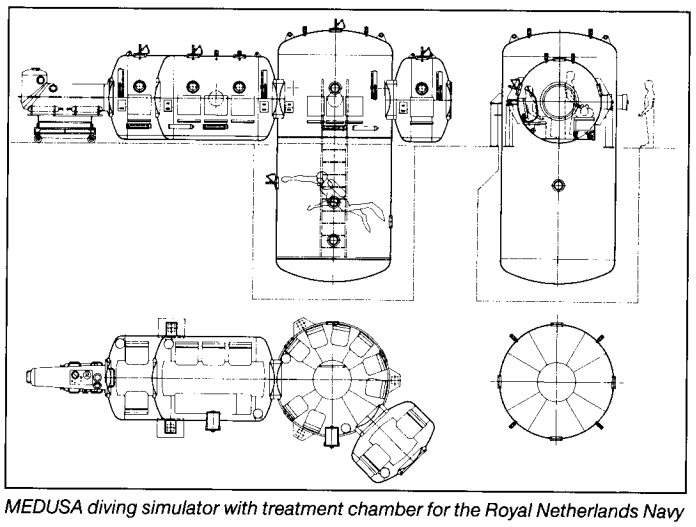
Contractor
Haux-Life-Support GmbH, Karlsbad.

VERIFIED

MEDUSA

Type
Diving simulator.

Description
MEDUSA is a new hyperbaric centre with integrated diving simulator. The system provides Hyperbaric Oxygen (HBO) treatment as well as tests and examination of divers and underwater equipment. The maximum working pressure of the system is 10 bar.



MEDUSA diving simulator with treatment chamber for the Royal Netherlands Navy

The hyperbaric centre comprises a treatment chamber and the actual diving simulator.

The treatment chamber is a horizontal cylinder with ante and main chambers where three and four persons respectively can be seated. The chamber is mainly designed for the treatment of sick divers, examination of students and hyperbaric treatment of civilians.

The main chamber of the diving simulator is a vertical cylinder (wet compartment) which can be equipped so as to function as an additional treatment chamber. With the antechambers, the diving simulator section and the treatment chamber section can be operated and used independently. The chamber is divided into wet and dry compartments by an intermediate bottom (grating). The wet compartment is mainly used for training divers and for tests of underwater equipment and working procedures and for diving aptitude tests.

The water column in the chamber is 3 m in height. The dry part of the main chamber can be fitted out with either eight seats or, if used as treatment chamber, four seats and two bunks.

Each chamber section has its own Haux-Starcontroller control centre from where all proceedings are controlled and supervised. The system can be operated by just one person.

Operational status
The system is in service with the Royal Netherlands Navy at Den Helder. The treatment centre is available for both national and international military and civilian use on a daily basis.

Contractor
Haux-Life-Support GmbH, Karlsbad.

VERIFIED

MW 1630B

Type
Underwater mine detectors.

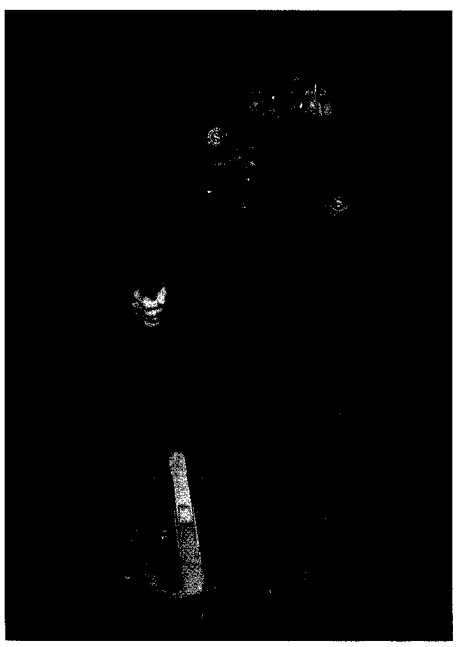
Description
The MW 1630, designed for use by divers, is watertight down to depths of 60 m and is balanced for use underwater. It is of one-stick construction and comprises all accessories required for detection work in river environments as well as in shallow water.

The successor model is the mine detector MW 1630B, which is designed in two parts. The electronics unit is carried on the leg of the diver and the search head with its light telescopic bar is hand-held.

The electronics are housed in a rigid cylindrical amagnetic case with sensitivity adjustment being carried out by a single mechanical rotary switch and a volume control operated by a two-step toggle switch. Both detectors operate in the time domain and can operate in salt water without loss of sensitivity and in the presence of a mineralised sea bed.

The search head is oval in shape providing a small (17 cm wide) swept path suitable for operation in areas of dense clutter such as rocks and so on. The detectors are powered by commercial batteries (MW 1630 – 4 × C size; MW 1630B – 3 × D size) monitored by an automatic battery voltage check. The detectors also feature permanent monitoring of the circuits and voltages without affecting the acoustic search signal. The unit provides constant sensitivity almost down to battery discharge level. An acoustic alarm sounds when the lowest voltage point is reached.

The detector can operate in fresh and salt water without loss of sensitivity.



The MW 1630B mine detector in use
(Vallon GmbH)

Operational status
In production. MW 1630 has been in service with the US Navy since 1992 as the Mk 29. The MW 1630B is in service with the Belgian Army, German Army, France, Netherlands and other countries.

Specifications
(MW 1630B)
Weight: 3.9 kg (in air), 1 kg (in water)
Length: 1,450 mm (long), 540 mm (short)
Power supply: 3 × 1.5 V 'D' size type IEC R20 or rechargeable KR 35/62 Ni/Cd cells

Contractor
Vallon GmbH, Eningen.

VERIFIED

Iran

HOD HOD 1

Type
Diver communication system.

Description
The HOD HOD 1 through water communication system is a multifunction system that provides diver-diver, diver-surface, diver-submarine and submarine-surface communication.

The equipment offers minimal distortion on speech clarity over a 1,000 m range under standard iso-thermal conditions.

The small, compact, rugged easy to operate equipment incorporates two diver units and a surface unit. The equipments feature 42 kHz of standard carrier frequencies, 300-3,800 Hz standard voice band, U-SSB modulation, PTT transmission control and 100 dB automatic gain control.

The equipments are powered by Ni/Cd rechargeable batteries with an endurance of 8 hours for the diver units and 12 hours for the surface unit. The diver units weigh 1,300 kg in water and have a depth rating of 450 m.

Operational status
In service.

Contractor
Iran Electronics Industries, Tehran.

UPDATED

HOD HOD 2

Type
Through water communication system.

Description
The HOD HOD 2 through water communication system is a multifunction system that provides diver-diver, diver-surface, diver-submarine and surface-submarine communication.

The equipment offers minimal distortion on speech clarity over 3, 6 or 10 km range under standard iso-thermal conditions.

The small, compact, rugged easy to operate equipment incorporates two diver units and a surface unit. The equipments feature 27 kHz standard carrier frequency, U-SSB modulation, PTT transmission control and 90 dB automatic gain control.

The equipments are powered by sealed lead acid chargeable batteries with an endurance of 10 hours for the diver and surface units. The diver units weigh 1.2 kg in water and have a depth rating of 100 m.

Operational status
In service.

Contractor
Iran Electonics Industries, Teheran.

UPDATED

Israel

DIVEGUARD Mk 2

Type
Distress and rescue system for special forces and divers.

Description
Diveguard Mk 2 is a personal safety device for special forces as well as civilian divers. The system enables a team of divers to communicate SOS or OK messages within the team as well as home on a diver in distress. Furthermore, the system has a unique 'remote SOS' feature which enables a diver to provoke SOS signals on a missing diver and then to home on the signals, all within the team and with no need for outside help. This enables precious time to be gained in case of emergency.

The system can be operated in darkness and in low temperature environments down to a depth of 50 m.

Diveguard Mk 2 weighs about 600 g in air and is slightly buoyant in water.

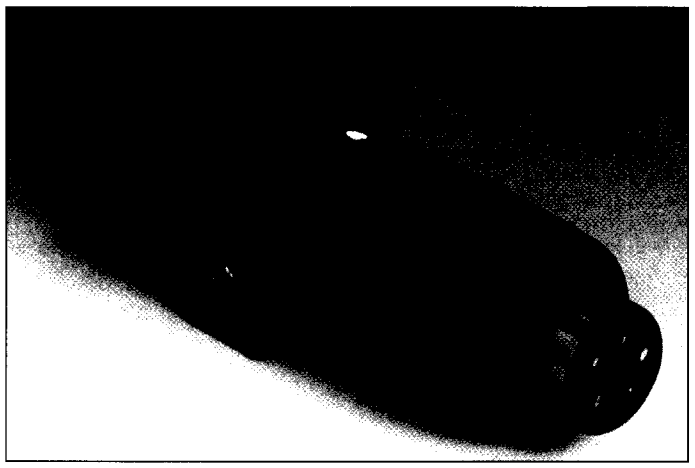
It has the option of automatic triggering of a beacon light that has been adapted for that purpose.

The system is efficient to a range of 500 m.

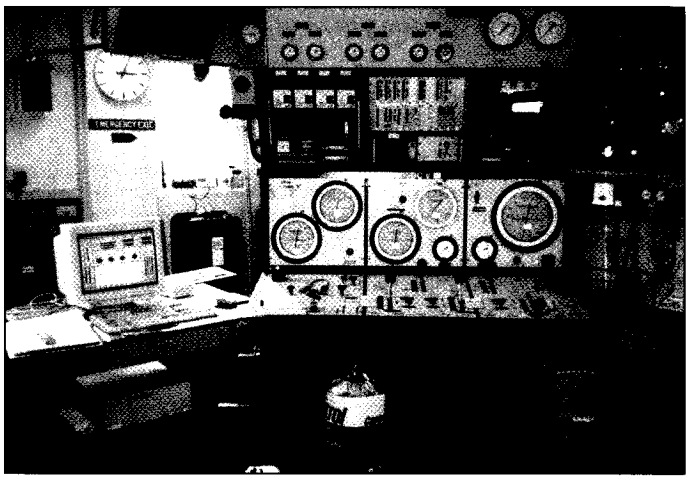
The unit transmits signals via a specially designed microprocessor controlled ceramic transducer.

Contractor
Rafael, Armament Development Authority Ltd, Ordnance Systems Division, Defense Directorate, Acoustic Systems, Haifa.

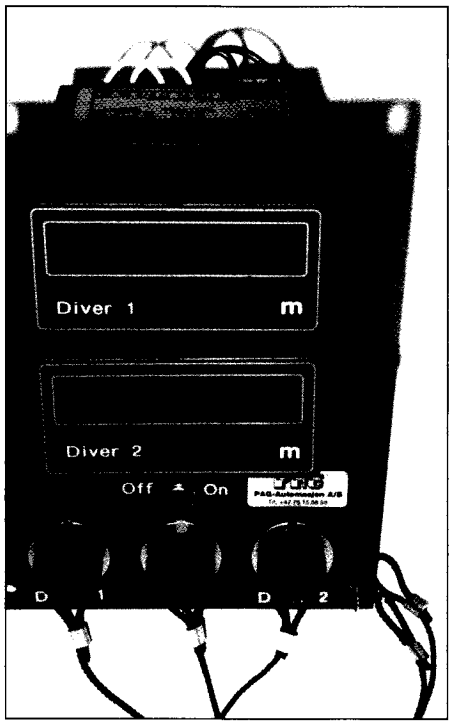
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Diveguard personal safety device (Rafael, Armament Development Authority)
0093522



A MoDive installation showing monitoring panel 0024836



Diving depth instrument module
0024835

Norway

MoDive

Type
Dive monitoring system.

Description
The MoDive air diving monitoring system is an online system offering a total dive overview of all important diver and decompression chamber parameters.

The system is user friendly and easy to operate but at the same time fulfils all specifications for an offshore and inshore dive data recording system.

The system features advanced dive log, surface interval timers, dive reports and multifunction control buttons using advanced software. The dive exposure matrix shows the diving activities during the last 18 days for each diver and is meant to be an aid for the supervisor to see who the next diver should be to carry out a dive. The digital value in each square in the matrix tells at which hour that particular dive ended. In the case of a repetitive dive this hour indication will be displayed in a red colour. The matrix updates itself automatically.

The online saturation diving monitoring system records diver, bell and habitat parameters which are presented both digitally and with graphical profiles. Additionally, a dive log records events and activities related to the dive. Alarms and manual inputs are also recorded in the log. To gain total control of time consumption during the dive, the bell and each diver have their own timers. All operations of the timers are registered in the dive log. To simplify use of software, all active objects are colour coded.

As a supplement to the standard diver and bell monitoring, the software is also able to monitor the valve positions in the bell. With colour codes it is possible to see if the valves are closed (red) or open (green). The tubes in the bell are also colour coded to monitor if they are connected to a closed or open valve. Monitoring the valve positions requires a minimum of additional equipment.

The MoDive offline dive monitoring system is a professional data acquisition system for monitoring depth and temperatures with very high accuracy. The system consists of three units: an offline dive recorder with carrying case; a battery charger and interface unit; and software for evaluating the collected data.

Fitted to a diver, the dive recorder measures depth, time, internal temperature and up to six external sensor parameters (for example temperatures). After the dive has been completed the recorder is inserted into the data socket in the charging/data interface unit and the collected data downloaded into the computer.

The offline software makes it very simple to evaluate the collected data, both on graphical profile diagrams and as an ASCII file for export to a spreadsheet or word processor.

As well as the MoDive data monitoring system, PAG has developed a diving depth instrument module with digital displays and necessary connectors for depth sensors and data logging. This system is specially made for military use and gives the user the possibility of connecting a mobile data monitoring system (for example a laptop computer).

A further development of MoDive is the monitoring and control system for hyperbaric treatment, called MoMed. This system is installed at NUI AS in Bergen, Norway and is also used by the parties involved in hyperbaric medical research such as the university in Bergen, Haukeland Hospital, Nutec, the Norwegian Navy and the State Diving School.

The new windows version of MoDive can be downloaded from the Internet on www.pag.no/modive.htm.

Operational status
In service with the US Navy, Norwegian Navy, French Navy and many commercial contractors like Stolt Comex Seaway, Rockwater, Global Industries, Triathlon Inc and so on.

Contractor
PAG Automasjon A/S, Stavanger.

UPDATED

South Africa

600 Series diver's heaters

Type
Diesel-fired diver's hot water machine.

Description
The 600 Series diver's heaters provide heated seawater for up to three divers for cold water or extreme exposures. The heaters are equipped with a diesel-fired burner and fresh water boiler that circulates heated fluid through a titanium heat exchanger. Cold seawater is pumped through the titanium heat exchanger where it is heated and then supplied to the divers through a hose incorporated in the divers umbilical. A temperature control valve provides accurate and reliable temperature control to within ± 1°C.

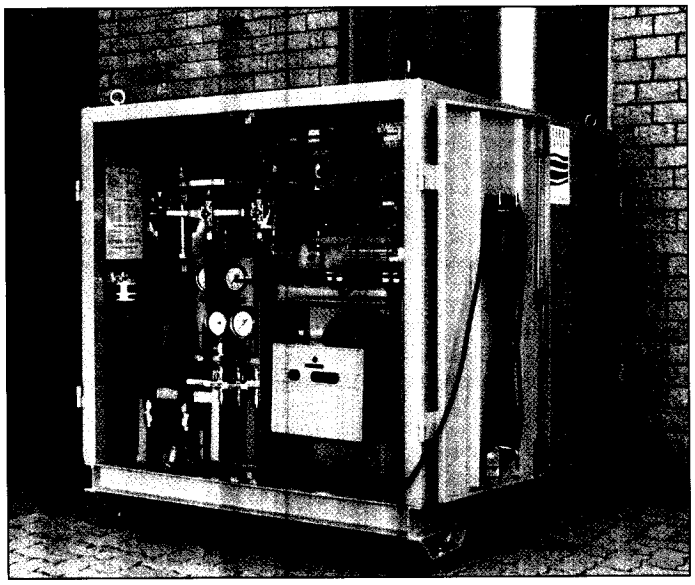
Operational status
Currently in service with the South African Navy and various diving contractors in South and West Africa, the Middle East and Russia.

Specifications

	Type 620 Diver heater	Type 630 Diver heater	Type 635 Diver heater
Hot water delivery	21 litres/mm	42 litres/mm	21/42 litres/mm switchable
Hot water supply pressure	10 bar	10 bar	10 bar
Temperature range	35-65°C	35-65°C	35-65°C
Temperature control	±1°C	±1°C	±1°C
Boiler thermal power output	82 kW	157 kW	157 kW
Absorbed electrical power	3 kW	4 kW	4 kW
Power supply	on request	on request	on request
Other voltages	220 V 50 Hz 1 ph	380 V 50 Hz 3 ph	380 V 50 Hz 3 ph
Length	150 cm	190 cm	190 cm
Width	125 cm	140 cm	140 cm
Height	141 cm	135 cm	135 cm
Weight	880 kg	1,050 kg	1,085 kg

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

VERIFIED



Type 635 divers' heater with deck enclosure (Courtesy Southern Oceanics) 0024834

BH Series carbon dioxide scrubbers

Type
Hyperbaric chamber carbon dioxide scrubbers.

Description
The BH Series carbon dioxide scrubbers are designed for use as primary or emergency scrubbers in diving chambers. They comprise a blower housing and bracket to which is attached a large, radial-flow CO_2 absorbent canister with dust filter. The absorbent canister is fitted to the blower by quick-release toggle catches for replenishment of the absorbent chemical. The blower motor is a brushless DC unit equipped with thermal overload and reverse polarity protection.

Two sizes are available:
- The Type BH 500 CO_2 scrubber is designed for use in main or living compartments and will provide carbon dioxide removal for four people.
- The Type BH 300 CO_2 scrubber is smaller and designed for use in transport chambers and entry locks. It will provide carbon dioxide removal for three people.

Operational status
Currently in service with various military and commercial users in Australia, New Zealand, South Africa and the UK.

Specifications
Type BH 500
Airflow (measures at 1 bar absolute): 0.6 m³ /min actual
Absorbent canister capacity: 5.5 kg
Maximum working depth: 200 msw
Power requirement: 24 V DC 1 A
Dimensions: 210 mm (diameter) × 320 mm (height)

Type BH 300
Airflow (measures at 1 bar absolute): 0.45 m³ /min actual
Absorbent canister capacity: 2.5 kg
Maximum working depth: 200 msw
Power requirement: 24 V DC 1 A
Dimensions: 160 mm (diameter) × 320 mm (height)

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

VERIFIED

LG 360

Type
Wet bell diving system.

Description
The LG 360 wet bell diving systems provide a safe and cost-effective diver delivery system for surface-supplied diving. The systems are designed with a standard 6 m ISO freight container footprint with ISO container corner castings and are easily transported and deployed.

Stainless steel is used extensively in the construction of the bell, the A-frame and skid and all components subjected to wear. All structural steel components are hot-dip galvanised for corrosion protection.

The LS 360 is available in two standard configurations:
- LG 360-A: wet bell system equipped for surface supply air diving to a maximum depth of 50 m
- LG 360-B: wet bell system equipped for surface supply mixed gas diving to a maximum depth of 90 m

The system comprises the following main equipment:
- 1.2 m ID acrylic dome with stainless steel mounting flange
- Stainless steel unconscious diver recovery hook arrangement
- 20 m³ onboard emergency gas supply in two 50 l 200 bar cylinders with first-stage regulators, cylinder contents gauges, demand regulators and LP hose whips with isolating valve for connecting to the diver's helmet bail-out supply
- Quick release stainless steel guide wire clamps
- Skid-mounted hydraulic bell handling system with folding A-frame.
- Bell winch with rope level-winding device, hydrostatic brake and fail-safe mechanical brake. Bell and guide wire winches mounted on top of the A-frame cross member, eliminating the need for wire rope sheaves in the system.
- Guide wire winch with rope level-winding device, hydrostatic brake and fail-safe mechanical brake.
- Bell and guide wire winches mounted on top of the A-frame cross member, eliminating the need for wire rope sheaves in the system
- Four robust stainless steel lifting eyes.
- Height adjustable sacrificial deck-mounting plates bolted into stainless steel mounting pads
- 11 kW main hydraulic pump
- 8 kW standby hydraulic pump
- Hydraulic fluid reservoir with filtration system, low fluid level/high fluid temperature cutout switches and integral drip tray.
- Hydraulic power pack with local controls for the bell and guide wire winches and A-frame fitted on the back end of the skid.

Specifications
Design standard: DNV Rules for Diving Systems
Maximum depth rating: 50 or 90 m
Main power requirement: 15 kW 440/380 V 60/60 Hz 3-phase
Standby power requirement: 10 kW 440/380 V 60/50 Hz 3-phase

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

UPDATED

LM series recompression chambers

Type
Master recompression chamber.

Description
LM series Recompression Chambers (RCCs) are designed for military applications requiring a comprehensive specification and high level of operational reliability.

They are equipped with transfer under pressure flanges and can be used as master therapeutic treatment chambers for naval medical facilities or for routine operational recompression procedures. They are available with inside diameters of 1.5, 1.8 or 2.0 m and can accommodate ranging from 6 to 12 people.

Standard configurations are:

- Type LM 1500/6 RCC: 1.5 m diameter - 6 occupants
- Type LM 1800/8 RCC: 1.8 m diameter - 8 occupants
- Type LM 1800/10 RCC: 1.8 m diameter - 10 occupants
- Type LM 1800/12 RCC: 1.8 m diameter - 12 occupants
- Type LM 2000/12 RCC: 2.0 m diameter - 12 occupants

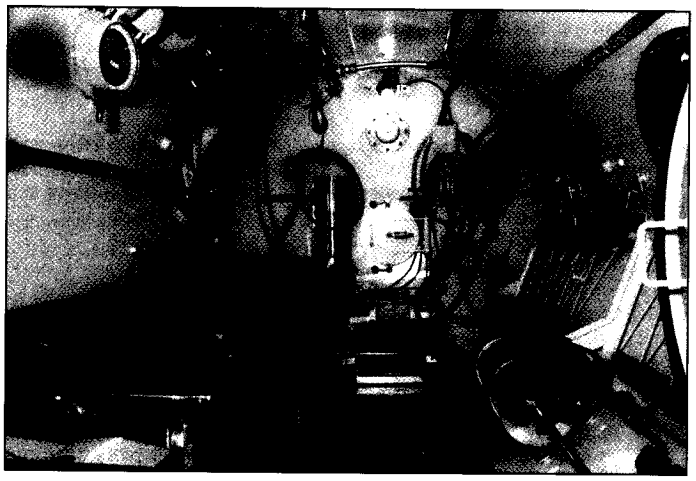
LM Series RCCs are available with aluminium alloy, carbon steel or stainless steel pressure vessels. Standard equipment includes a rotating or fixed NATO bayonet flange, 200 mm diameter viewports, large-diameter bayonet-type service lock with safety interlock, stainless steel bunks and seats with DNV-approved fire retardant mattresses, easily removed aluminium deck plates and epoxy paint system.

Standard life support systems include dual pressurisation, oxygen Built-In Breathing (BIB) system with overboard dump-type masks, back-pressure regulators and exhaust gas ejector system to reduce exhalation resistance at shallow depths, dual high-integrity ASME-approved safety valves, large-diameter precision depth gauges, oxygen and carbon dioxide monitoring system, temperature and humidity monitoring system, waterproof digital panel-mounted stopwatches, 80 Ah emergency power supply, alarm panel, DNV-approved hyperbaric lighting, high-quality duplex communication system and hyperbaric fire extinguishers.

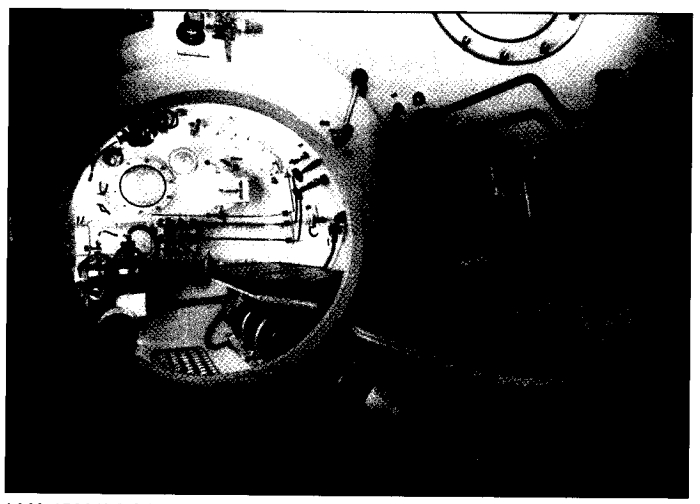
Comprehensive operating and maintenance manuals are provided in hard-copy and magnetic format for customer configuration management.

A wide range of optional equipment is available, including mixed-gas BIB system, atmosphere conditioning system, carbon dioxide scrubbers, metabolic oxygen injection, remote-control console, CCTV monitoring, sound-powered emergency communication system, external acrylic light-pipe illumination, water deluge fire suppression system and toilet, hand-basin and shower.

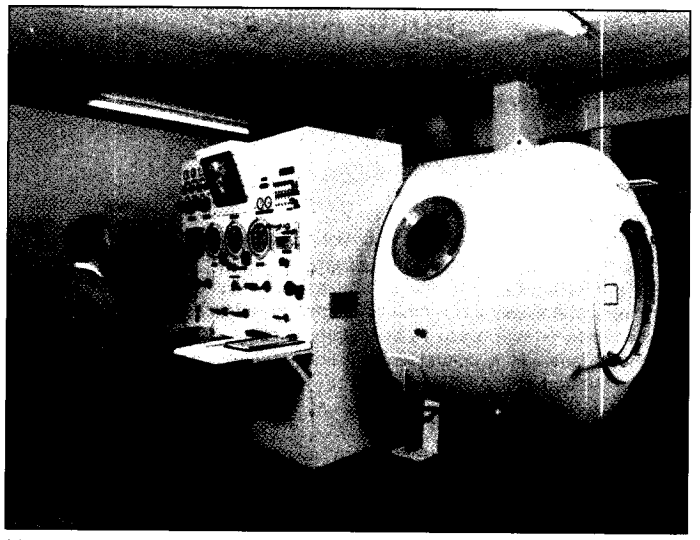
A select range of medical equipment is also available, including hyperbaric patient ventilator, suction system, high-intensity medical lighting, HBO therapy hoods and intensive care monitoring system.



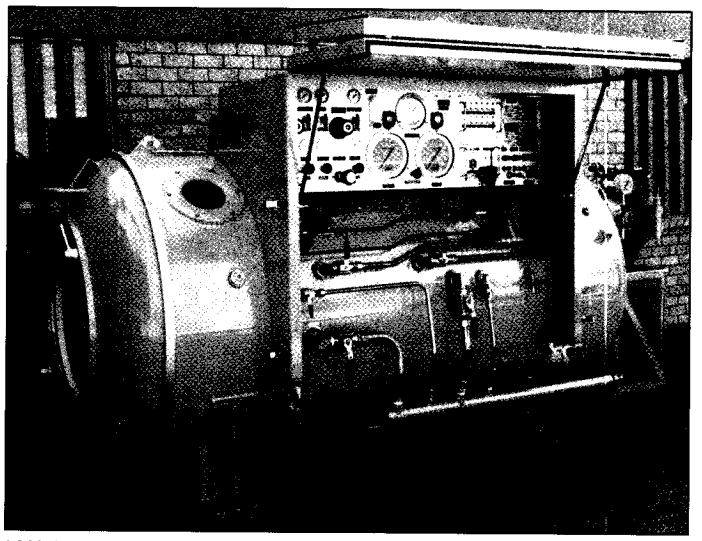
Interior view of LMC 1800/6 medical hyperbaric chamber (courtesy Southern Oceanics) 0024831



LMA 1500/6 RCC interior view 0024833



LMA 1800/6 medical hyperbaric chamber 0024832



LMA 1500/6 recompression chamber with aluminium alloy pressure vessel 0024820

The LM Series RCCs are also available in standard ISO container packages for transportable applications. The chamber and it support equipment are installed in standard 6 or 12 m ISO containers according to requirement.

A LM 1500 system supplied to the Royal New Zealand Navy is constructed of lightweight duplex stainless steel and is capable of holding six divers under normal decompression operations or up to nine occupants for a SUBSUK emergency. Alternatively two lying down patients can be accommodated for decompression illness. The system has been specifically designed for use on HMNZS *Kahu*. It is equipped with gas analysers (O_2 and CO_2), BIBS, CO_2 scrubbers, and communications.

Operational status
Eight LM Series Recompression Chambers are currently in service with the South African Navy and Air Force. A system was supplied to the RNZN in 2003.

Specifications
Design standard: ASME PVHO-1/Lloyd's Rules for Diving Systems
Certification authority: Lloyd's Register
Maximum depth rating: 100 msw

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

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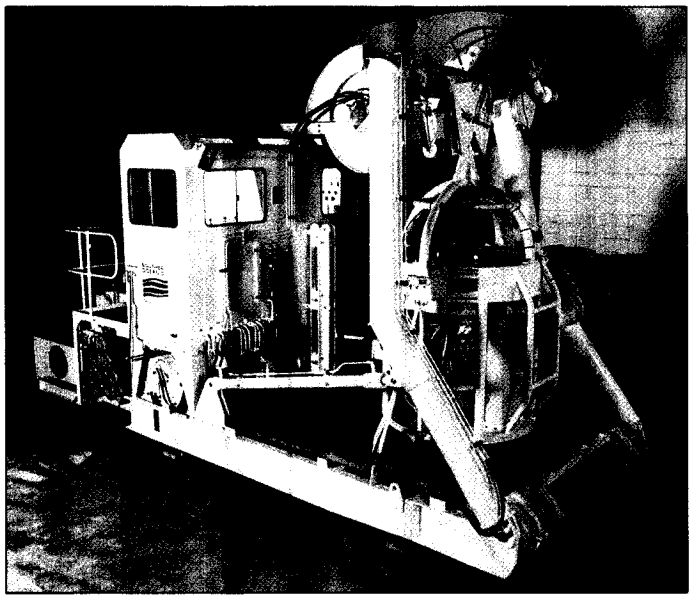
LS 370 wet bell dive system

Type
Wet bell diving system.

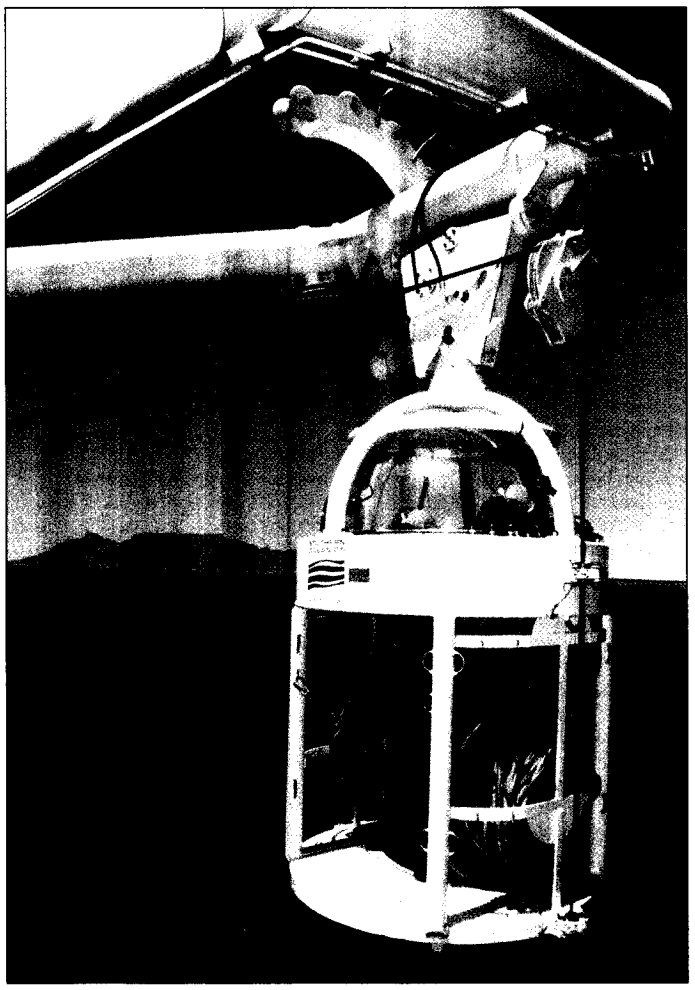
Description
The LS 370 wet bell diving systems provide a safe and cost-effective vehicle for deep, surface-supplied diving to a maximum depth of 100 m.

Standard configurations are:

- LS 370-A: equipped for air diving to a maximum depth of 50 m
- LS 370-B: equipped for mixed gas diving to a maximum depth of 100 m



The LS 370-A wet bell dive system



Launching an LS 370-A wet bell 0024830

The system is self-contained, transporting only divers breathing gas and electrical power supplies. It comprises the following main equipment:

- skid-mounted bell handling system with folding A-frame, bell safety latch, hydraulically powered umbilical sheave, guide wire system, bell and guide wire winches and hydraulic power pack.
- wet bell with acrylic dome, emergency onboard gas supply, lighting and main umbilical.
- control van with divers' air and gas supply panels, diver communications, divers' gas analysis panel, bell handling system control panel, main and emergency electrical switchboards, alarm panels and standby diver station.

A lightweight air-transportable version is also available for rapid intervention applications. This system is packaged in standard 6 m ISO containers and is quickly and easily mobilised.

Numerous options are available, including diver heating, recompression chambers, LPIHP breathing air compressors and gas storage banks.

Operational Status
An LS 370-B unit is in service with a south east Asian Navy.

Specifications
Design standard: DNV Rules for Diving Systems
Maximum depth rating: 100 m
Main power requirement: 35 kW 440/380 V 60/60 Hz 3-phase
Emergency power requirement: 25 kW 440/380 V 60/50 Hz 3-phase

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

VERIFIED

Offshore series recompression chambers

Type
Twin-lock diver recompression chambers.

Description
Offshore series recompression chambers are designed for routine operational decompression procedures. Occupant capacities range from two to six persons. They are robust, high quality commercial-style twin-lock chambers, available in five different diameters ranging from 1,10 m to 1,80 m configured as follows:

- Type 1100 Offshore RCC: 1.10 m diameter - two occupants
- Type 1220 Offshore RCC: 1.22 m diameter - three occupants
- Type 1372 Offshore RCC: 1.37 m diameter - four occupants
- Type 1500 Offshore RCC: 1.50 m diameter - six occupants
- Type 1800 Offshore RCC: 1.80 m diameter - six occupants

Stainless steel is used extensively in the construction of the pressure vessels for all components subject to wear or corrosion, including service locks, lifting lugs, bunks, door hinges, mounting brackets and shell penetrators. Standard equipment includes a weatherproofed control panel, precision depth gauges, Built-In Breathing (BIB) system, stainless steel service lock with safety interlock and three-way communication system.

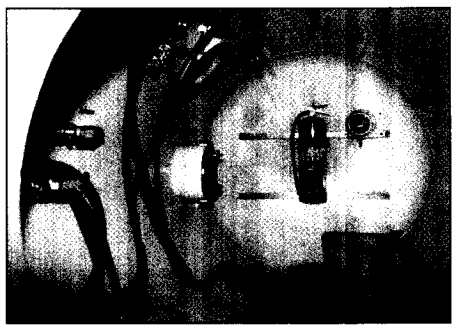
A wide range of optional equipment is available, including NATO transfer under pressure bayonet flange, stainless steel door sealing surfaces, mixed-gas BIB system, oxygen and carbon dioxide analysis system, hyperbaric lighting, carbon dioxide scrubbers, hyperbaric fire extinguishers and a selection of approved hyperbaric medical equipment.

Operational status
Several units in service in Australia, South East Asia and South Africa.

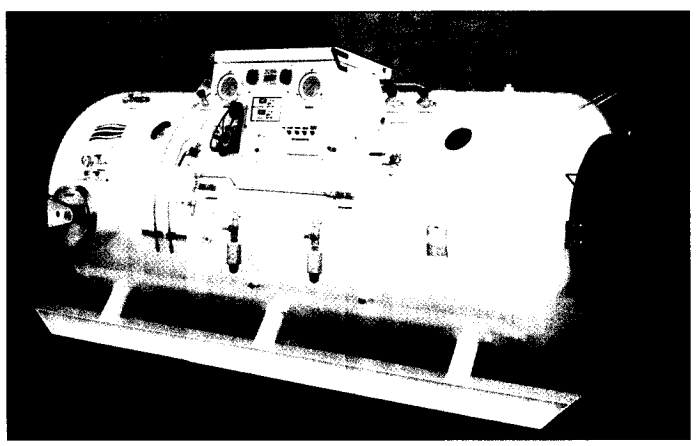
Specifications
Design standard: ASME PVHO-1
Certification authority: Lloyds register
Maximum depth rating: 60 msw

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

VERIFIED



Interior view of Type 1372-D offshore RCC (Courtesy Southern Oceanics) 0024828



Type 1372-D offshore RCC with stainless steel rotating NATO layout flange (Courtesy Southern Oceanics) 0024829

RD 2300 Hyperbaric chamber complexes

Type
Hyperbaric compression chamber complexes for naval diver training establishments.

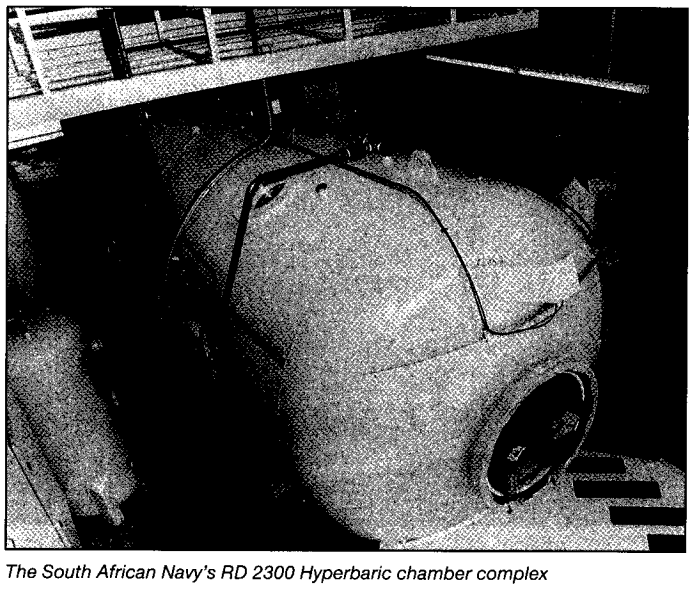
Description
RD 2300 chambers are designed for training establishments which require a multipurpose system capable of providing diving simulation and training, recompression treatments, clinical hyperbaric oxygen treatments and medical research. 'The chambers can accommodate from 8 to 16 people and are customised to suit each application. Available configurations for RD 2300 chambers include a main living chamber, transfer chamber, wet chamber and treatment chamber. The chamber is supplied with the following systems and equipment:

- Remote-control console
- Rotating or fixed stainless steel NATO bayonet flange
- Wide-angle viewports which permit 95 per cent visibility into the chamber
- Quick-acting stainless steel clamp-type service lock with interlock
- Stainless steel bunks and seats with DNV-approved fire-retardant mattresses
- Easily removable deck plates
- Heavy-duty chemically stable epoxy paint system
- Dual-pressurisation system with selection manifold for air and four mixes
- Exhaust and pressurisation fine control system
- High-performance stainless steel venturi-type mufflers
- Oxygen Built-In Breathing (BIB) system with overboard dump back-pressure regulators and gas ejector system to reduce exhalation resistance at depths shallower than 5 m
- Mixed-gas BIB system with selection manifold for two gas mixes
- Dual, high-integrity ASME-approved safety valves in each compartment
- 300 mm diameter precision depth gauges
- Environmental conditioning system
- Emergency carbon dioxide scrubbers
- Metabolic oxygen injection system
- Dual oxygen and carbon dioxide analysis system
- Digital temperature monitors
- Humidity monitors
- Emergency power supply
- Alarm panel
- CCTV
- DNV-approved hyperbaric lighting
- High-quality communication system with digital signal processor helium voice unscrambler
- Sound-powered emergency communication system
- Water deluge type fire suppression system in each compartment
- Comprehensive operating and maintenance manuals in hard-copy and magnetic format for customer configuration management.

Available options include:

- Classification society certification
- Other design standards for certification authorities
- Other maximum depth ratings
- Hyperbaric medical lighting which permits detailed medical examinations and minor procedures to be performed in the chamber
- Hyperbaric patient ventilator
- Medical suction system
- Oxygen treatment hoods
- Intensive care monitoring system
- Sanitary system with toilet, hand basin and shower.

Pressure vessels are fabricated from carbon steel; stainless steel is used extensively for all components subjected to corrosion or wear including service locks, door sealing surfaces, door hinges, bunks, lugs, mounting brackets and shell penetrators.



The South African Navy's RD 2300 Hyperbaric chamber complex

Operational status
An RD 2300 multipurpose compression chamber is in service at the South African Navy's diving school at Simon's Town.

Specifications
Design standard: DNV or Lloyd's Rules for Diving Systems
Inspection authority: DNV or Lloyd's Register
Maximum depth rating: 200 msw
Occupant capacities: Min 8 to max 16 persons
Inside diameter: 2,300 mm
Manway ID: 800 mm
Viewport ID: 280 mm
Power supply: 440/380 V 6050 Hz 3-phase

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

VERIFIED

SM-5

Type
Containerised dive system.

Description
The Type SM-5 containerised dive systems are fully integrated surface supply air and/or mixed gas dive systems. All the equipment for conducting intensive surface-supplied diving operations is packed into 3.6 or 12 m ISO containers, allowing rapid deployment of the system.

Five standard configurations of the system are available:

- Type SM-5A – air dive system in 6 m ISO container.
- Type SM-5AG – mixed gas dive system in 6 m ISO container.
- Type SM-5R – recompression chamber in 6 m ISO container.
- Type SM-5AV surface supply air dive control van in 3 m ISO container.
- Type SM-5AGV surface supply mixed gas dive control can in 3 m ISO container.

The SM-5A and SM-5AG dive systems are housed in structurally reinforced ISO steel units fitted out with a personnel access door, observation window, marine grade electrical system, fire extinguishers, recessed penetration plates for power and gas supplies and aluminium tread-plate or fire resistant rubber flooring. The containers are finished with a high quality epoxy paint system and heavy duty bituminous under floor sealant.

Standard equipment in the containers typically includes:

- A fully equipped Type 1400 or 1500 Offshore recompression chamber.
- A Type 957 three-diver air panel or a Type S385-B gas panel, as applicable.
- Three-diver rack-mounted air communications set of DSP helium speech unscrambler as applicable.
- Deck communications system.
- Standby HP air supply for the divers.
- Standby HP air supply for the recompression chamber.
- Various optional extras are available (see below).

The SM-5AV and SM-5AGV dive control vans are housed in 3 m galvanised steel frame ISO containers with forklift channels and ISO corner twist lock boxes. Bulkhead panels are composite polyester resin laminated plywood with polyurethane foam insulation. The units are fitted out with a personnel access door, deck observation window, marine grade electrical system, fire extinguishers, recessed penetration plates with power and gas supplies and fire resistant rubber flooring.

Standard equipment installed in the van typically includes:

- A Type 957 three-diver air panel or a Type S385-B three-diver gas panel installed in a control console with dive supervisor's workstation, lockable drawers and bookshelves for log books and manuals.
- Three-diver rack-mounted air communications set or DSP helium speech unscrambler, as applicable.
- Deck communications system.
- Optional extras are available (see below).

Operational machinery containers are available which house all the machinery required for diving operations. They also provide workshop and lock-up storage facilities. The machinery containers are structurally reinforced for securing heavy items of machinery and are fitted out with a personnel access door, marine grade electrical system, fire extinguishers, recessed penetration plates for power and gas supplies and aluminium tread plate flooring.

Standard equipment installed in the machinery containers typically includes:

- Diesel or electrically powered 1.7, 2.5 or 3.4 m^3/m LP breathing air compressors.
- Diesel or electrically powered 225, 260, 300 or 450 l/m Hp breathing air compressors.
- Diver heaters.
- Burning and welding equipment.
- Hydraulic power pack.
- Bulkhead stowage for umbilicals.
- Forced draught ventilation.

Operational extras for the dive systems include:

- Burning/welding circuit breaker with cable connection points outside the container.
- Two/three-diver hat light system.

- Diver umbilicals.
- Diver TV with the surface control unit, VCR and keyboard installed at the dive control; console.
- Container air conditioning and thermal insulation.
- Oil-free air compressors.
- Gas storage banks in galvanised steel handling frames with capacities of 60, 90, 120, 160 or 450 m³.
- Hydraulic power pack.
- A range of optional recompression chamber equipment including a rotating NATO bayonet TUP flange, mixed gas breathing system, oxygen/carbon dioxide analysis systems, sound powered secondary commutations, hyperbaric lighting, chamber heating/cooling systems, hyperbaric fire extinguishers and so on.

Contractor
Southern Oceanics (Pty) Ltd, Capetown.

VERIFIED

TC 1000

Type
Diver's transport chamber.

Description
The TC 1000 is a lightweight two-person stainless steel transport chamber that provides easily mobilised, on-site recompression treatments and transport of divers under pressure to larger treatment chambers. With two occupants under pressure, the chamber can be carried by 10 people and is fully transportable by helicopter or fixed-wing aircraft.

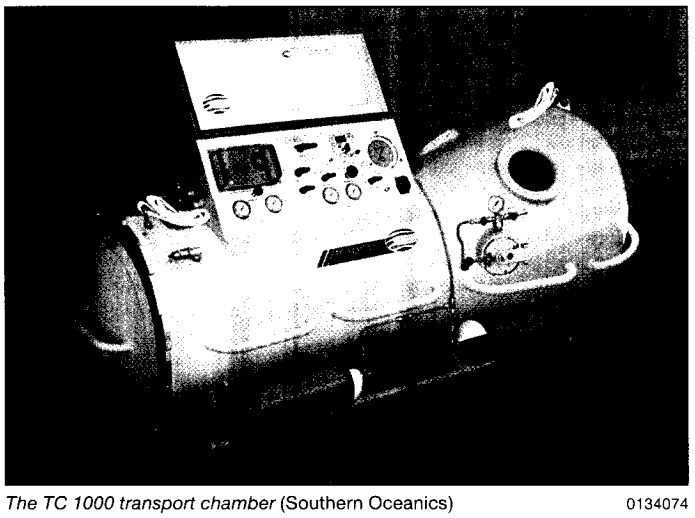
The chamber consists of two sections; a larger rear section in which the attendant sits on a padded seat with backrest; and a smaller cylindrical section with a removable rail-mounted stretcher for the patient. The attendant is allowed full access to the patient's head and torso for the administration of CPR and basic life support. Two large diameter view ports are provided for observing the occupants and a medical lock with safety interlock allows small medical and personal items to be passed in and out of the chamber. A NATO bayonet flange is installed at the man-way end for transference of divers under pressure into a treatment chamber.

The chamber is equipped with optional onboard air, oxygen and power supplies. Connecting points for external supplies are also provided as standard. The chamber can also be operated from conventional scuba cylinders. A safety feature built into the chamber is an automatic ventilation system that reduces oxygen and carbon dioxide build-up with main- and fine-control valves, while a sampling system allows the chamber atmosphere to be monitored for oxygen and carbon dioxide content.

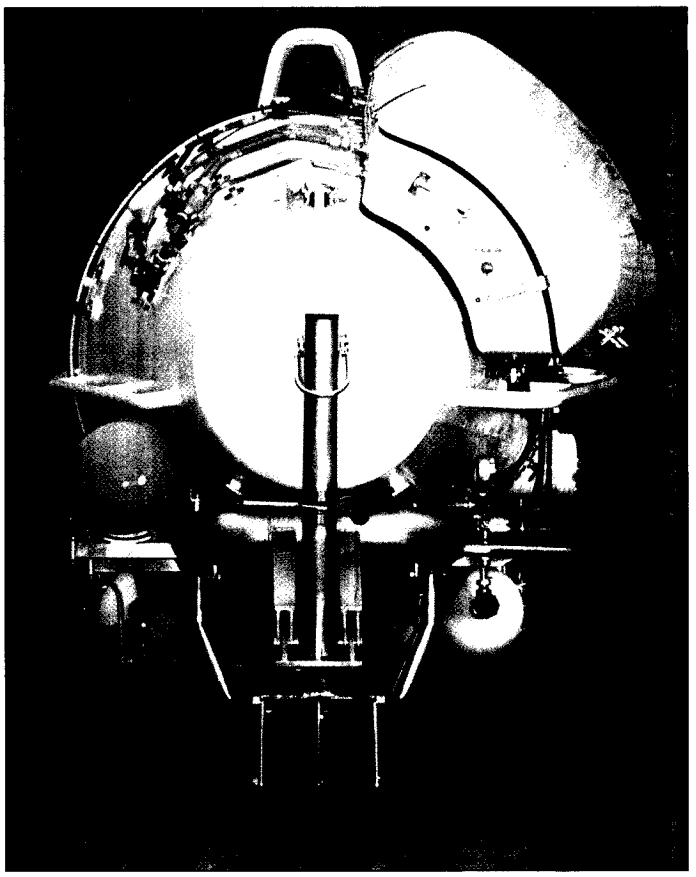
An optional non-magnetic version is also available for use aboard MCMVs.

Contractor
Southern Oceanics (Pty) Ltd, Cape Town.

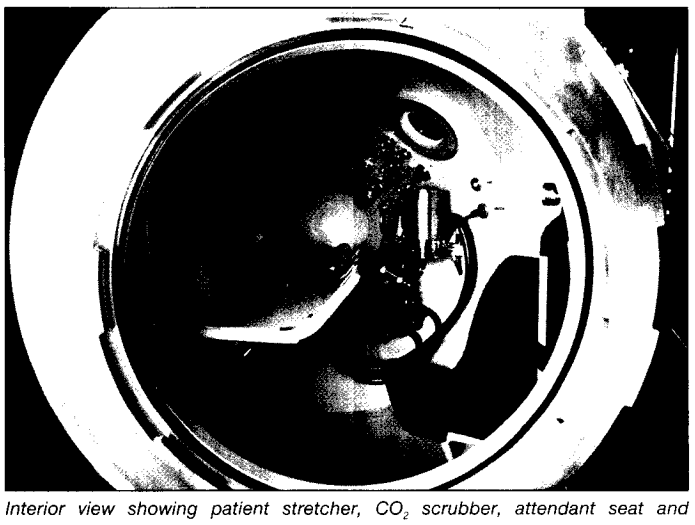
VERIFIED



The TC 1000 transport chamber (Southern Oceanics) 0134074



Rear view showing the height-adjustable handling system and onboard air, oxygen and power supplies (Courtesy Southern Oceanics) 0024825



Interior view showing patient stretcher, CO_2 scrubber, attendant seat and hyperbaric fire extinguisher (Courtesy Southern Oceanics) 0024826

TC 1150 transport chamber

Type
Diver's transport chamber.

Description
The Type TC 1150 transport chamber is designed for the administration of emergency on-site recompression treatments and for transporting divers under pressure to larger treatment chambers. It is equipped with an integral, wheeled handling system with steerable tow-bar which allows it to be manoeuvred by one person and is also fully transportable by helicopter, fixed-wing aircraft or light pick-up truck. A nylon web-type lifting sling set is included.

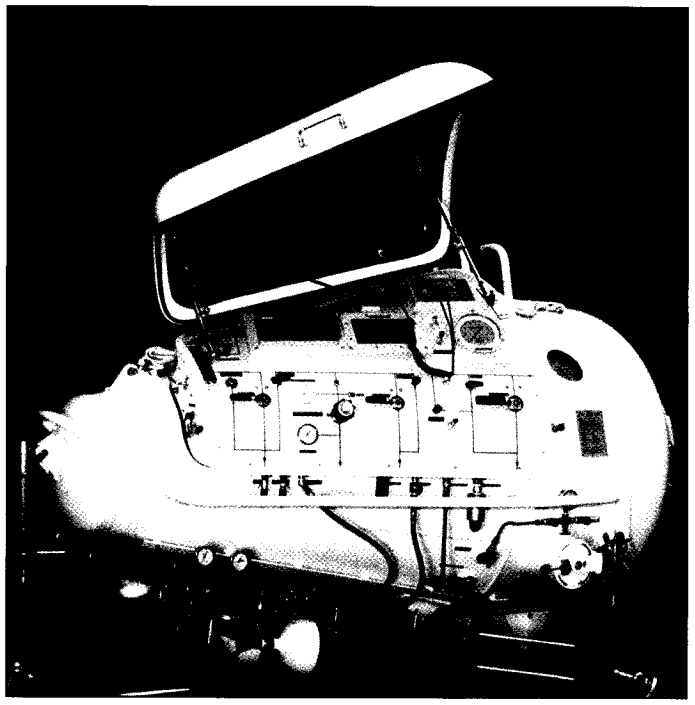
The TC 1150 will accommodate two divers or a recumbent patient and a seated attendant. An easily removed, rail-mounted stretcher with restraint straps is provided for the patient. The attendant has unobstructed access to the patient for administering CPR and basic life support.

The chamber is equipped with a NATO bayonet flange which allows it to lock-on to larger treatment chambers for transferring the divers under pressure. The stainless steel handling system is height-adjustable, allowing it to bayonet with treatment chambers of varying diameters and centreline heights. Two large-diameter viewports provide the operator with 95 per cent visibility of the chamber interior and a bayonet-type medical lock with safety interlock allows medical supplies and small personal items to be passed in and out of the chamber.

Life support for the occupants is provided by onboard air, oxygen and power supplies. Connection points for external auxiliary supplies are provided to supplement onboard supplies for extended therapeutic treatments and transport applications. All controls are housed in a weatherproof glass fibre control panel. Standard equipment includes an intercom system, overboard dump-type oxygen masks, chamber atmosphere sampling system, waterproof panel-mounted stopwatch, ECG penetrator and medical drip hook.

Optional equipment includes a detachable entrance lock, hyperbaric fire extinguisher, oxygen and carbon dioxide monitoring system, carbon dioxide scrubber, light-pipe chamber illumination system, mixed-gas built-in breathing system, 70 Ah onboard power supply, caisson depth gauge and various others.

The chambers are made of aluminium alloy or stainless steel.



Type TC 1150 transport chamber (Courtesy Southern Oceanics) 0024827

Operational status
TCA 1150-B specification is currently in service with the Royal New Zealand Navy.

Specifications
Design code: ASME PVHO-1
Certification authority: Lloyd's Register
Maximum depth rating: 55 m (seawater)
Inside diameter: 1,150 mm
Length: 2,750 mm
Height: 1,600 mm
Width: 1,560 mm
Weight: 585 kg (unoccupied)

Contractor
Southern Oceanics (Pty) Ltd, Cape Town. ***VERIFIED***

United Kingdom

BASAR

Type
Underwater breathing apparatus.

Description
BASAR (Breathing Apparatus Search and Rescue Mod A) has been designed to provide the diver with maximum breathing comfort (even under the harshest working conditions underwater or on the surface), to be as light as possible out of water, and to be always available for immediate use. The apparatus incorporates a stabilising jacket as an integral part of the diving set so that surface buoyancy can be increased, after rescue operations, while waiting for recovery.

A separate swim mask is used with the apparatus, which allows the diver to pinch his/her nose for ear clearing. The mask may be donned before jumping, or after entering the water.

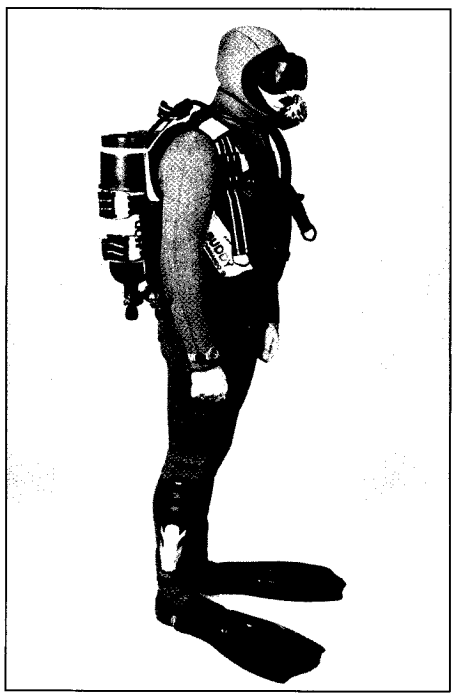
The free mouthpiece allows the diver to conserve air by not having to insert it until the last moment before jumping; to communicate with a survivor in the water by removing the mouthpiece; and to dispense with the mouthpiece when supported by the stabilising jacket while waiting to be picked up.

Using BASAR the diver can jump from a helicopter door (from up to 15 m) without impediment and can sit comfortably whilst wearing the set when the helicopter is airborne.

The breathing circuit of the apparatus is of the open circuit type. High-pressure air is supplied from two steel cylinders, through a manifold to the first-stage regulator which reduces the pressure. Air, at a reduced pressure, passes to the diver via the intermediate hose, the second-stage demand valve and the mouthpiece.

Exhaled air from the diver is discharged through the second-stage exhaust valve to atmosphere/water.

The main cylinder is consumed as per the Certificate of Clearance for Use (CCU) at which point the diver opens the reserve cylinder valve. Air flows from the reserve cylinder to the main cylinder to equalise the pressure in the two cylinders. This equalisation of pressure takes about 10 seconds and can be distinctly heard by the diver.



Diver wearing BASAR breathing apparatus (MSI - Defence Systems) 0024823



BASAR breathing apparatus (MSI - Defence Systems) 0024822

Equalisation of pressure is carried out a second time when the diver again finds difficulty in breathing. The necessity for the second equalisation must be taken as a signal to surface.

The BASAR commando stabilising jacket can be inflated either by mouth with the automatic mouthpiece on the corrugated breathing tube, or from an emergency cylinder. It provides: buoyancy for ascent in an emergency; buoyancy compensation at depth; underwater breathing in emergency; surface buoyancy before and after dives; high visibility for the pick-up crew.

A buoyancy ring and spherical float inflated by CO_2 from a small cylinder are stowed in pouches attached to the weight belt. These provide additional buoyancy if required during a rescue operation.

The apparatus is based on reliable, commercially available, proven components.

Operational status
Developed specifically for the Royal Navy's search and rescue organisation.

Contractor
MSI-Defence Systems Ltd, Norwich, Norfolk. ***UPDATED***

BIBS (SUBS) BU

Type
Built-In Breathing System (SUBmarineS) Breathing Unit.

Description
The BIBS (SUBS) BU is designed for use on Royal Navy submarines to enable the crew to breath diving-quality air in a variety of emergency situations.

The breathing unit comprises a balanced second stage demand valve without a manual purge facility, but fitted with a bite-on mouthpiece to ensure security of the air supply whilst personnel are moving along the BIBs rail, using a SEIS with partially closed hood. The breathing unit is supplied with air via a Pneumatic Components Ltd Quick Fit coupling at a supply pressure of 6.8 to 8.8 bar (equal to 75 MSW) above ambient pressure. The breathing unit exhaust is open to atmosphere during normal operation, but is compatible with the SEIS stole charging connector to enable the stole to be inflated prior to a rush escape.

The breathing unit provides a user with a minimum of 40 $lmin^{-1}$ BTPS (Body Temperature and Pressure Saturated) to a maximum pressure of 8.5 bar absolute. The set is designed to provide the user with an adequate supply of air to achieve a ventilation rate of 75 $lmin^{-1}$ BTPS at a maximum pressure of 8.5 bar whilst fully immersed in seawater.

The BIBS breathing unit is available with various lengths of intermediate pressure hose from 1.8 to 6.1 m.

Operational status
In service with the UK and Australian navies.

Contractor
MSI-Defence Systems Ltd, Norwich, Norfolk.

UPDATED

Buddy

Type
Through-water communicator.

Description
The Buddy diver communications unit is a compact, five frequency channel (8 to 42 kHz) through-water voice communication system for diver-to-diver, diver-to-surface or diver-to-submersible. The diver's unit is designed to interface with the Interspiro full-face mask but other masks can be interfaced if required.

The surface unit is powered from an external mains supply or an internal battery pack (typical life 8 hours) and incorporates a built-in loudspeaker and connections for a headset, microphone, dunking transducer and a tape recorder.

Communication is carried out using single upper sideband with a diver's unit having a typical power output of 1 W into the transducer. The maximum range of the diver unit is 1,500 m and of the surface unit 3,000 m, depending on the ambient noise, sea state and oceanographic conditions.

Operational status
Currently in service.

Contractor
MARCOM Defence, Chichester, W. Sussex.

UPDATED

Buddyphone

Type
Through-water communications system.

Description
The Buddyphone has been developed by Interspiro, in co-operation with Ocean Technology Systems.

The system allows for diver-to-diver and/or diver-to-surface communication.

Specifically designed for use with the Divator Mk II full face mask, the Buddyphone is a small, easy to use, compact unit that is attached to the head harness and sits directly over the diver's left ear. A single wire, running close to the face mask, from the ear unit, connects the 'push to talk button' and 'microphone'. These are located in the front port of the face mask to give good clear direct speech. The transducer is a ceramic cylinder.

Buddyphone is an ultrasonic transmitter/receiver unit which enables communication between users. Transmissions are carried using upper single sideband.

Specifications
Reference frequency: 32.768 kHz
Audio bandwidth: 300-3,000 Hz
Automatic gain control: >80 dB
Power supply: 9 V alkaline, 9 V lithium, or 9.6 V rechargeable Ni/Cd
Normal range: 50-500 m (dependent on sea conditions and noise levels)
Operating depth: 50 m

Contractor
Interspiro, Telford, Shropshire.

VERIFIED

Compression chambers

Type
Military diving compression chambers.

Description
Based on its experience over the last 15 years as in-service support contractor to the UK MoD for the Royal Navy's diving systems, MSI-Defence Systems has developed a range of compression chambers particularly suited to MCM/EOD operations. The range of configurations available includes: deck decompression chambers; recompression and treatment chambers; transportable chambers; and containerised compression chamber packages.

Military compression chambers supplied are designed to the application requirements. For example, they can be single- or two-compartment units with service locks; two-man or more occupancy; rated to the required depth; have low-magnetic signatures; be supplied complete with full controls, instrumentation, communications, Built-In Breathing Sets (BIBS); offer analysis where required; and Transfer Under Pressure (TUP) facilities.

Operational status
MSI-Defence Systems has won a contract in excess of £6 million from the UK MoD and supplies transportable, two-compartment recompression chambers to the Royal Navy for MCM operations. The chambers, fabricated in aluminium with a forged personnel entrance can accommodate two patients and a seated medic in the main compartment and one person in the entry compartment. They are rated to 80 msw and are fitted with full controls, instrumentation, built-in breathing systems, service lock and communications.

Contractor
MSI-Defence Systems Ltd, Norwich, Norfolk.

UPDATED



A transportable Delta, two-compartment recompression chamber rated to 80 msw, similar to more than 40 chambers being supplied to the Royal Navy

DCSC

Type
Mixed-gas diving system.

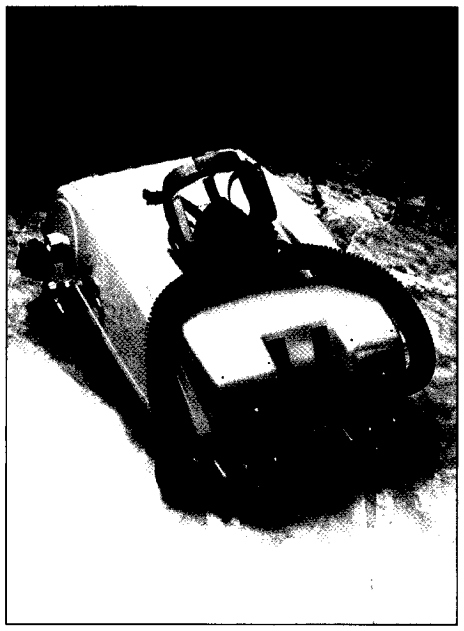
Description
DCSC is a development of the well proven ACSC which has been in operation for over 10 years.

The equipment is extremely simple to prepare and operate. The breathing work is minimal due to the large-diameter hoses. The equipment is neutrally buoyant in water giving ease and exactness in diving procedures. The system has been dived under active service conditions to 150 m and in simulators to 450 m.

The set features very low magnetic and acoustic signatures (which can be adjusted to suit customer requirements) and the safety aspect has been given high priority. A warning device, bypass and separate harness lifejacket system ensure comfortable handling and safe diving.

DCSC is a mechanical system, that is simple and easy to use. The mechanical dosage system keeps the percentage of CO_2 constant in the breathing circuit, independent of depth and ventilation. The design allows a two gas mixture to be used, which simplifies logistics with regard to back up and charging.

The diving apparatus comprises a gas cylinder, control unit and breathing circuit.



The DCSC mixed gas diving system
(Interspiro)
0009873

The gas cylinder contains the gas mixture which is dosed for different diving depths.

The control unit comprises:

- Dosage cylinder, to be used in combination with the selected mixture for the various depths
- Dosage unit and warning system
- Hydrostatic valve
- Bypass valve.

The breathing circuit houses the following components:

- Absorber canister
- Breathing bellows, of which the spirometric function measures the breathing volume of the diver and doses the amount of fresh gas to be supplied to the breathing circuit
- A diffusor, through which the surplus gas passes before it reaches the surrounding water
- Face mask (or mouthpiece).

Safety systems are built into the apparatus and include:

- Built-in warning of low breathing gas supply (approximately 10 minutes)
- Built-in warning of malfunction of gas dosing system and manual bypass.

Other features include: automatic buoyancy control via patented hydrostatic valve; single breathing gas charge which ensures the diver always receives breathable gas should a failure occur in the regulator or dosage system; mask capable of accepting most available diving communication systems.

Specifications

Length: 745 mm
Width: 345 mm
Height: 265 mm
Weight: 35 kg
Gas volumes
Breathing bellows: 4.3 litres
Absorber unit: 2.6 litres
Breathing mixture: 5.0 litres (at 200 bar)
Suit inflation (air): 1.0 litres (at 200 bar)

Contractor

Interspiro, Telford, Shropshire.

UPDATED

DEBRA

Type

Divers electronics beach reconnaissance aid.

Description

The DEBRA (Divers Electronics Beach Reconnaissance Aid) has been developed to provide part of an integrated system for combat swimmers and mine clearance divers enabling them to carry out rapid and accurate beach reconnaissance operations.

The device reduces the diver's workload by automatically measuring and logging own depth and altitude above the seabed, whilst simultaneously providing the diver with navigation information.

The equipment consists of a hand-held swim board manufactured from durable and corrosion-resistant materials including aluminium and nylon-reinforced plastic and incorporates a pressure sensor and echo sounder, together with GPS receiver, electronic compass and computer.

The GPS receiver accepts signals from a floating antenna attached to the diver and provides details of the current position (latitude and longitude or other grid reference). The echo sounder provides indication of the depth and height above the seabed of the unit. This data is stored in the memory of the embedded processor unit. This provides the diver with a measurement of water depth at any particular grid co-ordinate, or by operation of the manual entry control the grid location and depth below the sea surface of a bottom feature or obstacle.

During operation the diver can enter data such as grid co-ordinates and landmark bearings, and control the unit by means of menus shown on the display. This is managed using two three-position rocker switches designed for use by divers wearing neoprene gloves.

Data can be pre-inserted into the swim board prior to a mission using a standard port and downloaded from a laptop running software to generate 3-D models of the seabed. At the end of a mission all recorded data can be uploaded back into the laptop.

The swimboard incorporates an electronics compass to assist in navigating the diver along a survey grid.

Alphanumeric data including bearing, water depth, distance travelled, time, direction to swim to maintain a preset survey track and remaining battery life is shown on an adjustable electro-luminescent display. The display can be dimmed for operation at night. Additional icons indicate the attitude of the swim board, seabed profile, battery capacity and 'off-track' indicator.

Power is provided by a lithium-ion rechargeable battery that gives an operational endurance of 14 hours (four hours in active mode and 10 hours in standby). Batteries can be exchanged without losing survey data.

Operational status

Completing development and available for production early in 2005. The system is being demonstrated to a number of NATO navies.

Specifications

Dimensions: 320 mm × 310 mm × 110 mm (approx)
Weight: 5 kg (in air); (slight negative buoyancy in water)
Endurance: 14 h
Operational depth: <20 m (can be operated down to 80 m)

Contractor

BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

DIPS

Type

Diver Information and Positioning System (DIPS).

Development

DIPS has been developed to support Mine Counter-Measures (MCM) and Mine Investigation Evaluation (MIE) operations, particularly in conditions of zero visibility, both at depth and in the shallow water environment.

Future developments include target marking and real-time reconnaissance map generation, use of MCM/MIE databases, automatic generation of search patterns and integration into the new Closed Diver Breathing Apparatus (CDBA) life support equipment. The former DERA developed the DIPS in conjunction with Systems Engineering to produce a technology demonstrator capable of testing new sensors and techniques for MCM operations. This system is being used to produce realistic specifications for equipment to fulfil the operational requirements of the UK armed forces.

Description

The function of DIPS is to provide a diver with a means of locating targets, viewing text, drawings and position information, at depth and in zero visibility. This is achieved by linking together a hand-held sonar and integrated computer, compass, depth transducer and either a GPS receiver or a communications link to a surface unit.

A wide range of capabilities and expertise from the former DERA were used in developing DIPS, including: diving engineering; acoustic and magnetic signature reduction and assessment; life support equipment; diving physiology; sonar systems; ergonomics; a fully equipped dive team; various trials and test sites; and close links with the Royal Navy and Royal Marine dive teams.

The hand-held sonar is an SE500 high-resolution, electronic scanning sonar with an operating frequency of 500 kHz, the sonar picture being presented on a head-up display attached to the diver's mask. The sonar scans a horizontal sector 60° wide with 64 beams with a width of 1° with a maximum range of 50 m. Sonar controls are located at the rear of the unit and allow the diver to adjust the mode of operation to suit the operational conditions. Connections are provided to the power supply (a Ni/Cd battery pack or a 16 to 28 V DC surface supply), the head-up display and access to PC functions such as a Visual Graphics Array (VGA) monitor, serial ports and floppy disc drive when operated on the surface.

The processor is a 33 MHz Intel 486sl with 12 Mbyte RAM and 256 Kbyte ROM and a 40 Mbyte Kittyhawk disc drive. The unit has two serial and one parallel ports and four analogue inputs. The diver's head-mounted display is a red LED-based system with 720 × 280 pixel resolution.

The system features an RS232 datalink which enables the diver to be connected to either a surface PC for supervised diver mode or a floating GPS antenna enabling stand-alone diver navigation.

Operational status
The equipment has been sold to the UK and Singapore navies.

Contractor
Systems Engineering, Lancaster.

VERIFIED

Divator Mk II

Type
Breathing apparatus.

Description
The Divator Mk II breathing apparatus incorporates shoulder straps which have lockable buckles to prevent them from slipping. On the right shoulder strap there is a neat manifold to which the pressure gauge, the breathing hose, the extra air connector and the reserve air valve are fitted. The cylinder valve and the regulator are easy to reach on the back, and there is no risk of hitting the head on them when diving. The back pad distributes the weight of the cylinders evenly across the back and keeps the apparatus in the correct position. Breathing and pressure gauge hoses are placed in a position close to the body and there are no hose loops behind the head which can get caught or damaged during dives.

With the large-capacity regulator breathing resistance is very low, even when the cylinder pressure is low. When the air is turned on the reserve air valve control lever will automatically turn to the correct position. The reserve air cannot be activated until the pressure has dropped close to the preset reserve air pressure. An outlet on the regulator cover can be used for connection of a variable volume diving suit or a life jacket.

The apparatus incorporates a full face mask (developed jointly with the US Navy) which provides the diver with constant slightly positive pressure to prevent contaminated water from leaking in. For diving in clean water, a breathing valve without positive pressure can be supplied. Flushing the inside of the visor with dry air keeps the visor free from condensation. Airways are designed to provide very low breathing resistance and minimise dead space volume which prevents a build up of carbon dioxide.

The mask features an integral adjustable pressure equaliser and mounts for spectacles.

A divers' telephone can be integrated with the mask and a breathing valve with non-return valve minimises the risk of ice being able to form in the inlet port. A purge button makes it possible to drain any free water out of the valve.

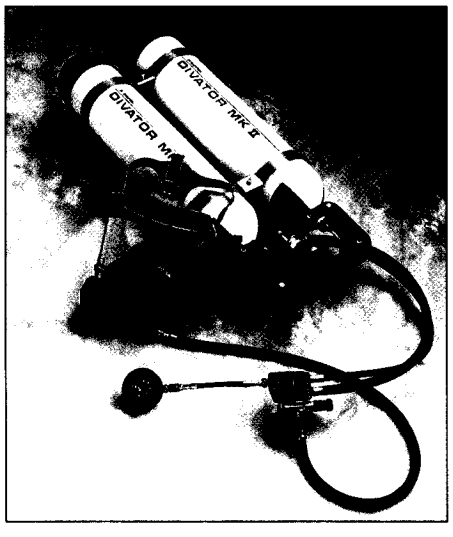
The low-profile twin cylinders are built of special steel alloy and filled at 300 bar pressure giving a light, compact apparatus with long duration times.

The breathing valve can easily be changed from the full-face mask to a mouthpiece, which is easy to wear and is not tiring to the jaw during a long dive.

Operational status
In service with a number of organisations worldwide, including the US Navy, UK MoD, Swedish military, Royal Netherlands Navy, Indian Navy, Oman Navy and Indonesian Navy.

Contractor
Interspiro, Telford, Shropshire.

UPDATED



Divator Mk II
0009579

DRS

Type
Diver Recall Signal (DRS).

Description
The DRS is a simple, one-shot underwater signalling device designed for signalling to divers and for other applications requiring an underwater acoustic pulse.

The device is housed in a corrosion-free plastic container, and the pyrotechnic flash composition is initiated by hydrostatic pressure. The ignition creates a single high intensity acoustic pulse, which has an audible range up to 200 m in still water.

Operational procedure involves selecting the number of signals for the requisite code, removing the end cap from the device and throwing it into the sea.

Operational status
In use by navy divers worldwide.

Specifications
Length: 240 mm
Diameter: 42 mm
Weight: 420 g
Operating depth: 6-8 m

Contractor
Flight Refuelling Ltd, Wallop Defence Systems Division, Middle Wallop, Hampshire.

UPDATED

Model 353X

Type
Multichannel air diving communications systems.

Description
The Model 353X modular air diver system has been designed to allow multiple channel communications for air diving teams. The three-channel design allows diving and support personnel communications to be configured at each stage of the task at the push of a button.

Each communications point requires a diver card (Model 3531). All cards have individual uplink and downlink volumes and can be switched into one of the three available channels simultaneously. There are 'Talk' and 'Listen' select buttons for each group, as well as a momentary and global press to talk. The supervisor also has full uplink and downlink volume control.

The 353X system is suitable for military applications where a permanently installed communication system is required for divers and deck personnel. It offers advantages over traditional single-channel diver radios and puts the control of the dive communications fully in the hands of the supervisor.

Operational status
In service with various navies', air diving teams.

Contractor
Nautronix Ltd, Kirkhill, Aberdeen.

UPDATED

Model 3220C two-diver telephone

Type
Underwater telephone for diver communications.

Description
The Model 3220C two-diver telephone is a two- or four-wire intercom unit. Using two wires to each diver the tender controls communications with one or two divers, or between two divers. Using four wires to each diver, up to five divers and the tender can participate in a 'conference call' bypassing the press-to-talk and cross-talk switches. A recording device can be connected when a complete record of all communications is required.

The Model 3220C is a heavy-duty telephone which has a wide range of applications for use with working divers, medical compression treatment chambers, and both naval and commercial operations. Its wide-frequency response provides good sound quality for helium atmosphere use to depths of over 60 m.

The unit is powered by easily replaceable 'C' cells, which are removed through the front panel. A rechargeable Ni/Cd battery unit is available as an option.

Operational status
In production.

Contractor
Nautronix Ltd, Kirkhill, Aberdeen.

UPDATED

Model 3342C

Type
Helium speech unscrambler.

Description
This two-diver helium unscrambler unit is a two- or four-wire intercom unit with two different unscrambler modes. Using two wires to each diver, the surface tender controls communication with one or two divers. Using four wires to each diver, a duplex connection allows the tender and up to five divers to communicate, bypassing the press-to-talk and cross-talk switches.

The two-diver unit uses an audio amplifier to allow communication between the tender and the divers. The unscrambler uses two complex forms of digital techniques to filter and lower the frequency of a diver's voice resulting in intelligible speech. Mode One is designed for use at normal depths with a normal microphone, Mode Two is intended for use in depths to 610 m using a high-quality microphone. A record jack allows a recording device to make complete records of all communications. A remote press-to-talk capability is available.

Operational status
In use by military forces, deep sea research organisations and for medical hyperbaric chambers.

Contractor
Nautronix Ltd, Kirkhill, Aberdeen.

UPDATED

Model 6280

Type
Diver-held pinger receiver.

Description
This sensitive, directional acoustic receiver enables a diver or small boat operator to precisely locate underwater pingers. The hand-held, battery-powered ('C' size alkaline batteries) receiver can be used to locate any pinger on a frequency from 8 to 50 kHz. The unit is constructed of corrosion-resistant anodised aluminium and can operate down to 305 m depth. The unit is fitted with a parabolic reflector with a hydrophone mounted at the focal point forming a very narrow listening beam for the precise location of pingers.

A frequency synthesiser allows error-free frequency selection; once the pinger's frequency is selected, fine tuning is unnecessary. Since the frequency controls are detented, the diver can change the receiver frequency by 'feel', even in zero visibility.

For operation the sensitivity is set to maximum and the frequency controls adjusted to match the frequency of the pinger. The area is scanned by moving the unit through the water and listening for the pinger's acoustic signal. When a ping is heard the sensitivity is reduced and the operator searches for the strongest signal. By continuing to reduce sensitivity while listening to the ping the operator can easily determine the direction to the pinger by homing in on the strongest signal.

Contractor
Nautronix Ltd, Kirkhill, Aberdeen.

UPDATED



Model 6280 diver-held pinger receiver

Model 6281

Type
Surface and diver pinger receiver.

Description
The Model 6281 battery-powered pinger receiver is capable of locating any pinger in a frequency range from 8 to 50 kHz. The unit can be used from a small boat and can then be rapidly converted to a diver-held receiver, allowing the diver to swim directly to the located pinger.

The complete system comprises: the Model 6515 antenna; Model 6280 diver-held pinger receiver; a headset for surface operation; and an adaptor to convert the system from surface to diver use. The entire system is housed in its own waterproof carrying case.

For small boat operation the antenna sections are fitted together with the directional hydrophone on one end. The cable threads through the connected sections of the antenna and its electrical connector is connected to the adaptor mounted on the receiver.

For operation the sensitivity is set to maximum and the frequency controls adjusted to match the frequency of the pinger. The operator scans the area by rotating the antenna through the water and listening for the acoustic signal. When a 'ping' is heard the sensitivity is reduced and the operator searches for the strongest signal. By continuing to reduce the sensitivity while listening to the ping, the operator can easily determine the direction to the pinger by homing in on the strongest signal.

For diver use the hydrophone is connected to the end of the receiver and the headset replaced by the waterproof earphone. The diver operates the unit in the same way as described above.

Contractor
Nautronix Ltd, Kirkhill, Aberdeen.

UPDATED

New Concept

Type
Drysuit.

Description
The 'New Concept' range of drysuits combine regular fabrics with breathable panels which allow sweat to escape while still keeping the wearer completely dry from external water. The suits are lightweight, exceptionally comfortable and highly mobile, allowing tasks to be carried out as efficiently wearing a drysuit as without.

Operational status
Developed and available.

Contractor
Typhoon International Ltd, Redcar.

VERIFIED

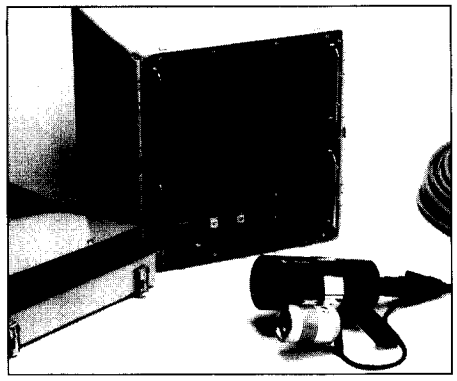


Special operations drysuit

OE 9020 Seahawk

Type
Diver TV system.

Description
The low-cost Seahawk underwater colour television system consists of a wide-angle Charge Coupled Device (CCD) camera complete with underwater lamp and pistol grip assembly, 50 m of cable and a surface control unit. The control unit



Seahawk diver TV system

incorporates a colour TV monitor, camera and lamp power supplies and a stowage bag for the camera/lamp assembly.

Operational status
In service with the Royal Navy and several navies worldwide.

Contractor
Kongsberg Maritime Ltd, Bridge of Don, Aberdeen. ***UPDATED***

Oxydive

Type
Closed-circuit breathing apparatus.

Description
The Oxydive set consists of the following components: oxygen cylinder, regulator unit, bypass valve; dosage unit; relief valve; buoyancy control unit; breathing bag, absorber unit, mouthpiece and harness.

The oxygen cylinder is placed between the absorber unit and the breathing bag in such a way that it will protect the main part of the breathing bag and the regulator unit. The 1.5 litres (standard) steel cylinder has a charging pressure of 200 bar (3,000 psi). Other cylinders for non-magnetic versions are available.

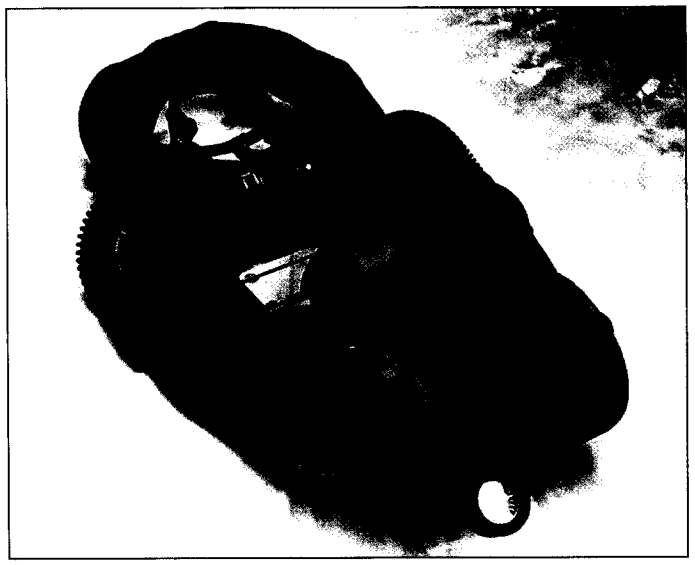
The regulator unit consists of four main parts: bypass valve; dosage unit; relief valve; buoyancy control unit.

With the bypass valve the diver can always add oxygen into the breathing circuit by activating the valve manually. The dosage unit measures the consumed oxygen volume and injects an equal volume into the breathing circuit at each inhalation. In this way the diver will stay neutrally buoyant during the whole dive irrespective of depth (except if the diver ascends so fast to the surface that the expansion rate of the oxygen volume becomes greater than the consumption). The dosage unit operates without causing or being activated by any breathing resistance.

An automatic relief valve is connected to the regulator unit. Also, a relief valve for the breathing circuit which is independent of the diver's swimming position will open if the pressure in the breathing circuit should exceed 200 mm water column.

The buoyancy control unit allows the diver to change buoyancy during a dive by actuating the buoyancy control unit. This makes the diver become a little heavier before breaking the surface to make an observation. With this unit the diver can select four different settings for more or less buoyancy compared to the individual adjustment made before starting the dive. The original buoyancy can be restored at will.

The accurate and automatic regulation of the buoyancy at each inhalation is of great importance as it enables the diver to remain in desired swimming position without effort. The waste of energy on constant adjustments of body position to compensate for an inadequate buoyancy is eliminated.



Oxydive 0009580

The breathing bag is placed on the diver's chest close to the lungs to achieve as low a breathing resistance as possible both during inhalation and exhalation. The small difference in hydrostatic pressure between the breathing bag and the lungs is mechanically eliminated when the diver swims in normal position. The breathing tag is uncomplicated and made of durable material.

The absorber unit consists of an absorber housing and an absorber cartridge. The absorber housing is made of glass fibre-reinforced plastic protected and insulated with rubber. The absorber cartridge is designed in such a way that there is always gas between the absorber housing and the sodalime. By insulating the sodalime from the surrounding cold water with rubber glass fibre-reinforced plastic and gas the duration time of the Oxydive set is almost independent of water temperature. The radial gas flow through the absorber cartridge has been proved to give superior utilisation of the sodalime and a low breathing resistance. The absorber cartridge can be prepacked and stored for a long time in a small plastic box to be instantly available when needed. For an extremely long-time mission an extra prepacked absorber unit in a plastic box and an extra oxygen cylinder can be brought by the diver. The design is such that if some water should leak into the breathing circuit it will be held in the absorber housing and not go to the diver's lungs.

Non-return valves in the mouthpiece ensure low rebreathing of carbon dioxide. The assembly can be shut off with a valve to prevent ingress of water.

The harness is simple and uncomplicated. The whole unit can be quickly released by slipping off the neck collar and opening waist buckles.

As optional equipment a lifejacket for integration with the harness is provided. When not in use the lifejacket is protected in a zippered cover. The lifejacket is inflated by means of a CO_2 cartridge or an air cylinder. The zipper of the cover opens automatically and the jacket inflates in to correct position when the knob is pulled to activate the CO_2 cartridge or the air cylinder.

For increased safety the lifejacket can also be furnished with a hydrostatic valve for automatic inflation in case the diver should accidentally descend to a dangerous depth. However, If the diver deliberately goes deeper than the depth preset for the hydrostatic valve; he/she should close the air cylinder in advance. Failing that, the diver will definitely hear when the hydrostatic valve starts operating and then he/she should close the air cylinder valve, return to a safer depth, reset the mechanism of the hydrostatic valve by pressing the preset knob and open the air cylinder valve again. To restore a correct buoyancy the diver must again adjust the buoyancy control unit to compensate for the buoyancy of the lifejacket. No bubbles will leave the apparatus during the whole operation.

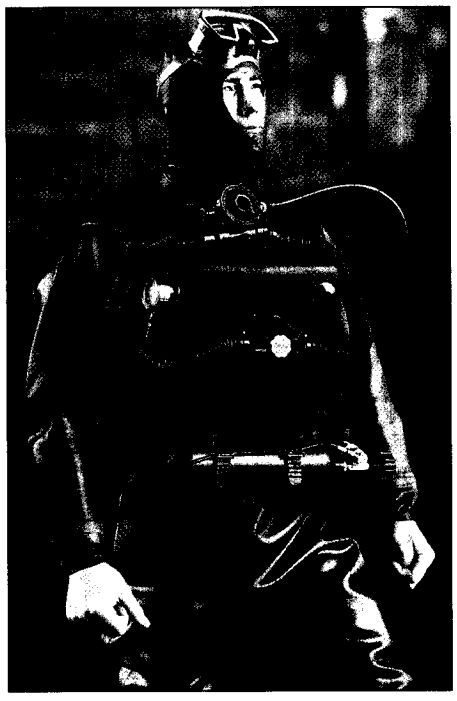
Operational status
The Oxydive set was tested by the US Navy Experimental Diving Unit (NEDU) in July 1982 and has been in service with the USN for some years. The system is also used by the Swedish forces.

Contractor
Interspiro, Telford, Shropshire. ***UPDATED***

Oxymax 3

Type
Closed-circuit oxygen diving set.

Description
Oxymax 3 is a compact oxygen rebreather set providing up to 3 hours endurance at depths of up to 10 m – dependant on conditions. It is inherently non-magnetic in



Oxymax diving set 0009577

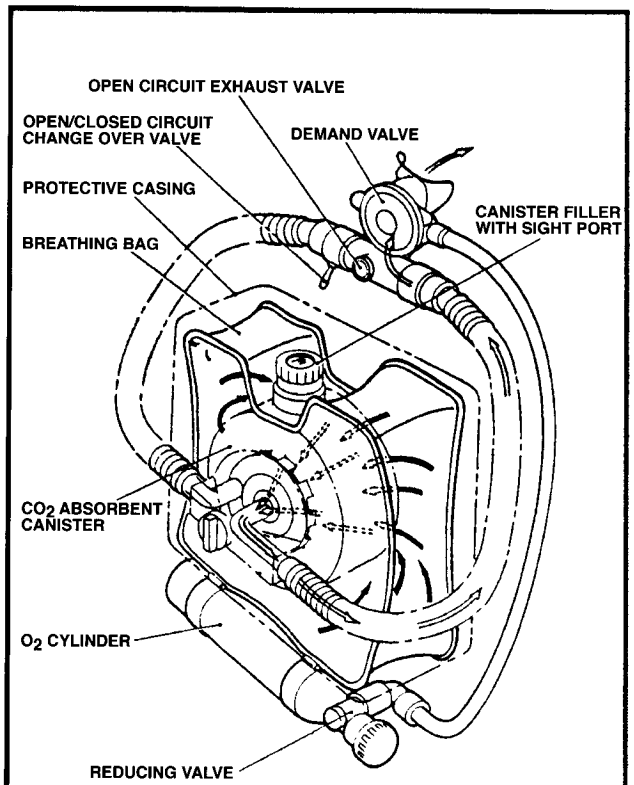


FIG. 1 NORMAL INHALATION - CLOSED CIRCUIT

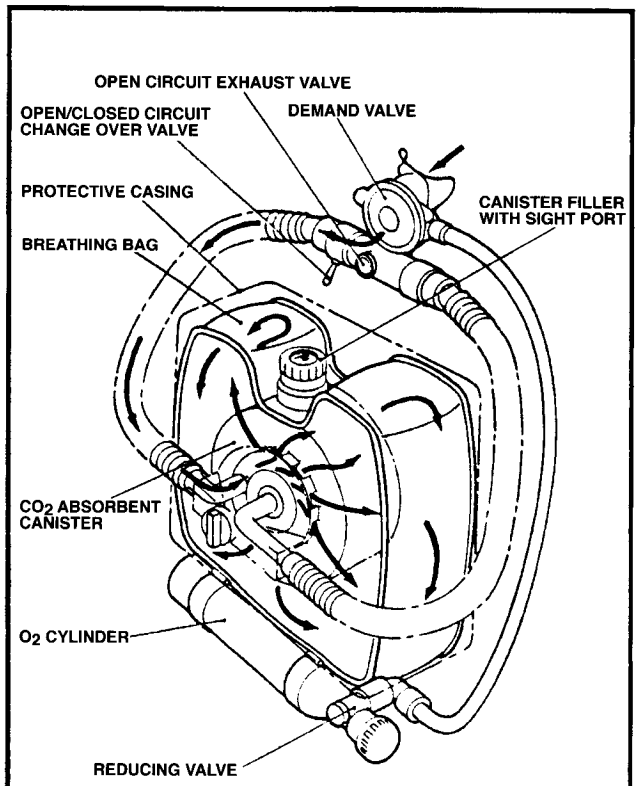


FIG. 2 EXHALATION - CLOSED CIRCUIT

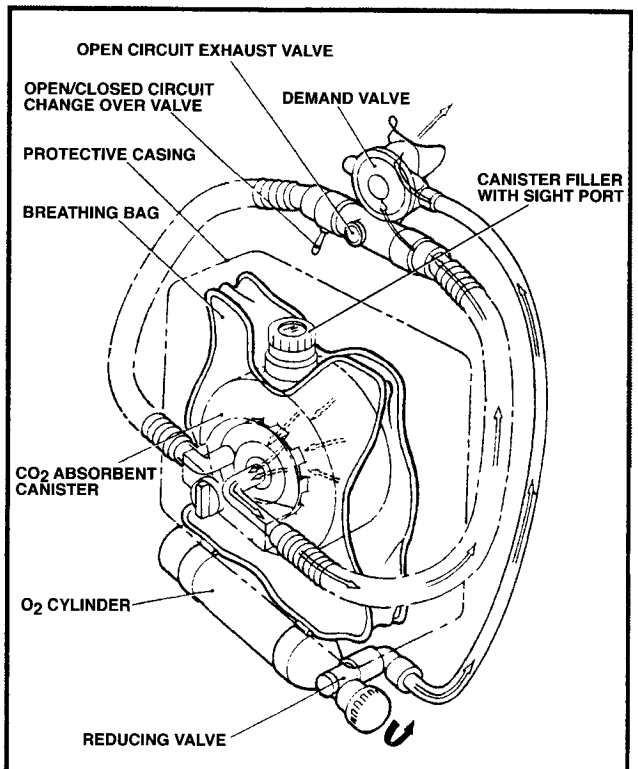


FIG. 3 INHALATION - CLOSED CIRCUIT WITH AUTOMATIC OXYGEN MAKE-UP

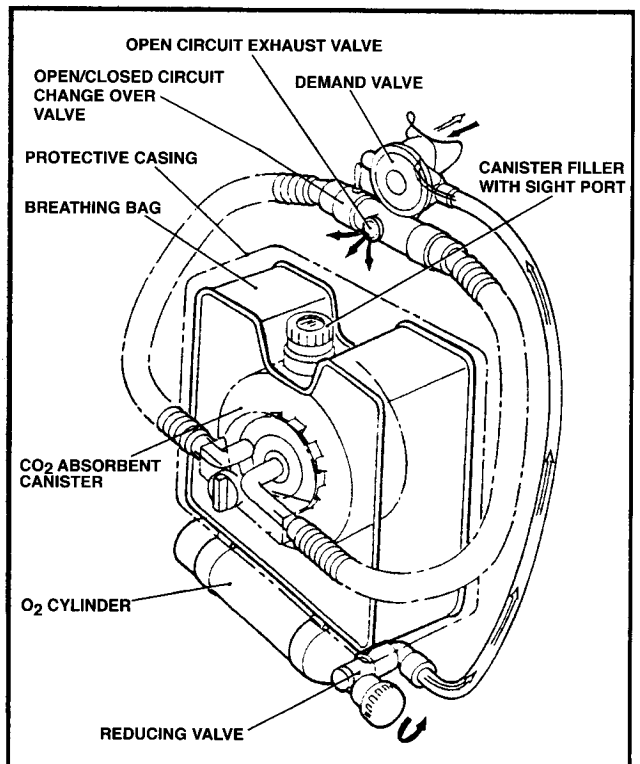


FIG. 4 OPEN CIRCUIT - EMERGENCY AND BAG FLUSHING

Oxymax 3 closed-circuit set

0009578

construction (but can be ratified as fully 'non-magnetic' to special order) and is characteristically low in operating noise.

A streamlined glass fibre carapace is provided, both to assist swimming and to protect the breathing bag. This is, nevertheless, easily removable for maintenance. A cylinder contents gauge is standard equipment and allows both diver and other divers to monitor gas available. This is especially useful during training.

The set features a demand-driven admission system for oxygen 'make-up' in the diver's gas. This is not only acoustically very quiet and consistent but also economical in use, giving adequate breathing gas for a given workload without wastage or under-supply. Depending on activity, therefore, long endurance may be achieved – especially in warmer waters where problems of diver heat-loss do not arise.

Oxymax 3 features a crossover valve within the mouthpiece allowing the unit to be turned into an open-circuit system. This patented valve allows the diver to have the set ready for an emergency dive in open-circuit mode without water entering the bag.

Additional features include: quick-release neck and waist straps for ease of ditching; transparent filling and emptying ports for ease of filling and sodalime inspection; hygienic and simple cleaning; and easy to read contents gauge.

Operational status
No longer in production or being marketed but remains in service with a number of navies worldwide including Norway.

Contractor
Divex Ltd, Westhill, Aberdeen.

UPDATED

Pro-Am/Pro-HD

Type
Rubber dry diving suits.

Description
The Pro-Am dry diving suit is designed to keep divers dry, warm and comfortable under all environmental conditions. Developed over a period of four years, the Pro-Am diving suit has been subjected to intensive laboratory and field tests under varying conditions. Each suit is individually tank tested in addition to the many other tests undertaken as part of stringent quality control.

Designed to cope with the most rigorous of underwater conditions, the suit is manufactured from a double layer of rubber/EPDM blend on a two-way stretch nylon lining to provide maximum mobility and toughness combined with easy dressing.

The suit is manufactured to 1,050 g/m², which has been specified as meeting the requirements of some military forces. The seams are fully vulcanised while the high EPDM content increases resistance to 'weathering'. High-risk areas such as shoulder, waist, knees and shins are provided with pyramid reinforcement. Heavy-duty latex wrist seals ensure a longer operational life for the suit. A latex or neoprene hood is also available. The suit is quick and easy to repair on site if punctured and a repair kit is supplied with each suit.

The Pro-HD 1,550 g/m² suit has been developed for heavier-duty military applications. The suit features heavier reinforcements than the lighter Pro-Am suit, while the interior lining is a heavy-duty woven nylon which is extremely hard-wearing and also adds extra warmth to the suit. Reinforcements are of a shallow dimple pattern for ease of cleaning in case of contamination. The boots are also slightly larger to allow for more underwear, which could be necessary on an extended dive.

The suit can be supplied with a variety of neck options such as standard latex neck seal, latex neck yoke for use with neck ring and clamping band, or rubber neck yokes to attach to air breathing helmets.

Operational status
Suits are sold worldwide and are in service with a number of navies, including the French and Netherlands navies. Also on the US Navy approved list.

Contractor
Hunter Division, Interfloor Ltd, Dumfries, Scotland.

VERIFIED

PRO-CBX 450

Type
Cordura/Butyl/Polyester trilaminate drysuit.

Description
The PRO-CBX replaces Gates' nylon trilaminate suit. This new material is softer and quieter than traditional nylon-type materials, making it ideal for use in covert operations. The Cordura outer is also extremely hard wearing, and taber abrasion tests have revealed no wear after 6,000 revolutions of an abrasive taber wheel. The seams are vulcanised, and a variety of boot and hood options are available.

Operational status
In service with several police underwater units and also some coastal rescue services.

Contractor
Hunter Division, Interfloor Ltd, Dumfries, Scotland.

VERIFIED

PRO-HRM 1200

Type
Vulcanised rubber suit.

Description
The PRO-HRM 1200 is a new addition to the existing range of NR/EPDM suits. It is manufactured from a new rubber compound which has a much higher degree of resistance to chemical permeation, in particular, hydrocarbons. The suit is available with ring and yoke systems for use in contaminated water diving situations.

Operational status
Going into service with police diving units, and also being trialed by some navy divers in South East Asia. Now operational with UK MoD Navy salvage divers.

Contractor
Hunter Division, Interfloor Ltd, Dumfries, Scotland.

VERIFIED

PRO-VSN 1100

Type
Hybrid stretch membrane dry suit.

Description
Developed in 1998 from a new stretch trilaminate material, the Pro-VSN is a unique stretch suit with the flexibility of a rubber dry suit and the toughness and durability of a nylon suit. The VSN has vulcanised seams with a lifetime guarantee. The boots are constructed from 5 mm neoprene and over-dipped with latex for flexibility and durability. Braces are included with the suit.

Operational status
Currently being used by several Police Underwater Units.

Contractor
Hunter Division, Interfloor Ltd, Dumfries, Scotland.

UPDATED

SAR drysuit

Type
Diving suit.

Description
The Divex SAR drysuit is a very flexible, lightweight, drysuit comprising a trilaminate membrane ideally suited for rescue divers, scientific divers, professional divers and as a lightweight military suit.

The drysuit is constructed from the best quality, double-textured, high-tenacity nylon trilaminate with an interply of butyl rubber.

Every care is taken to ensure the security of the diver - seams are twin needle sewn, glued and hand taped with 19 mm Aquatape. The suit has a bellows-type neckseal, latex bottle-type wrist seals, and a heavy-duty zipper. Vlar pads are fitted to the knees for extra protection. To finish, the suit is fitted with full rubber boots with heel and toe reinforcements. These are, however, fully flexible and make an ideal swimmer's boot.

A 6 mm attached neoprene hood is available. In colder climates professional divers often require the hood to be an integral part of the suit.

Operational status
In production.

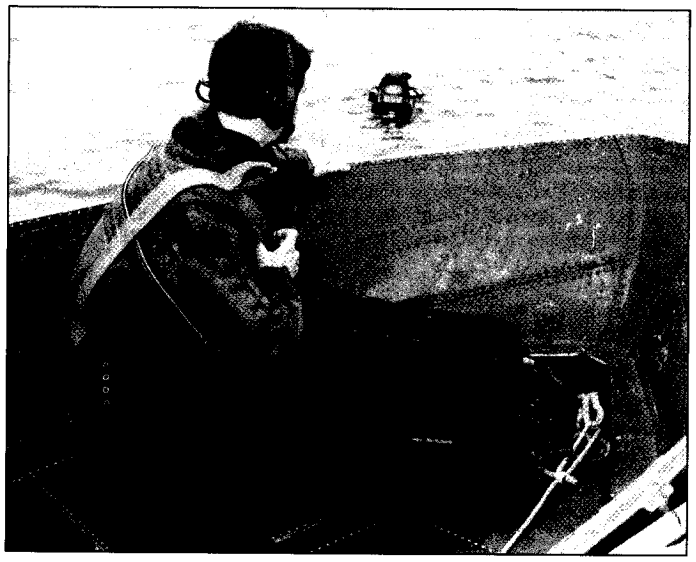
Contractor
Divex Ltd, Westhill, Aberdeen.

UPDATED

Sea Piper

Type
Diver communications system.

Description
The Sea Piper diver communications system is fully modular and allows underwater communications between divers, between divers and a control platform and between a submersible and surface vessel. The equipment caters for



Sea Piper diver communications system

divers working with compressed air or oxy-helium breathing apparatus, and provides line or through-water communications as required. A new design of helium speech converter, which gives increased clarity of speech together with simplified control, is a feature of the system.

In the tethered mode of operation, a four-wire neutrally buoyant cable is used. This doubles as a safety line and gives duplex or round-robin communications which, for divers using oxy-helium mixtures, feeds back an unscrambled version of the diver's own speech.

The through-water mode enables operators to communicate with one or more divers via a simplex link. This facility provides communications in the simplex mode between the diving tender, submersible and divers. In this mode, communications between two or more divers can be achieved without resorting to surface or submersible-carried equipment. For diver-to-surface communication, an adaptive headset is used by the surface operator; whilst the diver uses bone conduction earphones and microphones.

All parts of the system are designed for adverse environments. The control unit can be supplied as a backpack. The diver's module, constructed from plastic, is pressure-proofed to 100 m. The control unit carries its own internal rechargeable battery which has 8 hours duration but, in addition, external power from a ship's 115/240 V AC or 12 V DC supply can be used to power the control unit.

The system uses single-sideband, suppressed carrier HF transmitters and receivers. A two-way simplex communication is available, each transmission being preceded by a short tone-burst. The operation of the press-to-talk switch causes the changeover from receive to transmit.

When the electronic module is selected for long-range operation a minimum range of 1 km can be achieved. A short-range facility (less than 100 m) is available, range depending on propagation conditions.

Operational status
Developed under contract from the UK Ministry of Defence with 150 units purchased by the Royal Navy; also in use with Qatari, Dutch, Spanish and other special forces.

Contractor
AMS, Frimley.

VERIFIED

Shadow Excursion

Type
Combined closed circuit/semi-closed circuit UBA.

Description
The compact, lightweight (14 kg in air) Shadow Excursion combined closed circuit oxygen/semi-closed circuit nitrox UBA (Underwater Breathing Apparatus) that integrates a diver controlled gas supply changeover facility enabling diving to 24 msw. It is of modular design offering three different modes of operation with a 3 to 6 hour endurance. To meet different mission requirements, within minutes the diver may quickly reconfigure Shadow Excursion to either of the following modes of operation:

- Closed Circuit Oxygen
- Semi Closed Circuit Nitrox to a depth of 54 msw
- Combined Closed Circuit Oxygen/Semi Closed Circuit Nitrox to a depth of 24 msw.

Exploiting this versatility, Shadow Excursion may be employed in the following operationally profiles:

- Combat diving operations (Closed Circuit Oxygen mode) to a depth of 10 msw
- Combat diving operations below the safe depth of Oxygen (Combined Closed Circuit Oxygen/Semi Closed Circuit Nitrox mode)



Shadow Excursion
(Divex Ltd)
NEW/1067194

- Very Shallow Water Mine Countermeasures EOD (Combined Closed Circuit Oxygen Semi Closed Circuit Nitrox mode)
- Swimmer Delivery Vehicle (SDV) operations (Combined Closed Circuit Oxygen/ Semi Closed Circuit Nitrox mode)
- Submarine Exit and Re-Entry Casing Diving (Semi Closed Circuit Nitrox mode)

When in oxygen mode, oxygen is supplied via the automatic demand valve, which also serves as a manual bypass facility. When in nitrox mode, a constant mass flow orifice supplies nitrox to the breathing circuit together with the automatic demand valve, which provides adequate counterlung gas volume during descent and a manual bypass facility. The standard 200 bar, 2 l oxygen cylinder is augmented with an additional 200 bar 2 l nitrox (60 per cent O2/40 per cent N2). Both the oxygen and nitrox cylinder pressures may be monitored by easily accessible pressure guages.

Shadow Excursion is a chest-mounted oxygen rebreather with a potential endurance exceeding 6 hours, depending on the diver's oxygen consumption. The set is claimed to be similar in weight and size to other systems. The system can be interfaced with Divex Digicom 3,000 m range diver through water communications system and/or Divex stealth full face dual mode mask, which enables the diver to access onboard gas supplies such as the auxiliary life support systems incorporated in SDVs.

When in oxygen mode, oxygen is supplied via the automatic demand valve, which also serves as a manual bypass facility. When in nitrox mode, a constant mass flow orifice supplies nitrox to the breathing circuit together with the automatic demand valve, which provides adequate counterlung gas volume during descent and a manual bypass facility. The standard 200 bar, 2 l oxygen cylinder is augmented with an additional 200 bar 2 l nitrox (60 per cent O2/40 per cent N2). Both the oxygen and nitrox cylinder pressures may be monitored by easily accessible pressure guages.

Operational status
In service with UK forces since 2002 replacing the LAR V/VI set.

Contractor
Divex Ltd, Aberdeen.

UPDATED

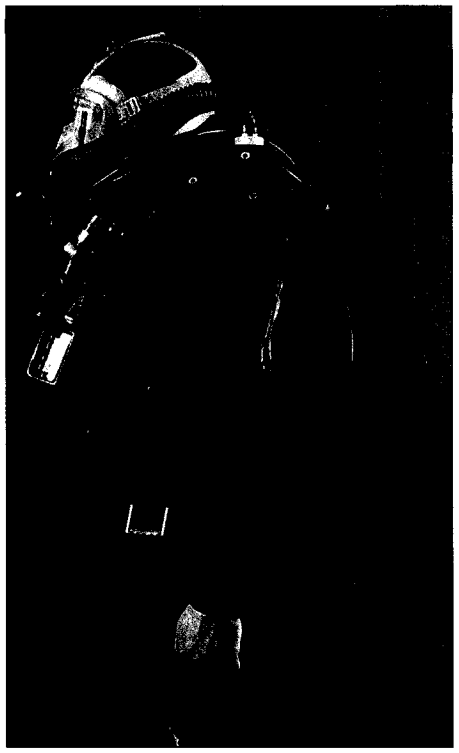
Stealth Combat and Stealth EOD

Type
Closed-circuit mixed-gas rebreathers.

Description
This military diving apparatus has been designed by Divex to meet the requirements of Explosive Ordnance Disposal (EOD) and special forces, incorporating modern materials, microprocessing power and current thinking on underwater breathing apparatus design.

The primary objective has been to create a very small package integrating primary and secondary (bail out) breathing systems complete with a buoyancy control facility in a swimmer-optimised configuration.

The Stealth rebreather is an electronically controlled closed-circuit mixed-gas rebreather available as two options for military diving. It features a buoyancy compensator and can be fitted with a bailout system. The Stealth SF for special operations forces uses a nitrox gas mixture, which is used when exiting and re-entering SDVs, submarines and when operating below the safe limits of oxygen



Stealth™
0009575

rebreathers and where a low magnetic signature is not required. The Stealth SF has a 6-hour endurance.

According to Divex, air may be used as the diluent to provide a nitrox breathing gas to a depth of 54 m. For deeper diving, heliox (a helium/oxygen mix) or tri-mix (oxygen/helium/nitrogen) mix may be used as the diluent offering a diving depth of 120 msw.

The Stealth EOD is a non-magnetic closed circuit mixed gas rebreather specially designed for MCM/EOD operations, including very shallow water where a low magnetic and acoustic signature is of paramount importance. The versatile Stealth EOD set can be used for all MCM/EOD tasks throughout the water column.

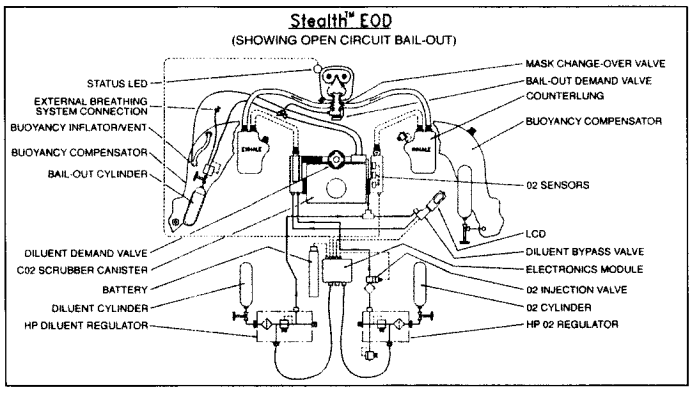
Closed-circuit breathing systems function by maintaining a breathable gas mixture for the diver at depth through removing the CO_2 from exhaled gas via the scrubber unit, and injecting pure oxygen to replace the oxygen metabolised by the diver. The aim is to replace the oxygen in the quantity at which it is consumed – whatever the breathing rate and metabolic rate. Stealth achieves this through a well-proven electronic control system and microprocessor monitoring system packaged in a pressure-proof housing.

The oxygen partial pressure (PPO_2) can be factory set to customer requirements, but is normally preset to 1.3 or 1.5 bar. This maximising of safe PPO_2 levels minimises the amount of diluent (helium or nitrogen) uptake by the body's tissues and hence reduces decompression time.

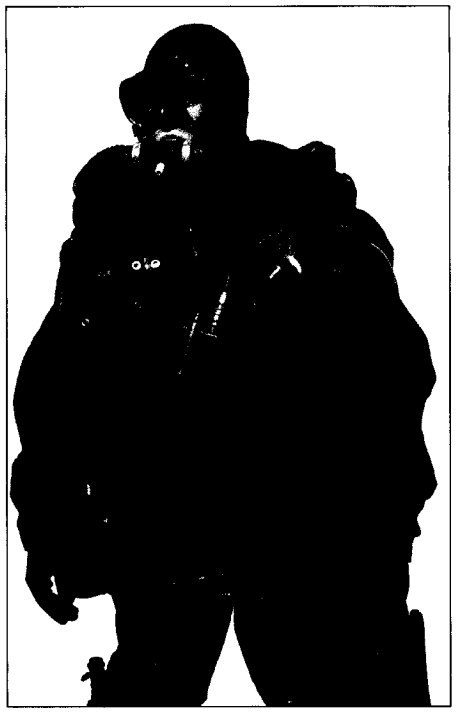
Three independent oxygen sensors (micro fuel cells) located in the scrubber outlet chamber continuously monitor the oxygen level in the gas and provide signals to the Electronic Oxygen Controller (EOC) and microprocessor monitoring module. The EOC analyses the three signals, creates an average and compares this to the desired set point. It then switches the oxygen addition valve on or off within a tolerance band of ±0.05 bar of the set point. This ensures that the PPO_2 is maintained at the preset level dependant on the depth. A diluent gas (air, Heliox or Trimix) provides gas volume within the closed circuit system, whilst CO_2 from exhaled gas is absorbed via the long endurance scrubber unit.

A Light Emitting Diode (LED) is fitted to the side of the diver's full-face mask. This warns the diver of any malfunction in the system, by changing the normal continuous green status LED to a flashing green for problem but not serious failure, to a flashing red if a dive abort is required.

An open circuit bail out breathing system is offered as standard but a unique semi-closed circuit system is available that provides additional breathing gas for ascent and long decompression requirements.



EOD showing open circuit bail out 0009576



Stealth EOD
(Divex Ltd)
NEW/1067195

The microprocessor also drives a back-lit Liquid Crystal Display (LCD) module located on a hanging pendant on the diver's right side. Attached to this is also a diluent bypass injection valve to enable rapid gas injection of a safe breathable gas into the counterlungs.

The display gives such information as: current average PPO_2, current depth, maximum depth, elapsed time of dive, oxygen content, diluent content, battery status, alarm/abort description. With the Stealth rebreather a diver can stay at a depth of 100 m for up to 20 minutes.

Operating endurance is between four and six hours.

Operational status

The Royal Navy ordered 30 Stealth Combat systems early in 1998. The Stealth EOD is in service with the UK Royal Navy, UK Royal Marine Commandos, the German Navy (205 sets) and the Italian Navy.

Contractor

Divex Ltd, Aberdeen.

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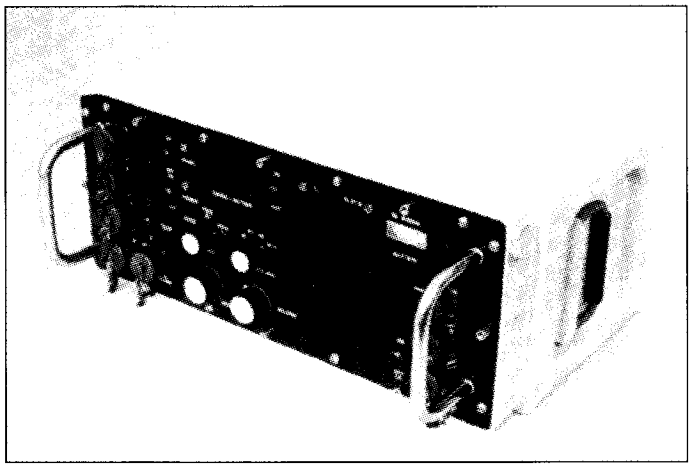
Type 2056 (EL050, EL057, EL067 series)

Type

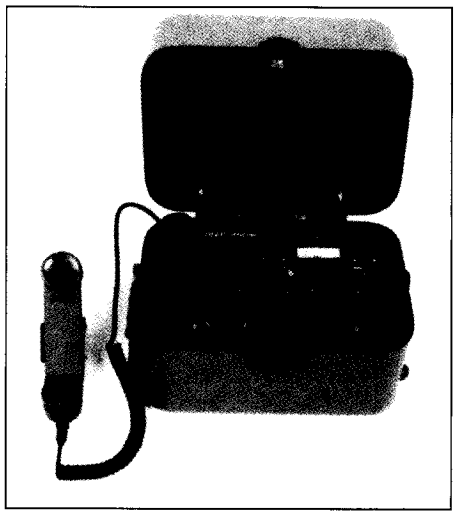
Deep-phone underwater telephones.

Description

These multifrequency units provide voice communication and pinger indication in the military submarine and diver bands. They are employed as both portable and installed units in submarines, surface ships and submersibles, from helicopters, and as secondary/emergency units in submarines. They are also used for parachute delivery with SUBSUNK emergency assistance teams and are installed in the Royal Navy's crew rescue LR5 submersible.



2056 unit



Deep-phone surface unit

The units provide diver-to-diver and diver-to-surface communication over ranges of 1,000 m. The diver's Ultra Short Baseline (USB) station operates at a carrier frequency of 40.2 or 42 kHz with a bandwidth of 3,400 Hz. It measures 78 × 300 mm (excluding helmet or hood microphone and earphones) and its weight in water is 800 g. An on/off switch is water-activated. Powered by Ni/Cd batteries, the unit provides 8 hours of operation at a 10 per cent transmit cycle. It is rated to a depth of 450 m.

The surface unit measures 200 × 300 × 280 mm (excluding handset) and weighs 8.65 kg. Its lead-acid battery provides 18 hours of operation at a 15 per cent transmit cycle, and it also incorporates a battery charger, a built-in loudspeaker and a tape recorder.

Operational status
In use with the UK Royal Navy, the Swedish Navy and several other customers. Another variant, ELO67P has been evaluated by the Swedish Army.

Contractor
Perry Slingsby Systems, Kirkbymoorside, Yorkshire.

UPDATED

UHDLS

Type
Diver locating system.

Development
Detailed predocking in-water surveys of the hulls of US Navy ships to assess damage is essential to accurately estimate time required in dry dock and to draw up work specifications. This enables time in dry dock to be reduced with considerable savings in cost. If such a survey shows only minor repairs are necessary it may even save the necessity of docking the ship at all.

The need to conduct these accurate underwater surveys of the hulls of US Navy ships has led to Oceaneering Inc in the US developing ShipShape, a database of all US Navy ship hull profiles from which a map can be drawn against which the diver can carry out an inspection.

However, to carry out such a precision inspection requires the positions of the diver to be tracked with great accuracy. To meet this requirement the UHDLS system has been developed.

Description
The UHDLS (Under Hull Diver Location System) is an underwater acoustic positioning system which can track a single diver with accuracies of 150 mm at ranges of over 500 m. Three sets of positional data have to be obtained and computed to obtain the diver's position: the diver relative to the seabed; the ship relative to the seabed; and the diver relative to the ship. It is necessary to carry out these measurements because no ship remains absolutely stationary, even when it is tied up alongside, and any movement will introduce positional errors.

To position the diver relative to the seabed, an array of four or more Compatt (computing and telemetering transponder) units is deployed in a long baseline configuration on a grid. These 'intelligent' units communicate with each other to establish the baselines between them. This data is telemetered to the surface where it is received by an in-water transceiver and displayed and computed on board the ship on a 486 computer running on DOS.

The diver is fitted with a transceiver and his position relative to the seabed array is displayed on board.

The seabed array of Compatts forms the basis for positioning the ship and diver relative to each other and the seabed. In addition, three Minirov transceivers are attached to the vessel's hull at known locations – usually two on the keel and one on the side. This enables the position of the hull to be determined in three dimensions relative to the seabed array.

The position of the diver is similarly determined and his co-ordinates transformed into co-ordinates in the vessel's frame of reference. All positional information is updated once a second.

The system operates in conjunction with an online conductivity/temperature/depth probe which provides continuous updates on the speed of sound through water.

Operational status
On trials off Charleston the UHDL system successfully tracked a ship and dive team.

December 1994 – System handed over to the US Navy. Had the added capability to track an ROV.

Contractor
Sonardyne International, Yately, Hampshire.

UPDATED

United States

AN/PQS-2A sonar

Type
Hand-held active/passive sonar.

Description
The AN/PQS-2A is a continuous transmission, frequency-modulated, hand-held, non-magnetic sonar set intended for use by divers to locate and close on submerged targets such as mines, lost equipment, downed aircraft and other targets to depths of 91 m. Because of its non-magnetic construction, the set can be used safely when working near magnetically influenced underwater explosive devices. The equipment can be used by divers using only one hand.

The equipment has an active (continuous transmission) mode and a passive (listening) mode for detecting underwater pingers. The diver adjusts the frequency until pulses or a constant tone are heard in the headset. In the active mode, one of three range scales is selected (18, 55 or 110 m) and an acoustic signal is transmitted over a 30 kHz bandwidth, swept from 115 to 145 kHz. When a submerged object is detected, a ringing tone, proportional in frequency to the distance of the object, is produced in the earphones. The sonar has a 6° beamwidth and can detect a 30.5 cm diameter air-filled sphere at 110 m. In the passive mode, the unit detects active sound sources (pingers) in the 24 to 45 kHz range. The sonar can detect a 39 kHz acoustic beacon at a range of at least 1,800 m.

The sonar has been upgraded with a spectral processing computer to create a video representation of the sonar's audio signal.

Operational status
In operation with the US Navy (over 200 units). The DLS-1 (Diver Locator Sonar 1), a commercial variant of the AN/PQS-2A, is currently available and in operation.

Specifications
Transmission: Continuous Transmission Frequency Modulated (CTFM) 145 down to 115 kHz (30 kHz bandwidth)
Active range: 18, 55 or 110 m
Passive range: up to 1,800 m
Passive detection: pingers from 24-45 kHz
Output: audio tone (or pulse) in earphones. Frequency variable with range
Power source: 2 rechargeable gelled electrolyte lead-acid batteries



AN/PQS-2A hand-held sonar

Operating depth: to 91 m
Operating temperature: –2 to +30°C
Weight in water: 0.23 kg (positive buoyancy collar included in accessories)
Size: 31.75 cm long × 11.43 cm diameter

Contractor
Harris Acoustic Products Corporation, East Walpole, Massachusetts.

UPDATED

AN/UQN-5 SANS

Type
Swimmer Area Navigation System (SANS).

Description
The AN/UQN-5 SANS is used by the US NSWG SEAL Team divers to perform grid searches of large areas of the sea bottom in conditions of reduced visibility. The system employs a diver-held receiver unit synchronised with two acoustic beacons placed at extreme corners of the desired pattern. The diver is given a real-time readout of position and heading and the ability to record the location of significant objects on the seabed. On completion of the dive, the receiver is attached to a printer which produces a hard-copy record.

Operational status
In operational service by US NSWG Seal Team divers.

Contractor
Allen Osborne Associates, Westlake Village, California.

VERIFIED

COBRA-TAC™

Type
Bathymetric and navigational diver board.

Development
The original technology for the COBRA-TAC™ was developed under sponsorship from the US Naval Research Laboratory (NRL) under the CLAM programme. This programme was initiated in 1993 for the US Navy SEALS in response to the NRL's interest in improving diver navigation in littoral areas where operations are complicated by poor visibility, unknown currents and lack of navigation aids such as GPS.

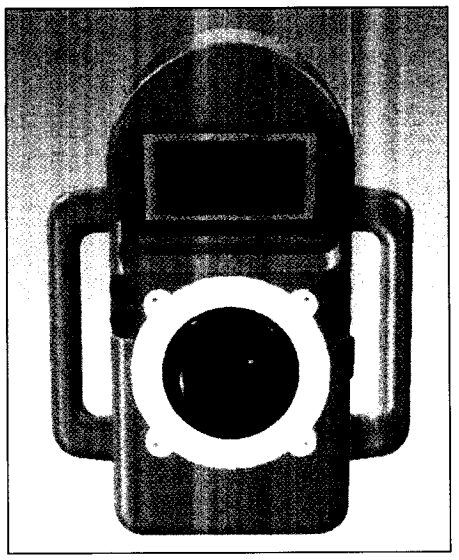
Description
The COBRA-TAC™ is being integrated into military dive programmes that focus on very shallow water MCM, EOD and marine reconnaissance. The equipment is smaller and lighter with improved software and diver interface compared with the CLAM system. The equipment allows the diver to map the bottom topography, record current speed, navigate accurate grid patterns, mark and relocate waypoints and download all mission data for review at the surface. COBRA-TAC™ carries out accurate navigation without the need to establish an acoustic baseline, as the diver enters a GPS fix at the start of the mission. The diver is able to stay on track at all times as the board automatically compensates for current drift.

Multiple mission profiles can be created using previously established geodetic position fixes (longtitude/latitude) and downloading these profiles to the diver unit directly from a PC or notebook computer.

With the system, the diver is able to carry out accurate hydrographic surveys and beach reconnaissance and download data into mapping software. During MCM beach surveys the diver can mark events with real-time latitude/longtitude position and create maps of event positions.

Operational status
In service with US Navy SEALs.

Specifications
Length: 41 cm
Width: 34 cm
Height: 15 cm
Weight: 6.5 kg
Depth range: 0 to 24 m
Depth measuring accuracy: 0.15% of velocity at 1 pulse/s



Top view of the COBRA-TAC™ showing backlit LCD (RJE International)
0097310

Contractor
Benthos Inc, North Falmouth, Massachusetts.

VERIFIED

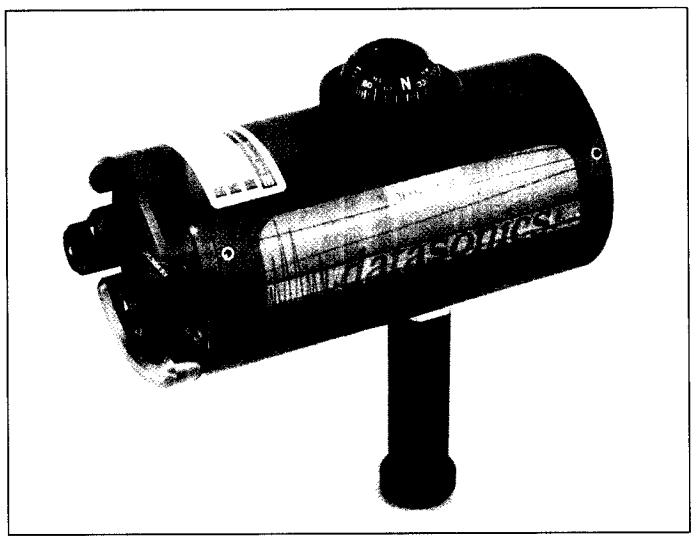
DHS-100

Type
Diver-held sonar.

Description
The DHS-100 diver sonar is a portable, self-contained sonar designed for use by divers to locate submerged objects. The system provides bearing and range information to the target and can also be used to locate pingers or other sound sources.

The unit is suitable for use in recovering submerged objects such as aircraft, vehicles and so on.

The sonar operates in a Continuous Transmission Frequency Modulated (CTFM) mode with an active mode for locating objects within 18, 55 or 110 m ranges. A continuous signal of varying frequency is transmitted and range information is determined by comparing the transmitted signal to the echo signal. When the target is located an audible tone is generated in the headset. A low tone indicates a close target while a high tone indicates a distant target. Moving in on the target causes the tone to gradually lower until contact is made. Experience with the system allows an operator to determine range and target characteristics from the echo signal. In the passive mode, the sonar provides bearing information to a pinger or other sound source.



DHS-100 diver-held sonar (RJE International) 0077536

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

Specifications
Length: 32 cm
Diameter: 11.4 cm
Weight: 3.6 kg
Range
active: 18, 55 or 110 m
passive: up to 1.5 km
Beam width
active: 15° at –3 dB points
passive: 30° at –3 dB points
Operating frequency
active: 115-145 kHz (30 kHz band)
passive: 25-45 kHz
Audio frequency: 250-2,500 kHz
Operating depth: 183 m

Contractor
Benthos Inc, North Falmouth, Massachusetts.

VERIFIED

DPL-275A

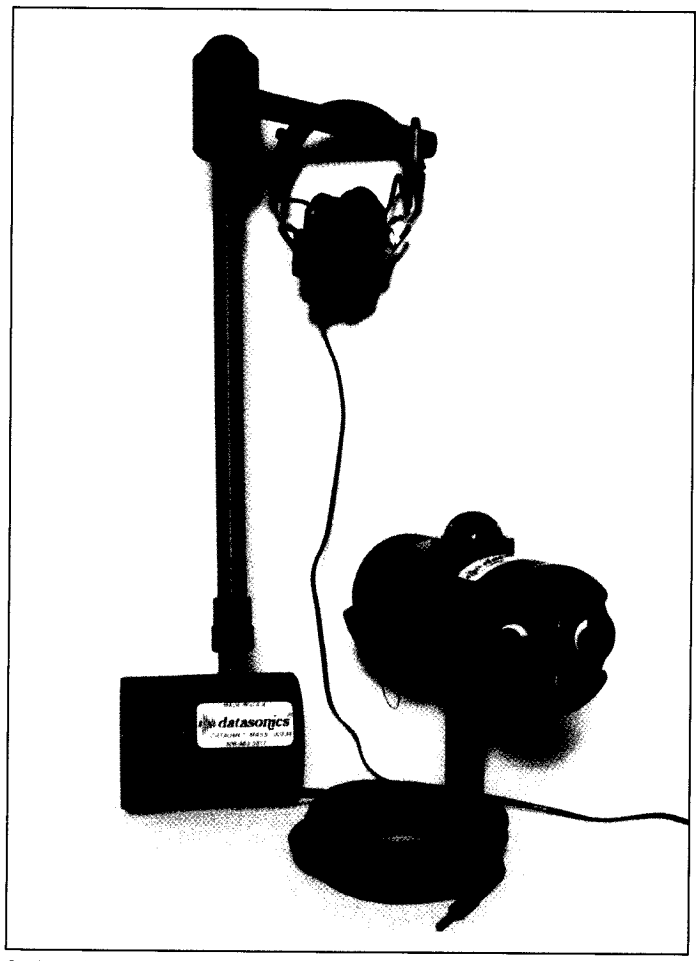
Type
Diver-operated pinger/receiver.

Description
The DPL-275A is used for locating and tracking underwater pingers. The unit guides the user to pingers operating between 5 and 80 kHz.

The unit is simple to operate requiring the operator to turn it on and tune into the frequency of the pinger to be located. The sensitivity control is adjusted to maximum. The operator then scans the area by moving the unit through the water while listening for the pinger signals. This is heard in the earphone as an audible ping. Once a signal is received and its bearing determined, the operator then moves in the direction of the strongest signal. By continuing this process, the operator can easily determine the direction of any pinger.

The DPL-275A incorporates a compass and a 12 V rechargeable NiCd battery pack, bone conduction earphone and manual.

The unit can be used as a diver unit or converted to a surface unit by using the optional DHA-151.



Surface directional hydrophone unit and the diver pinger receiver 0105322

Specifications
Length: 26.7 cm
Diameter:11.4 cm
Weight: 2.9 kg
Frequency range: 5 to 80 kHz
Bandwidth: 2 kHz
Sensitivity: 80 dB
Directivity: typically 30° between 3 dB limits
Operating depth: 200 m

Contractor
Benthos Inc, North Falmouth, Massachusetts.

VERIFIED

Hydrocom

Type
Diver speech processor.

Description
Hydrocom is the US Navy's standard helium speech unscrambler system. Using a full-duplex connection, Hydrocom allows communication between three divers and a surface tender without the need for a press-to-talk function. The unit operates with either powered or non-powered diver microphones. The power for the microphone can be multiplexed onto the diver's microphone lines and the tender has the option to isolate each of the divers' inputs or outputs in the event of cable failure.

The system provides quality communications in a helium environment using a single audio printed circuit board which uses a differential input stage for each diver to minimise noise and cross-talk picked up in the umbilical cable. Low-noise amplifiers are used to amplify divers' voices and a ground plane is incorporated to minimise noise. An optional helium speech unscrambler printed circuit board is available which can be bypassed from the front panel of the control unit for air operation. The unscrambler uses analogue and digital techniques to convert distorted helium speech transmission into intelligible audio. The unscrambling is achieved with audio high-frequency boost and time domain sampling and is suitable for operation at depths down to 610 m. At depths of 305 m better than 75 per cent intelligibility has been achieved.

Hydrocom also incorporates inhalation noise attenuation circuitry to reduce breathing noise if an oral/nasal cavity is included in the mask.

Operational status
In service with the US Navy.

Contractor
SEA Hydro Products, San Diego, California.

VERIFIED

LIMIS

Type
Diver sonar.

Description
LIMIS has been developed under sponsorship from the US Office of Special Technology and supervised by the US Naval EOD Technology Division.

The hand-held sonar provides underwater images down to zero visibility. LIMIS (Limpet Mine Imaging Sonar) operates at a frequency of 2 MHz with 0.3° resolution at a maximum range of 15 m. Range resolution is 1.8 mm at a distance of 3 m. A mask-mounted video monitor displays images from the sonar, which are updated 10 times a second for ranges up to 9 m. The imagery can be transmitted in real time to a display unit aboard a ship or quayside and can store up to 50 images for subsequent analysis.

LIMIS measures 18 cm (wide) by 20 cm (high) and 30 cm (long) including a 10 cm handle. The unit is neutrally buoyant in water which allows the diver to manage the instrument with one hand leaving the other free for other purposes.

The sonar can operate for up to 4 hours on a single battery charge, or for longer periods using auxiliary power.

Operational status
Development completed.

Contractor
Applied Physics Laboratory, University of Washington.

VERIFIED

Mark-Trak®

Type
Diver navigational system.

Description
The Mark-Trak® navigation system is designed for use by professional and military divers. The system can mark and track multiple objects or dive sites.

The receiver has a range of 300 m and directional indications shown by an LED bar graph that works like a stereo signal strength meter. When the receiver is pointed straight at the beacon all elements of the bar graph light up. The diver simply follows these indicators until the beacon is reached.

Specifications
Length: 17 cm
Diameter: 5 cm
Range: 330 m
Operating depth: 182 m

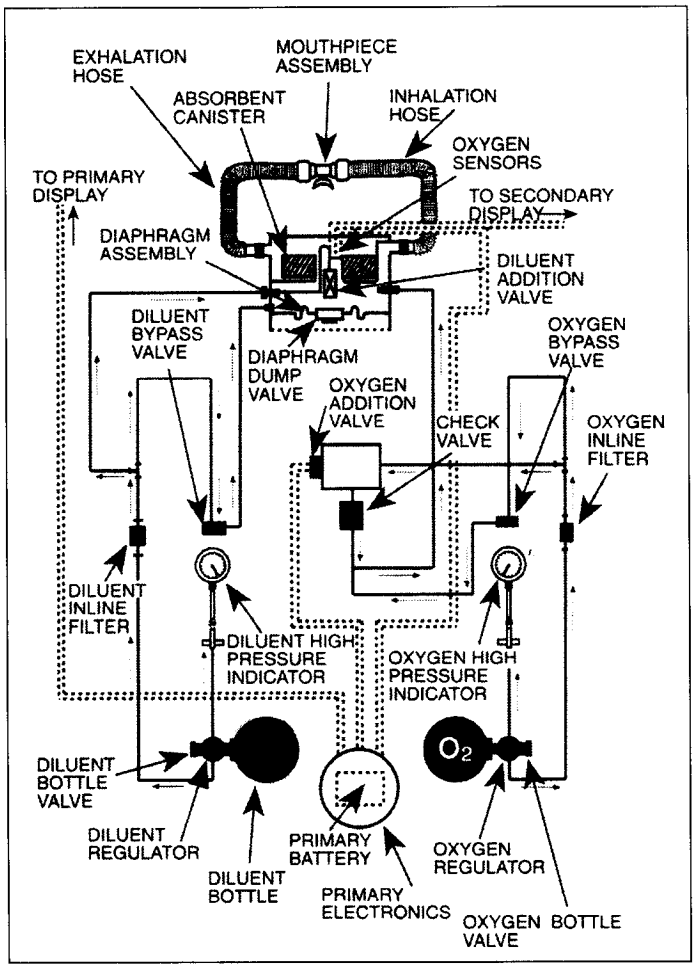
Contractor
Benthos Inc, North Falmouth, Massachusetts. ***VERIFIED***

Mk 16 UBA

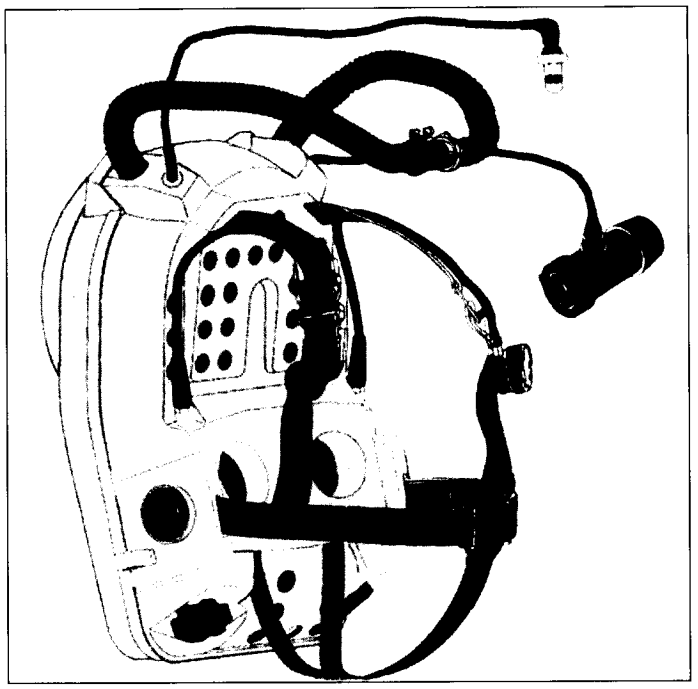
Type
Underwater Breathing Apparatus (UBA).

Description
The Mk-16 UBA is designed for EOD operations such as mine countermeasures or recovery and disposal missions against magnetic and/or acoustically sensitive ordnance. It is an electronically controlled, fully closed circuit, mixed gas, constant partial pressure breathing apparatus. The set permits completely autonomous diver operation with recirculation of 100 per cent of the mixed-gas breathing medium resulting in bubble-free operation. With electronic control of the PPO_2 (partial pressure oxygen), the Mk-16 allows divers to modify missions at will. These capabilities, combined with the equipment's extremely low magnetic and acoustic signatures, make the Mk-16 UBA well suited for mine clearance operations and special warfare operations, requiring minimum sound production and low-magnetic influence.

The rebreather is capable of mixing either nitrogen or helium depending on the depth of the dive, the limitations being 58 m with nitrox and 91.5 m with heliox (the UK Royal Navy uses heliox, rating the set to 81 m).



Block schematic of Mk-16 UBA 0024824



Arrangement of Mk 16 UBA (Carleton Technologies) 0114379

Use of special alloy metals, tightly controlled processes and high-strength plastics result in a low-magnetic signature. A low-acoustic signature is obtained through careful design of high-pressure gas passages and by using a custom-designed piezoelectric oxygen addition valve that provides quiet operation, minimal power consumption and low-magnetic influence that is not possible with a solenoid valve. The utilisation of high-reliability electronics to maintain a constant partial pressure from sea level to 90 m allows the diver to concentrate on the mission and not on the equipment. Other advantages of the system are efficient gas usage, extended dive duration, superior depth capability, and reduced breathing resistance.

As a closed-circuit rebreather, the Mk-16 was designed to: remove carbon dioxide produced by the metabolic activity of the body, add pure oxygen to the breathing gas to replace the oxygen consumed, maintain oxygen content at safe levels and recirculate the breathing gas for reuse.

The recirculation system consists of a closed loop (including inhalation and exhalation hoses), a lightweight mouthpiece or full-face mask (for use with communication gear – when diving, communication equipment is omitted for safety reasons in the presence of acoustic mines), a carbon dioxide scrubber, and flexible breathing diaphragm. The diver's breathing gases are recirculated to remove carbon dioxide and permit reuse of the unused breathing gas. Inhalation and exhalation check valves in the mouthpiece assembly ensure the unidirectional flow of gas through the system.

Movement of recirculating gas through the circuit is normally achieved by the natural breathing action of the diver's lungs. As the lungs are capable of only small pressure differences, the entire circuit has been designed for minimum flow restriction and extremely low breathing resistance.

Oxygen is maintained at a constant level through the use of a micro-electronic control system, that analyses the input from three oxygen sensors, and signals the piezo-electric valve to add the precise amount of oxygen into the breathing loop. The removal of CO_2 is accomplished by passing the exhaled gas over a bed of CO_2 absorbent, either Sodasorb or Sofnolime.

The principal components of the Mk-16 include: two high-pressure gas reservoirs with shut-off valves, high-pressure regulators, piezoelectric oxygen addition valve, carbon dioxide scrubber, oxygen sensors, electronics, counter-lung, mouthpiece assembly and two independent displays. The assemblies are contained in a rugged ABS plastic housing and cover. LED readouts and a head-up display provide effective monitoring of the system's operation throughout the dive.

Improvements are being developed that will be incorporated during overhauls of currently certified systems. The improvements are aimed at enhancing diver capabilities and safety and extending the service life of the equipment.

Diver safety is being improved by the addition of a full-face mask and an underwater communication system. The latter will provide real-time voice communications between divers and between a diver and the surface.

In addition the O_2 set point is being increased and new decompression tables are being developed which will reduce the susceptibility of divers to the bends and the in-water decompression time that limits divers operating at deeper depths.

Operational status
In use with US Navy EOD and special operations forces since the mid-1980s. Also in service with the UK Royal Navy and the Royal Australian Navy.

Specifications
Weight: 29 kg (in seawater)
Operating depth: 90 m (max)
Duration of dive: 40 min (at moderate work rate)

Contractor
Carleton Life Support Technologies Inc, Tampa, Florida. ***VERIFIED***

Sub-Monitor®

Type
Diver tracking system.

Description
The Sub-Monitor® tracking system monitors and tracks military divers training underwater with closed circuit rebreathers or open circuit SCBAs.

The surface station tracks up to seven divers simultaneously in real time using a target locating transponder. The relative position of the diver is displayed on a full colour radar-like screen, with each diver's range, bearing and depth accurately monitored. The small target-locating transponders are mounted on the diver and are powered by replaceable batteries. Divers can be monitored up to a range of 500 m.

The surface station is designed for operation from a small boat and is housed in a rugged, watertight carrying case that also houses a ruggedised notebook computer. The battery-operated equipment can support continuous tracking for up to 20 hours. The computer uses Windows-driven software with pull-down menus.

Contractor
Benthos Inc, North Falmouth, Massachusetts.

VERIFIED



Surface station showing the notebook computer in case (RJE International Inc)
0097303

ASSOCIATED UNDERWATER WARFARE SYSTEMS

Signature management
Acoustic ranges
Magnetic ranges
Multi-influence ranges
Degaussing systems
Acoustic control

Environmental measuring systems

Prediction systems

Oceanographic and hydrographic survey equipment

Training and simulation systems
Command team trainers
Mine warfare trainers
Submarine equipment trainers
Aircraft ASW equipment trainers
Sonar equipment trainers
Targets

General navigation equipment

Submarine radar

Consoles and displays

Transducers, hydrophones and pingers

Miscellaneous equipment

SIGNATURE MANAGEMENT

Introduction

Managing and controlling unwanted signatures on warships is now a major consideration for ship designers and operators. The advent of new generations of acoustic and wake homing torpedoes and modern acoustic/magnetic mines has led to an intense effort being devoted to reducing or modifying signatures created by ships and submarines in order to increase their stealth against the underwater threat.

Signature control slots naturally into a layered defence system. It can be used to counter a threat in all phases of the engagement from detection down to the terminal attack phase. In the detection phase careful signature control can force an opponent to deploy additional resources in order to achieve detection. In certain circumstances it may inhibit detection altogether. In the localisation phase it can inhibit the performance of the hostile platform's sensors, causing it to delay or preventing it from launching any hostile weapons. In this instance the hostile platform will be forced to launch its weapons at a much shorter range than desired, thus enhancing the hard kill defences of the target and putting the hostile platform itself under threat. Finally, in the terminal homing phase, careful signature control can increase the effectiveness of decoys and jammers enabling the target to evade the attacking weapon.

Some signatures, such as the magnetic signature, have been the subject of considerable attention for many years. Even during the Second World War technology was being applied either to reduce to a minimum the magnetic signature, or to install compensation methods which would cancel out the effect of such signatures. Development was spurred on by the increasing losses suffered by merchant shipping from magnetic mines, and the need to build minesweepers that would be virtually immune to the magnetic mine.

With the post-war development of acoustic mines, and acoustic homing torpedoes, attention turned towards reducing the effect of a ship's acoustic as well as its magnetic signature. This was achieved principally through the damping of systems that created noise such as propulsion machinery and so on, by the use of rubber shock absorbers. Using these protective measures had the added effect that if the ship were to suffer an explosion then equipment would be given some measure of protection from the effects of blast and whip.

However, ships also betray their presence in other ways. Such indications include unintentional electromagnetic emissions, chemical and bubble traces remaining in the wake, bioluminescence caused by the disturbance of minute organisms, and hydrodynamic pressure and surface wave patterns. Compared to acoustic, magnetic, IR and radar signatures, these are relatively insignificant. However as signature management of acoustic and magnetic emissions improves as well as reduction in IR and radar, these lesser signatures will gain in importance as a secondary means of confirming the presence of a target.

Stealth technology

The new science of controlling and modifying these signatures is now referred to as stealth technology. Currently, effort is not only being devoted towards reducing these signatures, but also to adapting them so that a ship is not necessarily made invisible to hostile sensors but appears as something totally different. Using stealth technology is referred to as signature management.

The relative importance of different types of signatures can be expected to change with time, as new and more sensitive sensors and more sophisticated signal processing techniques become available. The art of signature management lies in the ability to obtain the right balance between the differing signatures. The object of signature management is to achieve the optimum combination of external shape, coatings and internal treatments that will give the desired overall result at an acceptable cost.

Acoustic signatures

Surface ships and even more importantly submarines emit high levels of underwater radiated noise which can be detected and tracked by passive sonars, possibly hundreds of miles away in the case of towed array sonars. Vessels, which strongly reflect incident sound waves, are easily detected by active sonar systems. Not only does a high level of radiated noise make a vessel far more susceptible to detection, it also inhibits the vessel's ability to operate its own acoustic sensors.

Underwater acoustic radiation therefore, is still the primary means by which submarines betray their presence when they are submerged. Hostile forces also use the underwater noise signature radiated by surface ships for detection and classification of targets. Propellers and hulls create cavitation and broadband noise, while various internal pumps, generators and diesel engines produce distinctive sounds at specific frequencies and amplitudes that can both aid and hamper detection. So sophisticated are modern detection methods that, in many instances, not only can the hunter classify a target as a specific class of ship, but even the individual ship within a class can be positively identified from its very own distinctive sound signature. For example, it may have a shaft alignment problem or a pump with an uneven bearing which has been identified by intelligence and the specific sound signature so produced can be recorded for storage in a sound library for future comparison and so on.

Minimum acceptable noise levels are constantly being driven downwards by developments in sonar sensors and signal processing technology. Hence the techniques used to control radiated noise must also become more subtle and refined. One of the most important elements in achieving a 'quiet' design is the ability to predict the noise levels while a ship is still at the design stage. Minimum noise levels are further achieved by the design of high-performance isolation systems machinery and methods for reducing cavitation around propellers and so on. The hydrodynamic shape of the hull in water is also subjected to close scrutiny in order to minimise any sound signature that may be created by its passage through the water.

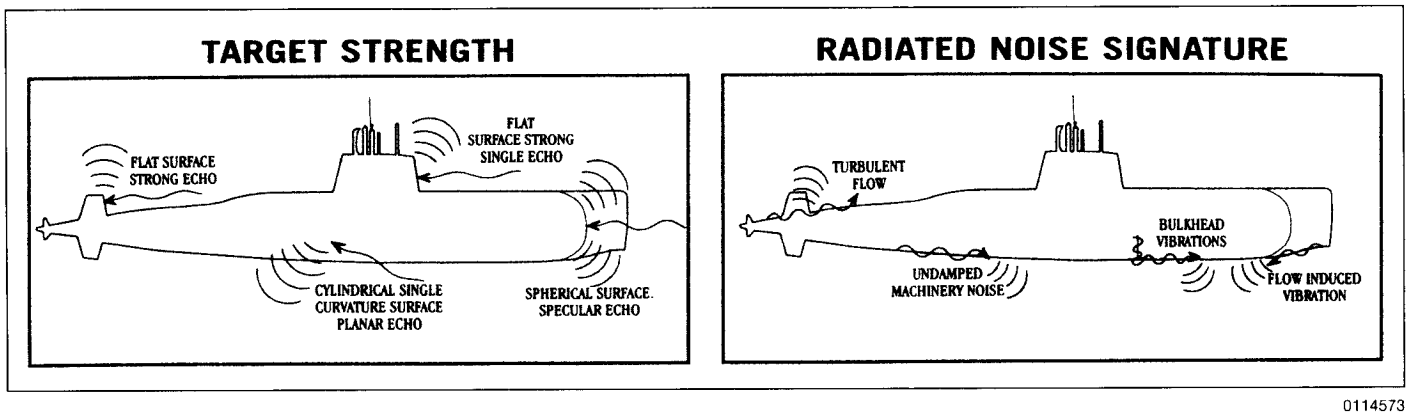
Noise isolation systems for surface ships and submarines employ a wide range of techniques, including double-elastic mounting systems where, in the case of diesel engines, high intrinsic source levels have to be reconciled with stringent target levels for underwater radiated noise. Increasingly, serious attention has to be paid to the secondary transmission paths in the design of such advanced isolation systems.

Active control techniques are currently under development to enhance the high degree of isolation, which can already be achieved through well-balanced, passive isolation treatments. These include systems designed for use with propellers and propulsors and their associated shafting systems, where dynamic interaction with the hull can play an extremely important part in determining the overall level of underwater noise radiation. In rotating machinery, for example, moving parts can be dynamically balanced to reduce the noise from shafts and connections to other machinery. In addition, the equipment can be mounted in special acoustically insulated housings, which are, in turn, carried on flexible mounts to isolate them from the hull. In some instances, large items of machinery are additionally flexibly mounted on rafts that are themselves flexibly mounted to isolate the whole machinery installation from the hull. As well as these detailed arrangements, items such as water inlets/outlets and so on, must also be isolated from the hull in flexible mountings to prevent any vibration from the pipe being transmitted to the hull and thence to the surrounding water in the form of noise.

One of the most important areas for noise reduction concerns the propeller. Propeller noise is generally divided into two main types:

- blade noise which is generated by the thickness of the blade and the loading on the blade as it rotates, which gives rise to low-frequency noise
- cavitation noise generated by the implosion of cavitation bubbles that form around the leading edge of the blade, across the low-pressure region of the blade and in the vortex behind the hub of the blade. Cavitation is a broadband high-frequency noise, which can only be avoided by delaying the onset of cavitation.

Coatings applied to hulls in the form of decoupling or damping layers designed to significantly reduce the level of machinery-induced noise radiated into the water, or anechoic coatings designed to absorb as much as possible of the incident energy generated by active sonar equipment, are becoming increasingly important in the science of controlling unwanted noise signatures. For some years the hulls of nuclear submarines have been treated with sound-absorbing anechoic tiles and this is now being extended to diesel-electric powered submarines. Anechoic tiles are not the same as decoupling tiles, being designed to absorb or scatter incident sound energy from hostile active sonars. They operate on the principle that the material absorbs the incident sound, which is then turned into heat; hence no sound, or only minimal sound, is reflected off the hull. In order not to inhibit own-boat sonars, sonar 'windows' are incorporated into the anechoic tiling system. However, for submarine use, decoupling tiles have to be specially designed to withstand pressure at great depths in order to maintain decoupling performance.



0114573

Other treatments include continuous coatings in which acoustic and anechoic material is applied to large flat or curved surfaces. RhoC (PC) materials are designed to match the impedance and speed of sound in seawater. Sonar materials can replace GRP for sonar domes and windows, and encapsulation in which large and small case encapsulation of arrays is achieved with controlled exotherm. The use of specially designed polymers, which match the acoustic properties of seawater, permits encapsulation technology to be employed to reduce flow noise effects.

The purpose of using acoustic control measures such as decoupling tiles (whose design is frequency and noise level dependent) and anechoic coatings and so on, is to reduce the detection range and classification capabilities of hostile sensors, at the same time improving the performance of 'own ship' sensors. However, the law of diminishing returns does apply and there comes a time when no amount of treatment will either (a) improve own detection range or (b) significantly reduce enemy detection range.

Air bubble screening has proved to be particularly valuable at higher frequencies and speeds although decoupling tiles for surface ships are considered by some to have a superior performance to such systems. This is particularly the case for vessels operating at slow speed or stationary, such as occurs in minehunting operations.

Radar cross-section

Radar cross-section signature control can be approached in a variety of ways ranging from the use of appropriate design techniques (avoiding re-entrant corners, shaping, sloping and reducing the overall size of superstructures and so on), to the addition of temporary or permanent Radar Absorbent Materials (RAMs) and coatings of various types.

The design of structures to avoid specular reflections is an obvious means, but this may not be fully effective on mobile structures and cannot be applied easily to existing vessels. Absorbent coatings represent a versatile solution that can be applied in conjunction with shaping to new designs or retrospectively to existing vessels.

Coatings can be designed to absorb radar signals over a wide or narrow frequency bandwidth, as appropriate to the application. Radar signature can also be controlled by use of structural Radar Absorbent Material (RAM) and materials of this kind are now available and can be considered at the design stage of new vessels. By appropriate formulation RAM coatings can be endowed with various special properties such as high friction. RAM structures operate on the thickness of the material used according to the angle of incidence of the beam.

Magnetic signature

The need to control and manage a ship's magnetic signature has long been the subject of study by naval architects, scientists and operators and so on. Passive countermeasures involve measuring the ferromagnetic mass of the ship itself (including all the individual items of equipment carried by the ship) and reducing the magnetic signature. This is achieved either by magnetically treating the ship in special magnetic treatment facilities (deperming); or by fitting the ship with special active degaussing coils through which electric current is passed, the strength of which can be controlled from within the ship itself, thus ensuring that at any time, in any geographic position the ship's magnetic signature (that is, its own inherent magnetic signature plus that caused by its movement through the earth's magnetic field) is cancelled out; or by a combination of the deperming and active degaussing processes. Most modern warships are fitted with active degaussing systems, and are also regularly depermed. Merchant ships, on the other hand, rely primarily on deperming.

Deperming involves putting the ship inside an arrangement of coils or placing an arrangement of coils around the ship, and then passing a powerful electric current through the coils to create a magnetic field in opposition to the magnetic field of the ship, thus cancelling out the ship's own magnetic signature. Alternatively, deperming can be used to create a permanent magnetic field on the ship that is matched to the area in which it will operate. However, the disadvantage of deperming is that it is not permanent, and the vessel will need to be checked periodically in order to maintain the desired effect.

Active degaussing coils, on the other hand, are built into the ship during construction to provide magnetic field correction facilities. The coils are continually fed with electric current provided from special computer-controlled generators to create an opposing magnetic field that is continually matched to the ship's changing magnetic field as it crosses the ocean. Even with this system, however, periodic checks are still necessary and are carried out on special magnetic ranges.

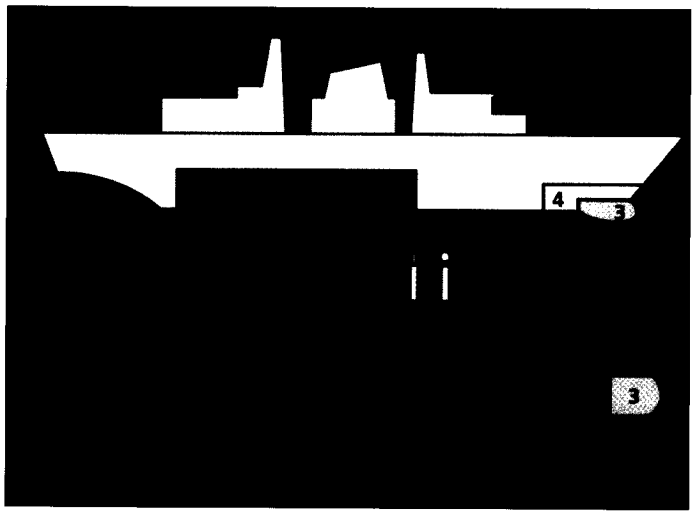
For vessels such as MCMVs it is necessary to deal with the basic problem of magnetic content right from the onset of design and wherever possible to substitute non-magnetic for magnetic material. In such work it is essential to ensure that the substitution of magnetic materials by those of low permeability does not compromise the performance of the equipment.

Electromagnetic Signature (EMS)

EMS differs from magnetic signature both in source of the fields and techniques used to measures and manage it.

There are three main types of EMS: Underwater Electric Potential (UEP – sometimes called Static Electric (SE)); Corrosion Related Magnetic (CRM); and Extremely Low Frequency Electromagnetic (ELFE). Each type of signature results from the electric currents produced in the water around the hull as a result of electro-chemical reactions induced by corrosion of the hull and by the use of Impressed Current Cathodic Protection (ICCP) equipment designed to reduce corrosion of the hull.

The UEP signature is an electric field associated with a DC corrosion current. A primary cause of generation of UEP is the cathodic protection system designed to reduce the corrosion on a metal hull resulting from contact with seawater and the



Typical acoustic treatment for surface vessels and submarines -1. External acoustic cladding and internal structural damping; 2. Decoupling tiles; 3. Sonar dome material and hydrophone encapsulation; 4. Structural damping; 5. Acoustic structural composite material on sail and control surfaces 0123663

minerals in the salt water. Galvanic currents flowing in the hull and in the water around the hull of a ship are created by electrochemically dissimilar metals used in construction which are in electrical contact with each other and the sea. Hence they build up underwater potentials which cause a ship to act as an electric dipole leading to hull corrosion. Without the use of an ICCP protection system the steel hull acts as an anode and the propulsor as a cathode. The current between the anode and the cathode leads to corrosion of the anode (in other words the hull becomes corroded) and the potential between the anode and the cathode produces the UEP signature. The ICCP system provides a negative potential to the hull to ensure that it behaves as a cathode rather than an anode, hence preventing hull corrosion. However, the UEP signature is also associated with the use of corrosion protection currents and the UEP signature flows through the water and creates a near field mine threat.

ELFE signatures are propagated over significant distances at two lower frequency bands and comprise alternating magnetic and electric fields that are generated from four main sources:

- Modulation of corrosion currents (at the propeller and blade rate frequencies)
- Onboard electromagnetic machinery (at power frequencies)
- Ripple in onboard degaussing and ICCP current
- Inadvertent earth currents.

When currents flow through a propeller shaft they are modulated in the bearings by the revolving shaft, and an ELFE electrical field is created and radiated into the water. The ELFE signature can be separated into two definable frequency bands. The power frequency band is measured in the low hundred of Hz, and the shaft rate frequency band up to tens of Hz. The main source of this ELFE signature is modulation of corrosion protection currents resulting from badly filtered ICCP system power supplies. The shaft rate ELFE signature results from the modulation of corrosion protection current flowing to the propeller due to fluctuating electrical resistance in the shaft bearings as the shaft rotates. The frequencies generated are dependent on the fundamental and on the harmonics of the number of revolutions.

ELFE signatures can be used not only as a means of detection in their own rights, but can also be used to confirm an acoustic contact.

The CRM signature is the coupled magnetic field associated with the UEP signature, and becomes significant as the ship's magnetic signature is reduced. Because it is not created from a ferromagnetic source but from the water surrounding a vessel, the CRM signature cannot be controlled or reduced by degaussing. Hence while a GRP MCMV may exhibit virtually no magnetic field, it does exhibit a CRM field.

ELFE signatures can be suppressed by short-circuiting the current loop, and through Passive Shaft Grounding (PSG) and Active Shaft Grounding (ASG). PSG involves adding a slip ring and bushes to provide an extra electrical connection between the shaft and the hull to reduce resistance between the hull and shaft and hence reduce the shaft rate signature. Active Shaft Grounding (ASG) involves sensing the shaft-to-hull voltage difference, the resulting signal being used to control a current which counteracts the galvanic current, resulting in a near zero current in the bearings.

Improvements in sensor technology and data analysis enable these very small signals to be detected and analysed.

The UEP and ELFE signatures can both be used to activate mines, while all three signatures can be used for general detection of a target at much longer range. In fact the CRM signature may have a range much greater than the ship's normal magnetic signature, as it decays at a much lower rate than the latter.

UEP and CRM signatures can be reduced by careful design of the ICCP system so that it provides an adequate level of cathodic protection without creating high levels of UEP and CRM signatures.

UEP and CRM signatures vary over time as a result of a number of factors and hence need to be measured regularly on a range and the ICCP system adjusted.

With the advent of high speed desktop and laptop computers the processing of acoustic and ELFE measurements can take place during the degaussing ranging process without increasing ship time spent at the range site.

Multi-influence Ranging

Multi-influence ranging and signature analysis capability has now become a primary asset in determining the mine threat to a vessel or class of vessels. It provides characterisation of vessel classes, and can identify signature sources on board the vessel. In addition it can provide data on the presence of anomalous signatures such as those caused by fault conditions in equipment on board the vessel and so on.

The now widespread use of high speed desktop and laptop computers enables the processing and measurements of acoustic and ELFE signatures whilst a vessel is undergoing degaussing ranging. This considerably helps to reduce the time a ship has to spend on the range. These technologies have greatly increased navies' flexibility in gathering and analysing the complete spectrum of signature data in the shortest time possible. This flexibility is being further enhanced by the use of transportable, self-calibrating multi-influence ranges which can gather both electromagnetic and acoustic ship signatures both in home waters and in the forward operating area.

Ranges

The sophistication of modern sensors, fire-control systems and weapons demands that the various signatures of warships be reduced to the lowest level possible, in order to reduce the risk of detection and lower their vulnerability to modern weapons. While considerable attention is paid to reducing a ship's various signatures to a minimum, both at the design stage and during construction, it is an undisputed fact that a ship still retains a definite signature, which, like the human fingerprint, enables it to be detected and identified. In order to overcome this limitation, it is essential that the user knows the precise nature of the signatures of his ships, and has available the means to reduce or nullify them or, as is so in some cases, to actually turn them into an advantage.

It is not only ships' signatures that are a vital factor in modern naval operations. Weapon performance and behaviour is continuously under close scrutiny, especially as the ranges and speeds of weapons increase. The discriminating user demands to be reassured as to precisely how a weapon behaves under various operating procedures. This is particularly so in the case of underwater-launched weapons. However, the user doesn't only want to know how the weapon behaves, but also how effective it is in various situations against differing types of target, and how well it can overcome countermeasures which might be directed against it.

The question of knowing precisely what a ship's signature is and how an underwater weapon behaves is achieved using the underwater range. These ranges are so specialised, using such advanced technology to make the delicate measuring equipment, that only a few companies are capable of manufacturing them.

In addition to ranges for measuring acoustic and magnetic signatures, there are also tracking ranges for weapon system development and proving, mine warfare ranges and a very specialised type of calibration range known as FORACS (Fleet Operational Readiness Accuracy and Check System), of which two main ranges for NATO are sited in Norway and Crete.

Acoustic ranges

Acoustic or noise ranges for static and underway measurements of surface vessels and submarines are among the largest and most sophisticated systems worldwide and are normally sited in deep water. However, the shift in emphasis in underwater warfare to the littorals means that it is essential to understand the acoustic radiated noise of quiet submarines in very shallow water conditions. The measurement of noise radiated by a submarine when navigating immersed can be perturbed by reflections of the acoustic waves on the sea surface, which interfere with the acoustic wave coming through the direct path. This is a major issue in very shallow water, where reflections can also come from the bottom and the resulting signal is severely degraded. Somehow this problem has to be overcome both for a submarine to be aware of how its discretion is being eroded when operating in the littorals in very shallow water conditions and for the ASW forces to be aware of how the acoustic transmission from a submarine can be affected in these conditions.

Acoustic ranges are primarily designed for the measurement of radiated noise emissions in order to allow reliable and quantitative assessments of signature reduction measures. The objective is to estimate the acoustic signature transmitted to the receiving hydrophone via the direct path. By siting the range in deep water the amount of energy received at the hydrophone from other paths, particularly via the seabed, is thereby reduced. However, the choice of site for a range is often dictated by other factors such as nearness to the home port (in order to save time by not having to transmit a long distance), and a sheltered area (to avoid interference from the elements which could delay the ranging procedures). Such considerations may mean that ranges are eventually sited in much shallower waters and for this it is essential that propagation loss figures between the platform and receiving hydrophone over the full frequency range of interest are fully known.

Modelling studies have shown that propagation loss is strongly influenced by source depth, especially at low frequencies. This feature results from what is termed as 'surface de-coupling' in which the real source is close to a negative image of itself, and reflected in the (pressure release) sea surface. As the source approaches its image the radiation pattern of the two 'sources' becomes like a dipole which decreases the efficiency of radiation of the source. In addition propagation loss increases with increasing wind speed at higher frequency, but is unaffected at lower frequencies. These, and other factors, have important consequences for direct calibration of a range.

The main types of noise range are:

- the underway fixed range – used to measure the acoustic signature of ships at various speeds and range and
- the portable range – a somewhat less sophisticated version of the fixed range, which can be set up at different sites to measure acoustic signatures.

The portable range comprises a number of hydrophones, suitably deployed from a surface ship or temporarily attached to fixed moorings on the seabed, to measure the noise characteristics of a submarine or surface ship at various ranges, speeds and depths. It is useful for measuring acoustic signatures under different environmental conditions, or when it may not be convenient to send a ship back to a fixed range, or where budgetary restrictions or environmental conditions may preclude the setting up of a fixed range. Portable systems typically cover a circular area of a 2 km radius and can operate suspended from the surface, in depths down to 300 or 400 m. The hydrophones in a portable range must be specially customised to overcome the problem of pressure changes acting on the ceramic head resulting from wave motion which, if severe, can saturate the front end of the preamp in the hydrophone.

Tracking ranges

Modern tracking ranges are capable of tracking up to six vehicles at speeds up to 75 kt with a maximum turn of about 20°/s. Positional accuracy is in the region of 5 m. The hydrophones are laid in a carefully planned arrangement and are calibrated from a surface vessel whose precise position can be fixed with an accuracy of about 2 m.

Magnetic ranges

Equally as important as a ship's acoustic signature is its magnetic signature. In the case of MCMVs it is vital that this signature be known in detail and checked at frequent and regular intervals. It is also essential that such a signature be measured whenever a vessel is assigned to another theatre of operation hundreds of miles away from its current area of operation. A ship's magnetic signature is not only governed by where it was built and with what materials, but also by the earth's magnetic field at that point. Even moving a relatively short distance can considerably alter a ship's magnetic signature. It is essential, therefore, to protect ships from the threat of magnetic influence mines. This can be achieved in three ways by:

- designing a ship for low magnetic content (of paramount importance in MCMV design)
- providing the ship with degaussing coils to compensate for its magnetic field
- treating the ship electromagnetically by the application of a powerful external magnetic field to cancel out its magnetic field (deperming).

Like acoustic ranges, magnetic ranges are configured to fulfil different functions. There are five main types of magnetic range currently in service around the world:

- the open range – used to check the magnetic level of all types of ship and to adjust degaussing coil settings
- the fixed range – used to measure the magnetic effects due to eddy currents, stray fields and induced magnetic fields from which the magnetic field components can be separated using a Z-loop
- the land-based range – used to carry out magnetic measurements on ship equipments, or for modelling purposes on new designs or modifications to determine the coil system necessary to reduce the magnetic signature
- the transportable range – used to process MCMV signatures in the area of operations
- the treatment range – used to deperm, or wipe, a ship using an externally created magnetic field. With the increasing sophistication of modern influence mines, not only MCMVs but also drone sweepers and hunters and ROVs must now have their signatures carefully measured.

The tasks of the degaussing range are to measure the ship's magnetic fields and analyse them to provide resolved components on three axes, synthesise the degaussing coil settings required, and record the measured values for archive purposes and reporting.

Early ranges were of the large fixed type and relied on manual tracking and analysis, which required the vessel to make numerous runs over the range in order for the shore-based operator to manually interpret the plotted signatures and to overcome accuracy limitations. These ranges relied on the comparison of signatures in opposing headings to differentiate between induced and permanent magnetisation. They suffered from the limitation that the horizontal field could not be determined. The next generation of range used automated computerised tracking to achieve faster and more accurate tracking of the ship, determining its position within 1 m. Using triaxial sensors the range provided data on the horizontal field. The computer analysis of the results provided, in addition to a much more accurate signature plot than the manual system, contour and three-dimensional plots. A major step forward with these systems was the ability to carry out coil current synthesis, from which the coil current on the ship could be set to counter the ship's magnetism.

Fixed ranges of any description, however, are not easy to put down, requiring a considerable civil engineering effort and extensive surveying. Nor are they cheap, although they are most cost-effective.

Description of specific types of range is almost impossible as ranges are tailor-designed, built and laid out to suit each specific requirement. Any description of a system must therefore be in general terms.

UPDATED

ACOUSTIC RANGES

Australia

RS5D

Type
Short baseline acoustic positioning system.

Description
The RS5D short baseline acoustic positioning system is designed for deep-water tracking and can be supplied to operate in one of two frequency ranges (22 to 30 kHz or 48 to 56 kHz), the lower frequency band providing a greater operating range.

High accuracy is achieved using multiple hydrophone arrays in a short baseline configuration, offering an accuracy of 0.5 per cent of water depth under normal operating conditions. The basic system uses four hydrophones as a minimum and is capable of operating with up to eight hydrophones.

Signal processing is performed by multiple DSP processors with the main processing power provided by an industrial standard, PC-based processor. The user interface is Windows-based.

The MMI features a keypad on the control display unit, with numeric keys for entering parameter values with software menu options being selected by use of a cursor moved by arrow keys.

The unit retains data relating to the hydrophone and beacon offsets, which obviates the need to re-enter this data when moving to a new location. All the operator has to do is enter the water depth.

The RS5D is ideally suited for dual redundant configurations in which two systems operate independently of each other but in a side-by-side configuration. The RS5D can be configured with up to eight hydrophones, but needs signals from only three of these (selected automatically) to operate; thus, the system has multiple redundant solutions.

Data from one tilt telemetry and three position beacons can be received simultaneously. Position information is compensated for vessel pitch and roll from the data provided by the system's VRU.

The system is available with beacons having source levels which range from 186 dB to 192 dB. In normal circumstances where there are no adverse conditions affecting acoustics, the unit has an operating depth of 2,000 m.

Specifications
Range: 2,000 m slant range (22-30 kHz); 1,000 m slant range (48-56 kHz) with 192 dB beacon
Frequency band: 22-30 kHz (standard); 48-56 kHz (optional)

Contractor
Nautronix Ltd, Fremantle, Western Australia.

VERIFIED

RS 910 series

Type
Ultrashort baseline/long baseline acoustic positioning system.

Description
The RS 910 series of acoustic tracking systems have been the industry standard in ultrashort/long baseline acoustic tracking since first introduced in 1978. The RS 910 models are an upgrade from the RS 900 resulting from replacement of the control console and central processor electronics.

The RS 910 series uses very robust, reliable, free-running pingers, transponders or responders to ensure that the system is tolerant to high ambient noise levels. Applications include ROV and towfish tracking, manned submersible tracking, subsea object positioning, and drilling rig positioning with riser angle differential capability.

The RS 910 electronics upgrade is based on the latest developments in digital signal processing and computer technology, featuring industry standard, PC-based processors, Windows format with high-resolution graphic displays, user-friendly trackerball keypad or mouse interface, a built-in spectrum analyser for online trouble shooting and continuous automatic self-test.

Three modules are available in the RS 910 series.

The RS 912 is a pinger-based USBL positioning system which determines position by phase comparison. It can track up to six beacons with tilt and depth telemetry and differential display of two beacons showing their positions relative to one another. It operates in the 22 to 30 kHz band (17 channels at 0.5 kHz intervals). A low-band frequency option is available. The system is accurate to within 0.5 per cent of slant range for horizontal ranges up to 100 per cent of water depth and to within 1 per cent of slant range for horizontal ranges up to 200 per cent of water depth.

RS 914 is a pinger/transponder based USBL positioning system which determines position using a combination of ultrashort baseline techniques. It offers all the capabilities of the RS 912 plus transponder mode operation for determining position by phase comparison and slant range. It can interrogate five channels at 7, 9, 11, 13, 15 and 17 kHz and respond in 17 channels in the 22 to 30 kHz band at 0.5 kHz intervals. Again, a low-frequency band is an option. The RS 914 is accurate to within 0.5 per cent of slant range for horizontal offsets up to 200 per cent of water depth.

The RS 916 is a pinger/transponder, combined USB/LBL system which can handle the entire spectrum of offshore applications. It offers all the capabilities of the RS 912 and RS 914 plus long baseline operations to determine position relative to a three or four transponder grid. It allows simultaneous operation with both long and ultrashort baselines, and submersible-mode operation using a relay transponder on the submersible. The system can operate in both high (22 to 30 kHz) and low (6 to 15.25 kHz) bands. For high-band frequencies accuracy is 1 m or less with a three or four transponder grid. For low-band frequencies accuracy is 2 to 5 m with a three or four transponder grid.

Operational status
In service with the USN Submarine Development Group for ROV, DSV and DSRV submarine tracking. The oceanographic research ships of the US Navy Thomas G Thompson class (AGOR 24, and 25) and NOAA oceanographic ships have combined RS 916 USBL/LBL tracking systems.

Contractors
Nautronix Ltd, Fremantle, Western Australia.

UPDATED

SARA

Type
Noise range.

Development
The construction of Australia's Collins class submarine by the Australian Submarine Corporation (ASC) mandated a submarine ranging facility in South Australia for the evaluation of the vessel signatures. Nautronix was selected by the RAN to construct a development, and finally a production ranging facility at an offshore location in South Australia. The SARA (South Australian Ranging Activity) facility for the Royal Australian Navy was installed and commissioned during mid-1998. Since that date, the facility has been used for the ranging of Collins and Oberon class submarine as well as numbers of surface vessels.

Description
An essential part of the SARA system is a four octave, nested array of hydrophones that can be deployed either vertically or horizontally in the water column. Varying the orientation of the array permits the operators to provide optimum performance by taking into account the directionality of the ambient noise field. The on-shore processing system includes both conventional beamforming and the unique, synthetic aperture processing (SYNAPS) on all elements in the hydrophone array to provide both temporal and spatial processing gain. The system therefore offers industry standard beamforming and vessel ranging tools while simultaneously providing advanced signal processing algorithms to extract as much information as possible from the vessel signature.

SYNAPS is an innovative underway radiated noise-ranging capability, designed to measure the signatures of vessels that emit very low levels of acoustic noise relative to the background noise environment. Synthetic aperture techniques exploit the movement of the vessel being ranged and long observation times to provide high processing gains as well as information about the distribution of sources on the target vessel. SYNAPS can significantly reduce the complexity of the array, making it cheaper to construct and easing deployment and recovery tasks. In addition to the conventional output products available, SYNAPS technology provides visualisation of the intensity and locations of acoustic sources superimposed on a plan view of the submarine being ranged.

Conducting ranging operations in the unsheltered waters of the facility can place onerous demands on the skills of the vessel operators. To facilitate the ranging operation Nautronix provides a high-accuracy, active acoustic tracking system for deployment on the target vessel. By utilising the co-operative tracking system, the location (range and aspect) of the vessel can be monitored continuously during the ranging, considerably easing the task of both the range and vessel operators as well as improving range safety. Utilising spread spectrum techniques ensures that the low spectral density tracking signals do not contaminate the vessel signature. Moreover, as part of the co-operative tracking system, a low data rate telemetry channel is provided from the target vessel to the range operations centre. The provision of vessel telemetry from a source such as the target vessel combat system can provide invaluable information such as shaft RPM, vessel speed and so on, thereby considerably facilitating the task of interpreting the acquired data.

The SARA facility features:
- high processing gains from the array and SYNAPS processing
- identification and spatial location of noise sources on the target vessel
- extremely effective in high-noise environments

- robust and easy to deploy and recover
- industry standard multiprocessor VME platform using COTS boards
- backups available on digital linear tapes (DLT)
- displays
- power spectrum and power spectral density
- LOFAR diagram with 16 levels of greyscale
- FRAZ displays
- user selectable bandwidth including ⅓ octave spectra over the full band of interest
- Uniform, Hamming, Hanning, and Flat top windowing functions

The SARA system is operated almost entirely from the desktop of a Sun Workstation. All software has been developed in C++ using commercial class libraries where available and appropriate, thereby minimising development time and ensuring system reliability. The data processing platform utilises a multiprocessor concept based on industry standard VME boards. System architecture has been carefully designed for high data throughput and reliability. All acoustic data from each hydrophone is streamed to disk and tape for backup and subsequent detailed analysis.

Data processing software is divided between the real-time and post processing functions. Real-time processing includes beamforming, shading, and steering of the beam to produce various spectral, outputs. Post processing incorporates synthetic aperture processing, transient and spectral analysis, together with generalised database manipulation.

Operational status
The system is fully operational.

Contractor
Nautronix Ltd, Western Australia.

VERIFIED

France

Acoustic ranges

Acoustic Ranges
Using high-dynamic signals input, these ranges are used to locate, identify and measure noise sources on ships. The immersed measurement arrays are made up of hydrophones and/or LF and HF passive antennas.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

GIB-FT

Type
Portable acoustic tracking range.

Description
The GIB-FT (Fast Tracking variant of GIB – GPS Intelligent Buoy) acoustic tracking range has been developed to track high-speed underwater platforms such as torpedoes, decoys, targets and submarines, as well as ASW surface vessels during exercises and trials. The system is able to track simultaneously four underwater vehicles including high speed ones, and four surface or air vehicles.

The system comprises a network of between four and 12 drifting buoys positioned by D-GPS from a rubber boat, acoustic pingers mounted on the platforms to be tracked, surface-air mobile tracking units and a control and display station. The buoys can be anchored to prevent them from drifting. In this configuration they can be fitted with an optional release mechanism, which allows them to be released from the mooring line by a radio command prior to weapon launch. This allows the buoys to overcome any problems encountered by underwater obstacles such as mooring lines. For use in some environments where buoys may not be moored, ACSA has developed a self-propelled buoy (Basil) whose main functioning mode is position keeping.

The buoys are connected by a local radio link to a control and display unit installed on a support ship or ashore at up to 10 km away from the trials area. The buoys periodically transmit their position and the times of arrival of all acoustic signals by radio. Prior to the commencement of trials, the buoys are anchored in position to prevent them from drifting. At the commencement of trials, the buoys are released from their mooring lines by radio command and become drifting buoys. This suppresses any underwater obstacles such as mooring lines.

The buoys comprise a DSP board that accurately time-stamps the acoustic signals when received, a two-way radio modem, a radio controlled release mechanism to release the buoy from its mooring wire and a GPS receiver. The DSP board can detect pingers on four different channels, allowing four different underwater targets to be tracked simultaneously. The current frequencies for pingers range from 8 kHz up to 70 kHz. A remote positioning unit fitted to surface ships or helicopters allows the tracking of above water platforms. The system is compatible with more than 16 different types of pinger. Knowing the time of detection of the acoustic signal on at least three buoys allows the system to calculate the 3-D position of the acoustic pinger. From these signals, real-time 3-D tracks are processed and displayed on the operator's monitor in the control unit. The control unit comprises a deck unit incorporating the radio network controller and two consoles.

Operational status
In service with the German Navy since September 2001. A basic system designed to track one or two vehicles has been supplied to the navies of Denmark, France, Italy and Portugal.

Specifications
Height: 6 m
Weight: 60 kg
Pinger frequency: 8 to 70 kHz
Acoustic detection range: 3.5 km (44 kHz pinger); 2 km (50 kHz pinger) max
Tracking accuracy: <3 m
Autonomy: 8 hours in operational mode, 4 weeks in stand-by
Deployment and recovery: typically 5 min

Contractors
Orca Instrumentation, Brest.
ACSA Underwater GPS, Meyreuil.

UPDATED

Italy

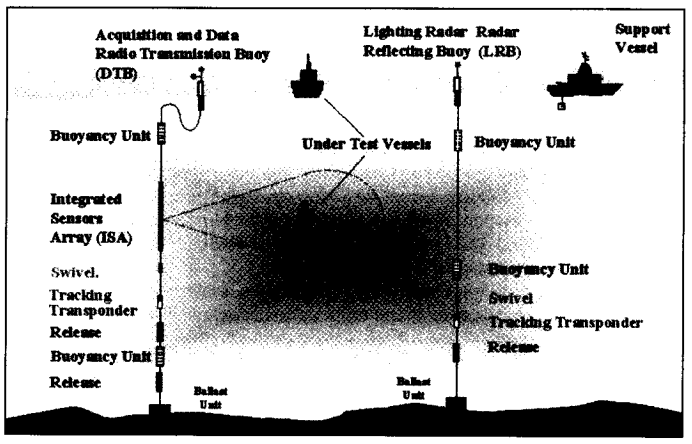
Panor

Type
Transportable acoustic range.

Description
The range consists of four main subsystems:

- The underwater subsystem comprises a hydrophone sensor array connected to a surface buoy, which is linked to a support ship by radio, and an auxiliary mooring for the tracking utilities. The hydrophone mooring includes hydrophone stations, submerged buoys, releasable transponders and vibration insulation components.
- The data acquisition subsystem features a synchronised GPS clock used to collect and record data on-board the support ship. The signal recording and control equipment is contained in an easily transportable shelter that can be installed on the support ship or on the surface vessel being measured. It includes an acoustic navigation system. To ensure complete acoustic silencing of the support ship the equipment is completely powered by batteries.
- A computer operated navigation subsystem uses a synchronised GPS clock for navigation control of the ship or submarine under test. This is located on the ship being measured and includes compensation for the sound speed profile and deformation of the moorings due to tidal streams. To measure the deformation, the moorings are fitted with transducers.
- A data processing subsystem for signal analysis is based on a modern computer system with appropriate peripherals and specially developed software. One-third octave and line spectral data are compensated for frequency-dependent propagation loss and bottom plus surface interference, prior to time and space averaging.

The compact flexible system can be launched and recovered from small vessels. Analysis tools include third-octave analysis, LOFAR analysis, DEMON analysis, transient analysis and accelerometer analysis.



The Panor testing configuration using hydrophones moored on the seabed and radio link for data transmission to a support ship (Whitehead Alenia Sistemi Subacquei)

NEW/1022767

Specifications
Frequency range: 10-40,000 Hz
Acoustic navigation accuracy: better than 2 m
Operating depth: 200 m
Survival depth: 500 m

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

VERIFIED

PTR

Type
Tracking range.

Description
The PTR (portable test range) is a mobile 3-D underwater tracking range used for testing modern underwater weapons in different environmental conditions. It is able to track simultaneously (in real time) the weapon, the launching unit and the target, both in shallow and deep waters, and is capable of offline analysis of the trajectories.

The system consists of between three and 20 retrievable surface buoys connected to underwater hydrophones hung beneath the buoys and providing simultaneous tracking of surface and underwater mobile targets, including artificial targets. The buoys carry UHF transceivers and a GPS link to transmit data between the buoy and the parent surface vessel. Each vehicle to be tracked is fitted with an acoustic transmitter.

The tracking range acoustic technology is based on a long baseline system with SFSK (space frequency shift keying) acoustic signalling suitable for high-speed vehicle tracking. Signalling is accomplished using coded 40-bit transmissions with up to eight operating frequencies available.

The mobile 3-D underwater tracking range can be arranged in different configurations to meet specific requirements and can be laid down in different water depths.

The range has an accuracy of <5 m in the horizontal plane and <1 m in the vertical plane. The range can operate in depths between 10 and 350 m and can provide simultaneous tracking of three underwater devices.

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

VERIFIED

PUAPS

Type
Precise underwater acoustic positioning system.

Description
The PUAPS (Precise Underwater Acoustic Positioning System) is a baseline underwater acoustic positioning system, conceived for oceanographic and offshore applications where high operational accuracy is required. It can position and navigate sea surface and/or underwater vehicles at depths from a few metres down to 1,000 m.

Computed positions are sent in real time by serial link to the external world, allowing operations integrated with other systems.

Two standard configurations are available — long baseline and short baseline configuration. The long baseline configuration provides from 3 up to 8 ITR 100M transponder/releasers, an optional ITR 100M transponder releaser, an acoustic module mounted on the vessel, an acoustic module fitted on the underwater vehicle, a DMR 100M digital range meter mounted on the vessel and connected to a PC system, and a system management based on the PC. This system provides an area coverage of 2,500 m² with a positioning accuracy of ±5 cm (with sound velocity compensation).

The short baseline configuration provides four hull-mounted acoustic modules, a transponder fitted on board each target, a DRM 100M digital range meter mounted on the vessel and connected to a PC, and a system management based on the PC. The system provides range coverage up to 2,000 m with accuracy less than 0.2 per cent of slant range with ray bending compensation and short baseline dimensions of 14 m.

The systems can track and position up to six units.

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

United Kingdom

Noise ranges

Type
Fixed and transportable noise range.

Description
Thales Underwater Systems has manufactured a complete portable noise range for a European navy, which can be deployed in deep water to accurately measure submarine signatures. The data is recorded on IRIG-compatible magnetic tape for subsequent analysis ashore using a mainframe computer.

Standard hydrophones specially designed for noise ranging, manufactured by Sonar Systems, produce a very good polar pattern up to 150 kHz. Different gains, acoustic heads and other variations are available on the standard product, which is suitable for either fixed or portable ranges. These hydrophones are used on a number of UK ranges, including the underway noise range at Rona and the static noise range at Loch Goil, as well as portable ranges for two European navies.

The transportable noise range is highly modular and in its standard form provides three noise measuring hydrophones at selectable depths suspended from a surface buoy some 400 m from the deployment vessel. An active transducer is suspended from the deployment vessel which emits pings for the tracking system. The vessel being ranged carries a self-contained transponder which replies to the active transducer ping. The noise measuring hydrophones receive both the ping and the reply, enabling dynamic position fixing of all elements of the system. The data processing and recording equipment is fitted on board the deployment boat, enabling on and offline position line plotting and noise analysis. Software is also included for offline range normalisation of recorded noise. To assist submariners, the system includes a sonar beacon which may be switched on and off as required.

The fixed underwater acoustic noise range incorporates five variable depth underwater sensors, each connected by its own five-core cable to processing equipment in an onshore, prefabricated, air conditioned building.

The position of vessels being ranged relative to the underwater sensor array is determined by a laser tracking system for surface ships and an acoustic tracking system for submerged submarines, both independent of the normal equipment carried by either platform.

The three-dimensional tracking system has been designed to cover an area of up to approximately 70 km². Capable of operating in up to Sea State 4 the range comprises 20 easily deployed nodes each consisting of a surface buoy and seabed unit which form a distributed system. The nodes accept synchronised acoustic transmissions from vehicles operating over the range. These signals are compressed and sent via radio link to a central receiving and processing vessel. The nodes can be deployed in depths to 300 m and are designed for operations for up to three days before recovery. The system can be quickly deployed and recovered by a small vessel.

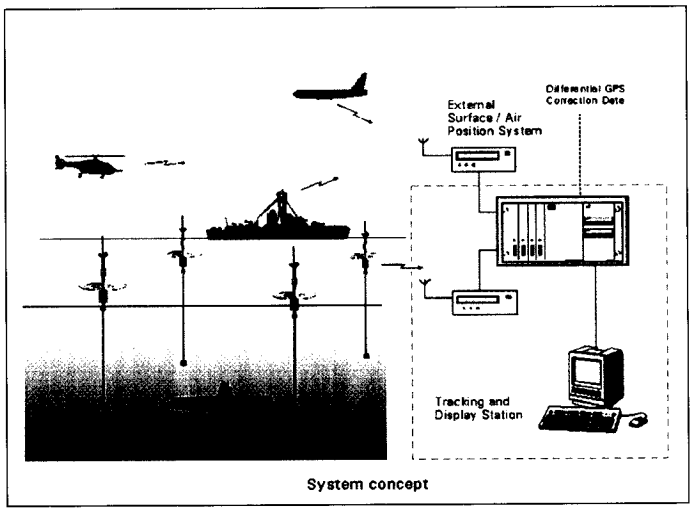
Operational status
In service.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

SMARTTRAK

Type
Open-ocean acoustic tracking system.



Schematic of operation of SmartTrak (Ultra Electronics, PMES) 0043176

Description
SmartTrak is a portable underwater acoustic tracking system that combines well-proven sonar and acoustic technology with specific tracking techniques.

The system comprises four buoyed receiver units and a tracking and display station. The receivers are battery powered and free floating and feature integral GPS. They remain operational in up to Sea State 4. SmartTrak provides accurate positioning to within ±5 m and tracking of up to five separate frequency pingers within a 25 km² area. This can be expanded if required. The system covers all locations from shallow water to the open ocean.

SmartTrak requires no cabling, no seabed deployment and no special lifting equipment or transport. There is also no need for shore-based infrastructure. All items are compact, man-portable and easily deployed from a small vessel.

Operational status
In service.

Specifications
Frequency range: 7-25 kHz

Contractor
Ultra Electronics, PMES, Rugeley, Staffordshire.

UPDATED

UDAMS

Type
Underwater Digital Acoustic Measurement Systems (UDAMS).

Description
The UDAMS is a measurement and analysis system for assessing the acoustic signature of surface ships, submarines and other vessels while underway. In use, the target vessel sails along a defined course across the noise range, past a set of underwater acoustic sensors. The on-shore electronics processes the signals from these sensors to analyse and measure the spectral components of the noise emitted by the target vessel. The system also tracks the actual position of the target vessel as it crosses the range, so that the measured noise can be associated with an aspect angle of the target. The processed signal and target position is also recorded for subsequent re-analysis, either at the range facility, or at a remote noise laboratory.

The acoustic sensors consist of a pair of vertical line arrays of hydrophones placed 100 m either side of the expected track of the target vessels, together with three separate wide-band omnidirectional hydrophones: one placed alongside each line array, the third placed below the expected track, on the seabed. The signals from each of the hydrophones is digitised and transmitted to the shore based processing systems over optical fibre links. The signals from the line arrays are each processed to form a steerable beam that attenuates signals that are incident on the array at angles other than the direction in which the beam is steered. The position of the target vessel is used to modify the beam steer angles for the two arrays so that the target vessel remains within the beams throughout its passage across the range. This allows the noise signals from the target vessel to be analysed with greater sensitivity, since the ambient sea noise from other directions is attenuated. The beam-formed array signals are passed, along with the omnidirectional hydrophone signals, to spectral analysis and recording systems.

Combined acoustic and GPS tracking, based upon PMES' SmartTrak portable tracking equipment is fully integrated into the system. The incorporation of electronic charts, and a specialist Windows® MMI provides a flexible user friendly operation.

Operational status
In service with the Swedish Navy.

Specifications
Frequency range up to 50 kHz

Contractor
Ultra Electronics, PMES, Rugeley, Staffordshire.

VERIFIED

MAGNETIC RANGES

Finland

MGS-900

Type
Signature measurement range.

Description
The MGS-900 is a range system for magnetic, pressure and acoustic signature measurements, optionally also for UEP/ELFE measurements. The system has been developed for use as a permanent or a portable measuring range. The entire system can be built into transportable operating cases managed by two people. The operation of the range is completely computer controlled starting from the sensor units on the seabed. All measured signals are digitised within the sensor unit and sent to the Range Processing and Display Unit (RPDU) via an underwater digital data bus. All signature types are measured simultaneously in one overrun.

The magnetic sensor is a three-axis linear fluxgate magnetometer with a dynamic range of ± 100 μT with an accuracy of 1 nT. Several measurement ranges can be selected. The pressure sensor measures the depth of the sensor unit as well as the pressure signature of the ship. The static pressure range is from 0 to 500 kPa and the dynamic signature range is ± 40 kPa with 20 Pa accuracy. The acoustic signature is measured up to 96 ksamples/s with a maximum signal level of 180 dB re 1 μPa. The sensor units are mounted into GRP installation frames without gimballing and using built-in inclinometers the tilt correction is made by software within ± 15°. The maximum deployment depth of the sensor units is 50 m.

The data link from sensor units to the RPDU is based on the 'LAN on the seabed' technology. The data cabling and protocol meet the requirements of a standard IEEE 802.3 Ethernet LAN (Local Area Network). The sensor units are connected by 45 m long cables to an underwater concentrator (UHUB) unit which is connected to the land-based equipment with a fibre optic cable up to 3 km in length. The standard LAN interface of the UHUB unit allows addition of new types of sensors or other underwater equipment to the same data bus, even independent of the operation of the MGS-900 measurement range.

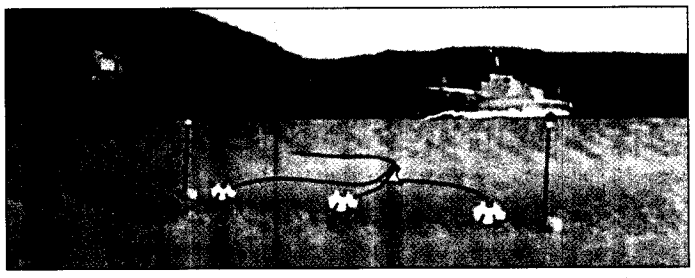
The position of the ship is determined with a laser tracker, laser radar or a differential GPS receiver with radio modem onboard the ship. The heading and trajectory of the ship passing the range are determined by a curve-fitting algorithm, which filters out random errors in ship tracking.

The RPDU computer is a PC workstation. The MS-900 software has a standard Windows user interface for measurement control, graph and report generation and magnetic modelling of the ship. The algorithm models both the ship's signature and DG coil effects on the signature, as well as optimisation of the DG coil current values. The acoustic signature analysis software includes standard narrowband FFT, 1/3 octave and octave analysis features.

Operational status
Seven systems have been delivered since 1994. The latest delivery took place in 2004.

Contractor
Elesco Oy, Espoo.

UPDATED



The MGS-900 with three magnetic/pressure sensor units and the underwater concentrator (UHUB). The onshore shelter houses the RPDU and the ship tracking system
0089204

France

Magnetic ranges

Type
Overrun and component ranges.

Sea degaussing range
The two types of degaussing range manufactured are the open range, in which the vessel follows a track across a line of sensors, and the fixed range, in which the vessel is moored in a stationary position above the sensors. The ranges feature a limited number of sensors and highly sophisticated modelling software. These are used to predict a ship's magnetic signature under varying conditions and to prepare the design of degaussing systems. Ranges are operational in the UK and Norway.

Magnetic land range systems
These systems are used to carry out a full analysis of the magnetic characteristics of all equipments to be installed on a ship. The systems comprise a fixed magnetic range to measure magnetic signatures from which the necessary degaussing corrections can be calculated, deperming equipment studied, and the effects of roll and pitch on magnetic signature together with stray field effects measured.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Germany

Component range

Type
Magnetic ranging facilities for components.

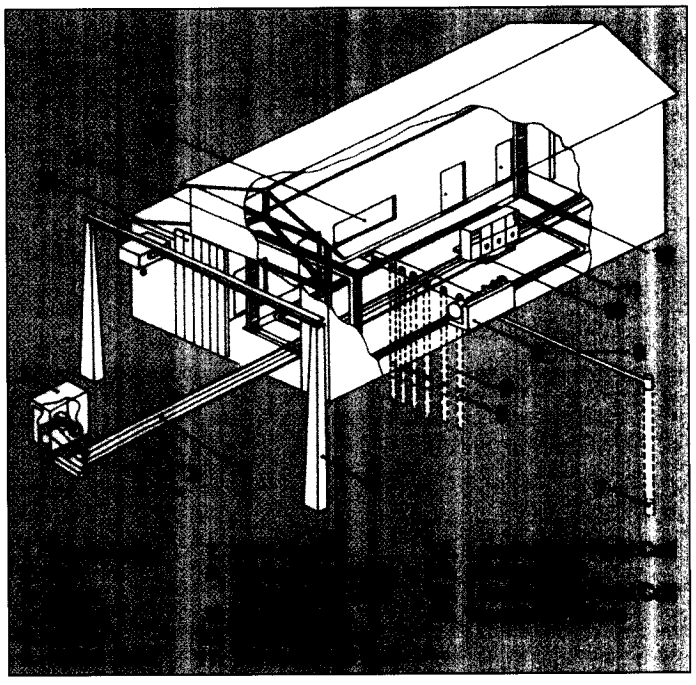
Description
This type of range is designed to provide measurement of magnetic conditions and magnetic treatment — if considered necessary — of components such as diesel engines, generators and so on, prior to installation on board the MCMV.

As an additional feature, the range provides facilities for the evaluation of magnetic models concerning the ship's magnetic behaviour.

Measurements and treatment activities are computer-controlled and supported by suitable software measures.

Contractor
SAM Marine Electronics GmbH, Hamburg.

VERIFIED



Magnetic ranging facility for components

Land range

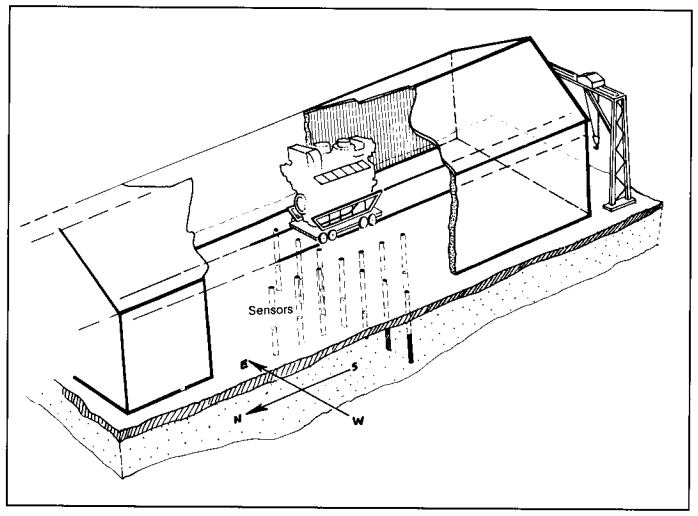
Type
Magnetic measurement system for ships' components.

Description
The magnetic measurement of items of equipment for installation in a ship constitutes part of its proof of performance to appropriate specifications.

The measurement, deperming and degaussing are consecutive operating processes which may need to be repeated until the minimum or acceptable interference field is achieved.

The equipment to be measured is traversed over a specially defined arrangement of sensors on a measuring track arranged in a north-south direction. The non-ferromagnetic test carriage is provided with a platform which can be rotated through 360°. The object-specific permanent fields, the fields induced by the earth's field and, where necessary, the electromagnetic stray fields produced by the object under test itself are measured, analysed and recorded. The sensors and the measuring electronic equipment are all components of the Foerster Magnetomat magnetic measuring system.

Contractor
Institut Dr Foerster GmbH & Co KG, Reutlingen. ***UPDATED***



Magnetic measurement system for ships' components

DEG-CAD

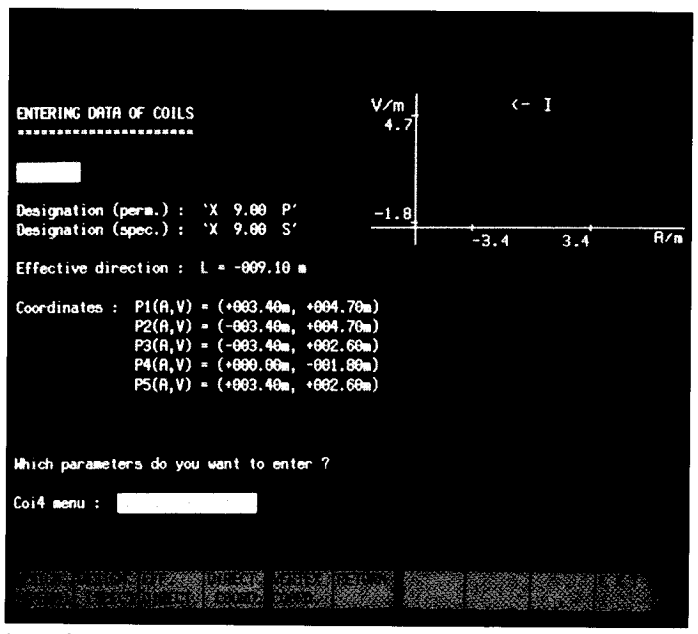
Type
Magnetic modelling system.

Description
DEG-CAD is a computer supported design tool for the magnetic modelling of non-magnetic ships such as MCMVs. It allows prediction of the magnetic behaviour of the vessel at an early stage in its design.

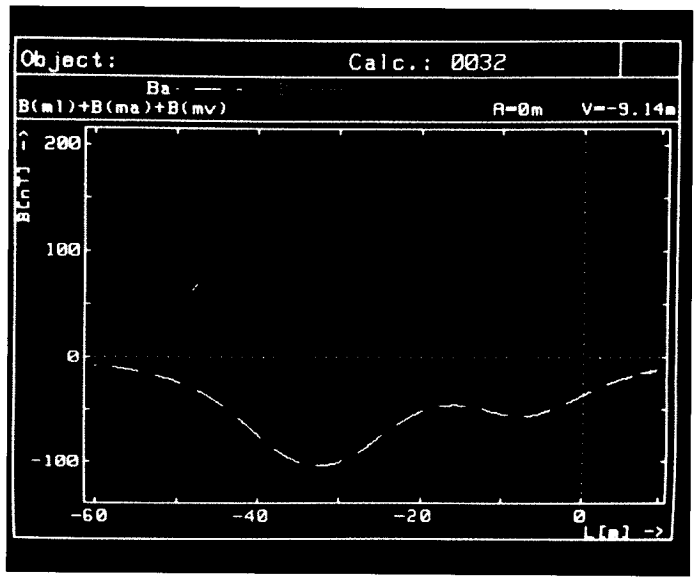
In addition, the system provides algorithms for calculation of the degaussing coil system needed and allows a forecast of the ship's degaussed condition.

The magnetic model is generated individually for each type of vessel. This is achieved by simulation of the magnetic dipole distribution of the ship.

Magnetic modelling requires basic information concerning the general layout of the vessel, its steel components with their installation co-ordinates, permanent and induced magnetic moments and so on. Based on these inputs and taking up to 1,200 dipoles into account DEG-CAD creates a magnetic model and calculates the interference field of the undegaussed ship.



Input of coil parameters of DEG-CAD (SAM Marine Electronics) 0131874



Interference field of an undegaussed ship, calculated by DEG-CAD magnetic model (SAM Marine Electronics) 0131875

The interference field is calculated for the desired depth level and represents the vertical, longitudinal and athwart ship magnetisation of the vessel.

The tool provides the capability for calculation of the magnetic performance of any degaussing coil configuration. As a prerequisite for the calculation the physical arrangement of the coil system within the hull as well as the electrical data, have to be defined.

In subsequent operations, DEG-CAD calculates the magnetic field created by the coil system.

By superimposing both the interference field of the undegaussed vessel and the magnetic field generated by the degaussing coils, DEG-CAD determines the ship's magnetic signature in the degaussed condition.

Iterative modifications of the coil data such as change of turns and/or coil currents permits improvement of the degaussing condition until the magnetic goal is achieved.

DEG-CAD provides support to the naval architect in the design stage of a ship in order to predict the expected magnetic signature of the ship. The tool further allows immediate verification of design changes concerning their magnetic effects.

Contractor
SAM Marine Electronics GmbH, Hamburg. ***VERIFIED***

Mobile overrun range

Type
Transportable open range.

Description
Open sea ranges are primarily check ranges. The initial object of ranging is to check a vessel's degaussed state before operation and to perform magnetic calibration exercises. Being simple and rapidly installed the transportable degaussing (overrun) range, which requires only one range array, provides a cost-effective solution to providing facilities to meet logistic and operational requirements in areas where fixed facilities are not available. The transportable range can be set up in a very short time using a limited number of sensors and structures. Such a system can provide measurement, recording, analysis and reporting of actual magnetic states of ships.

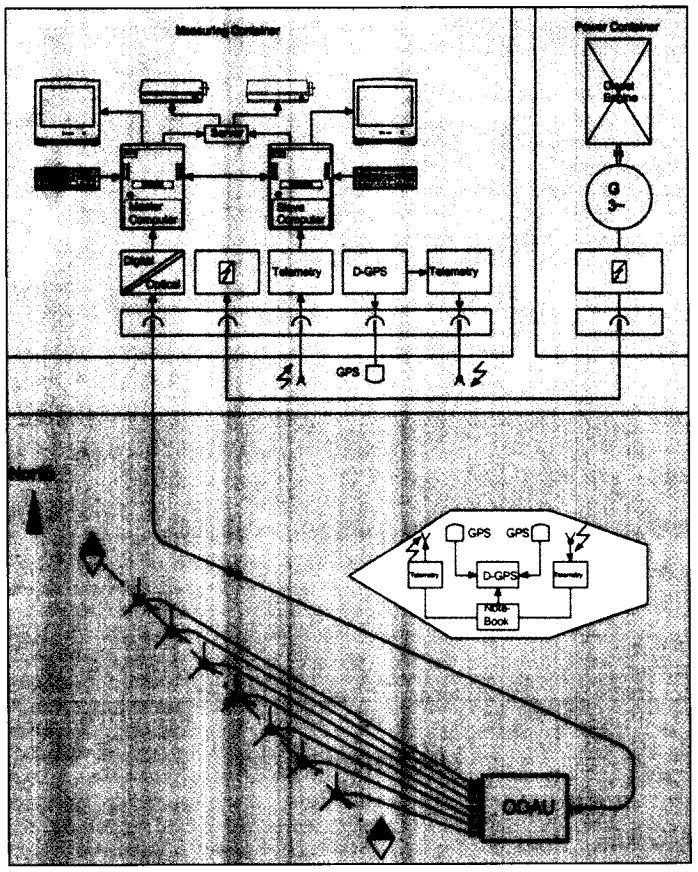
The main components of the range are a transportable framework, an ISO container used as the range house, the Foerster magnetic measuring system Magnetomat and the tracking system (no separate system is necessary as specialised software and range sensors are used).

Contractor
Institut Dr Foerster GmbH & Co KG, Reutlingen. ***UPDATED***

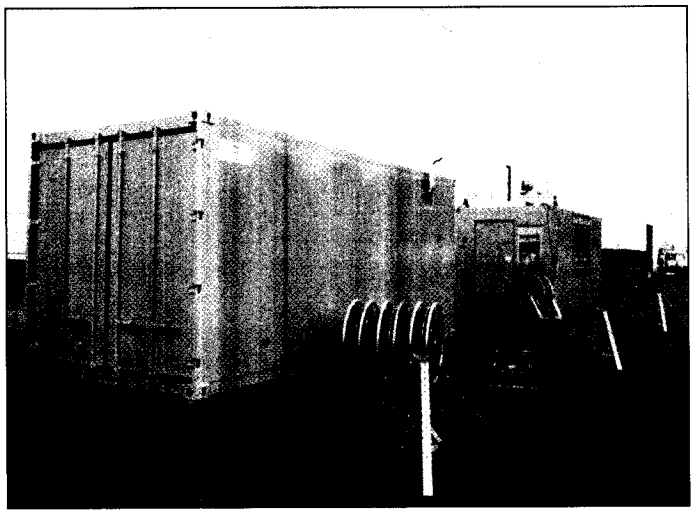
Mora Sym

Type
Mobile magnetic ranging system.

Development
The development of advanced magnetic sensors and versatile application software for data evaluation and analysis has made possible the development of mobile



Mora Sym system configuration (SAM Marine Electronics) 0131876



Power and storage and measuring ISO container with offshore equipment (SAM Marine Electronics) 0131877

magnetic ranges combining high performance with reduced expenditure for equipment and infrastructure.

Description

All the equipment for the Mora Sym mobile magnetic ranging system is housed in two 20 ft standard ISO containers that are sea/air/land transportable. The range is fully independent of extensive shore support and offers rapid mobilisation and demobilisation without the assistance of divers.

The system features active triple probes with front-end electronics and data transmission via a fibre optic transmission path with active underwater interface unit. The probe array is suitable for ranging all classes of naval vessel and requires a minimum of manoeuvring space. Tracking of the vessel being ranged is accomplished using DGPS. Mora Sym uses extensive software for data processing and analysis of ranged data. There is growth potential for the integration of additional sensors to expand the range's capability.

The range comprises an intercardinal probe array for ranging MCMVs, steel surface vessels and submarines and the offshore data acquisition unit (ODAU) including fibre optic cable, and the containerised onshore facilities for acquisition and analysis of the probe signals and control of the entire range facility.

The minimum configuration of the probe array comprises five active triple probes with front-end electronics and suitable probe housing for underwater installations. The alignment of the probe array is in intercardinal direction (45° with reference to magnetic north).

Ship overruns during ranging can be effected on cardinal headings as well as on intercardinal headings.

The triple probes are connected to an offshore data acquisition unit via conventional cables and underwater plug connections. This unit converts the probe signals into corresponding data telegrams and transmits them, via the optical transmission path, to the shore-based data processing system.

The data processing system analyses the raw data of the probes taking into consideration the course data obtained from the DGPS. It transforms them into sets of measuring data correlated to the coordinate system of the vessel.

In addition, the system performs all control and monitoring functions during the ranging process.

The DGPS comprises stationary onshore equipment, a GPS reference station and mobile ship equipment that is temporarily placed on board during ranging. The GPS reference station receives corrective satellite data and transmits them for processing in DGPS-mode.

For analysis of the measured data the operator is provided with extensive user-friendly system software, having a clearly structured operator interface.

Contractor

SAM Marine Electronics GmbH, Hamburg.

VERIFIED

Open range

Type

Dynamic overrun measuring system.

Description

Dynamic overrun measuring systems are permanently installed monitoring stations for strategically important ships endangered by mines.

If the interference field exceeds known critical limit values, degaussing measures must be taken. Further overrun checks qualify the ship for the intended operation.

Following a north-south course and then an east-west course, the ship passes over a perpendicularly arranged chain of magnetic field sensors. This enables measurement to be conducted in two extreme courses with respect to the earth's field. The vertical Z component of the interference field is usually measured with uni-axial sensors. The depth and spacing between the sensors are matched to the type of ship in question.

Measured value acquisition, data processing and representation are carried out using several channels, analogous to the number of sensors or their measuring axes.

This produces, for example, graphical weighted pictorial relief representations in the longitudinal and cross-direction of the ship and these can be assigned geometrically by tracking the ship visually.

Contractor

Institut Dr Foerster GmbH & Co KG, Reutlingen.

UPDATED

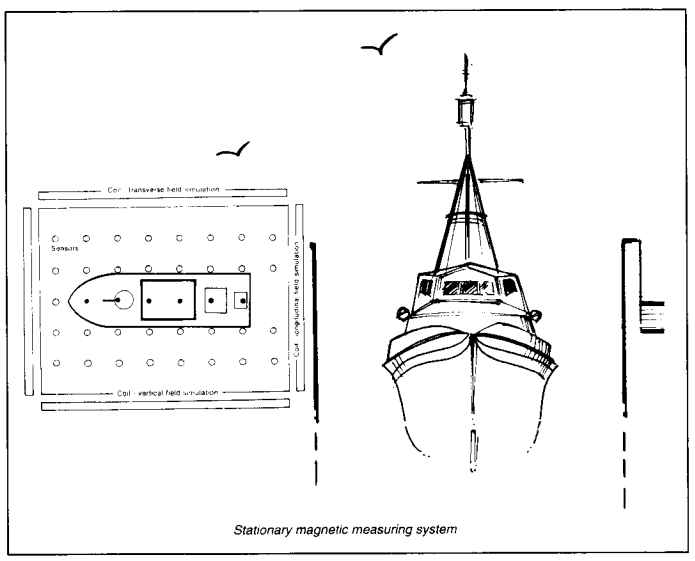
Stationary range

Type

Stationary magnetic measuring system.

Description

A stationary measuring system with simulation equipment enables all magnetic fields occurring during operation of the ship to be measured and analytically



Stationary magnetic measuring system

separated in rest conditions. These comprise the ship's own permanent fields, course-dependent induced fields, electromagnetic stray fields, and course and position-dependent eddy current fields resulting from pitching or rolling.

The ship rests above a carpet comprising multi-axial sensors whereby the integral interference field is measured with one, two or three axes in a horizontal plane beneath the ship.

Because of the array of sensors distributed over a large area comparable with the size of the ship and owing to measurement in several axial directions, the interference field analyses and the results of monitoring are more precise, provide more information and are thus more reliable. The advantage of a stationary system as compared with the dynamic overrun measuring system lies in the fact that any particular and temporary change in the earth's fields can be simulated with the aid of large area current coils arranged horizontally and vertically. This also enables the stray field of the entire ship to be monitored in the rest condition for pitching and rolling. It is also possible to simulate known earth field data of intended zones of operation and thus obtain and program the degaussing variables required for self-protection.

Contractor
Institut Dr Foerster GmbH & Co KG, Reutlingen.

UPDATED

Italy

Mine warfare testing range

Type
Mine warfare range.

Description
The range is designed to evaluate the effectiveness of mines against naval targets, the effectiveness of MCM operations against various types of mines, and the level of risk for MCM vessels and military and civil traffic.

The range consists of various equipments deployed at sea together with a shore base comprising a master and two remote stations.

At sea a series of exercise mines is acoustically linked with control buoys, and with a mine positioning system installed on board an auxiliary ship and able to compute, before each exercise, the exact position of all the mines in the range.

A communication system links the buoys to the computing centre in the master station. A ship positioning system tracks all the surface ships (targets) with high accuracy using interrogators in the master and remote stations and transponders installed on the target ships.

The computing centre acquires the information from the mines (activation, self-protection) and correlates the data with the time and with the ship positioning information. Data is displayed in real time on a graphic workstation and recorded on magnetic tape for subsequent analysis. Plottings and colour printouts are available to the operators.

The computer system comprises a DEC high-resolution graphic workstation equipped with disks and tape units. Peripherals include a printer, colour hard-copy, plotter and an alphanumeric terminal. The application software is written in Ada and it has been designed with the HOOD methodology with extensive support of CASE tools (Teamwork).

Operational status
The range is installed near the naval base at La Spezia and has been in use with the Italian and other NATO navies since 1997.

Contractor
Datamat Ingegneria dei Sistemi SpA, Rome.

VERIFIED

United Kingdom

Magnetic signature measurement

Type
Magnetic sensor assemblies.

Description
The fixed range system includes a linear intercardinal array of equispaced three-axis magnetic sensor assemblies individually mounted either on concrete limpets or on pile-type structures in the seabed.

At each end of the line array additional seabed structures incorporate an acoustic transponder for unit position measurement and a depth measuring sensor. Optionally, this unit can also be modified to monitor noise signals of the vessel. The data processing approach used does not demand a high alignment accuracy but does require an accurate knowledge of the actual position of each sensor. Digitised data from the sensors are transmitted by cable to a shore instrumentation facility.

The control instrumentation both supplies the array sensors with power and translates the communication link for use by the range computer. The cable has been designed to ensure very reliable operation after long-term immersion on the seabed. It is of small diameter with single cables being used for each sensor. This minimises the problems in cable laying, recovering and relaying, and enables proven wave zone protection techniques to be used. Avoidance of the use of junction boxes and use of single cables significantly increases range availability, particularly when cable damage occurs.

The computer system is based on the MicroVAX II, as this meets the processing requirements, providing the power necessary to implement the data processing approach and to make available the required signature and coil prediction data to the operator on demand.

Associated with, and digitally linked to the shore instrumentation facility is a laser-based tracking system which also provides data for the helmsman. The data, in the form of distance to go to array and distance off track, are communicated to the vessel by RF link. The laser tracker also requires the temporary addition of two omnidirectional prism reflectors to the vessel so that heading information can be obtained. For the transportable system, which would use single-axis magnetic field sensors assembled into independent but coupled sub-arrays, and as an option on the permanent range facility, magnetic tracking can be provided.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

United States

MSMS

Type
Magnetic Signature Measurement System (MSMS).

Description
This advanced system measures with precision the magnetic signature of ships and gathers, records, processes, stores and displays the data during magnetic ranging and treatment operations.

The system accurately and rapidly ranges both submarines and surface ships to determine the need for magnetic treatment. It also provides critical magnetic measurement readings throughout the deperming process.

With this system, magnetic signals emitted by ships are sensed by underwater magnetometers and recorded simultaneously. Shore-based data acquisition and analysis equipment receives and processes the sensor data to provide, in minimum time, an accurate profile of a ship's magnetic state.

Field measurements are achieved through the use of submerged magnetometers placed in tubes located in the ocean floor. These sensors can also be inserted in a bottom-mounted tube structure, at a customer's option, to give transportability to the system.

Each magnetometer provides a DC voltage that is proportional to the magnitude of the magnetic field component along its magnetic axis.

These sensors are capable of measurement of dynamic range of ±200,000 nT, noise of less than 0.1 nT in a DC to 10 Hz bandwidth, resolution equal to or less than 0.1 nT, and linearity of 0.005 per cent.

Magnetometer outputs can be digital or analogue. These outputs are routed through junction boxes to the interface electronics in the data acquisition console and to a digital computer.

Signatures for keel and athwartship are processed, analysed and displayed. A determination is then made as to whether to record the information.

Raytheon measurement facilities are interactive systems. Software controls the intra-system interface between magnetometers, the interface electronics and standard computer peripherals.

The operator directs the system computer to collect and analyse magnetic field data using appropriate software programs. These programs direct system activity and query the operator for data inputs and desired measurement parameters for ships undergoing treatment.

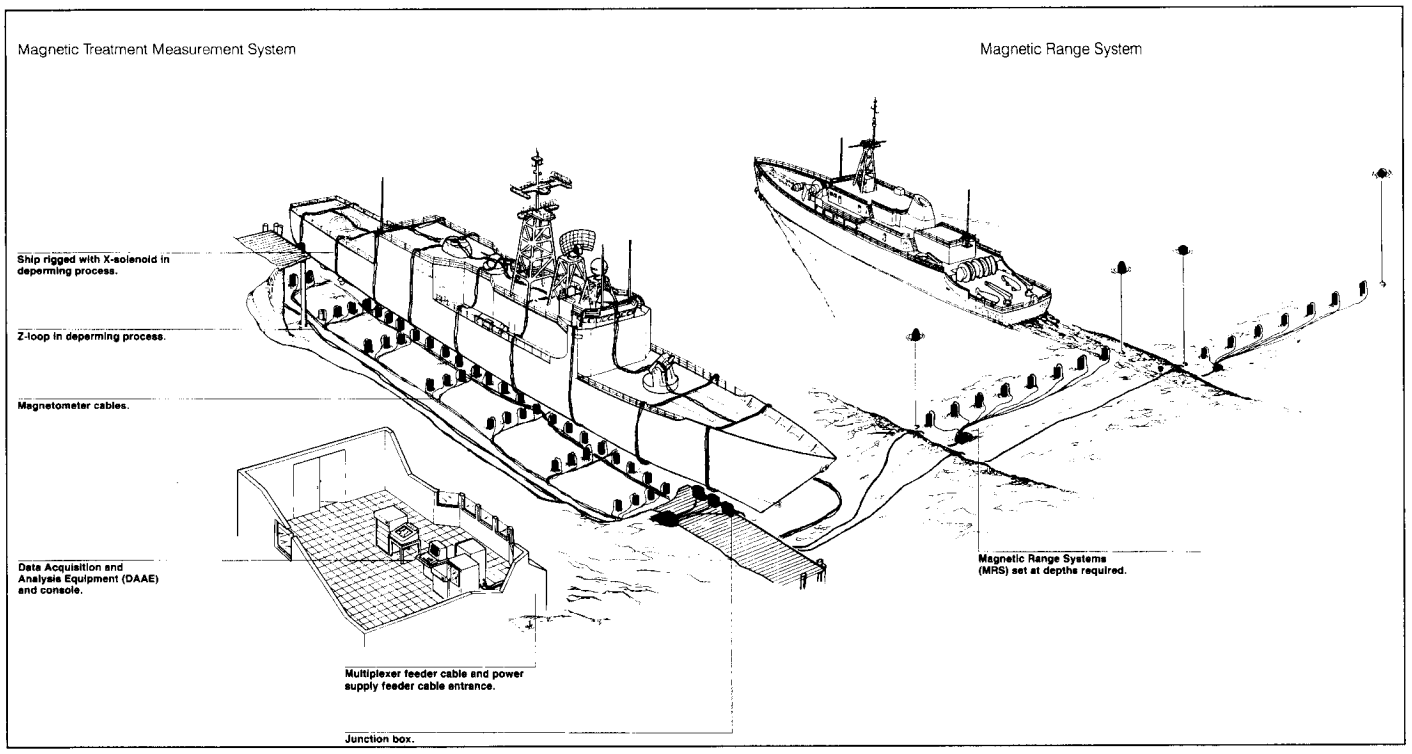
In response to data and computer commands entered by the operator, the system collects and stores magnetometer data, performs calculations and displays results relative to the magnetic treatment process.

The system is highly automated and includes data processing and display equipment and specially designed underwater magnetic sensors. It consists of several distinct subsystems.

The Magnetic Range System relies on two arrays of magnetometers, shallow and deep, to range ships. User vessels pass over the sensor arrays at least once in each direction, with signatures continuously recorded via shore-based equipment. This subsystem can also be used to calibrate ship degaussing systems.

The MSMS operates in conjunction with a fixed deperming facility. It uses a keel line of magnetometers to measure signature levels before, during and after deperming operations. User ships are moored over the sensor array and signatures recorded on command and at the appropriate time via shore-based equipment.

These subsystems, although independent, share common data acquisition and analysis equipment. Off-the-shelf hardware is used extensively throughout system designs. A modular approach to design, with key components separate from one



Raytheon MSMS system

another, will enable new features to be incorporated in the future with minimal system upgrade.

Operational status

MSMS is fully operational and meets US Navy requirements for performance, logistics support and life cycle costs. Early in 1991 Raytheon was awarded a US$21.9 million contract to design, build and install an advanced magnetic treatment at the US Navy's Trident Magnetic Silencing Facility in Kings Bay, Georgia. The automated system rapidly scans the submarines to determine the required magnetic treatment and then deperms them by removing or altering their permanent magnetism. In May 1991, Raytheon won a US$16 million contract to build two Type IV magnetic silencing ranges at San Diego, California and Mayport, Florida. The two systems are now operational.

Contractor

Raytheon Systems Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

VERIFIED

MULTI-INFLUENCE RANGES

France

MIR 2000

Type
Portable multi-influence ranging system for surface ships and submarines.

Description
The MIR 2000 is a multi-influence portable ranging system for any kind of vessel. It can be used either in a fixed range mode or in a portable mode.

As a result of new environmental conditions or the installation of new equipment configurations, the signature of a MCMV may be degraded. Before commencing mine sweeping or minehunting operations, the officer-in-command must evaluate the vessel's signature to determine safety limits under which it can carry out the operation.

The MIR 2000 is an easily transported system which can be fitted on board any vessel including MCMVs or smaller vessels. It is a fully autonomous system which is deployable in less than 4 hours. The system carries out simultaneous measurement of: magnetic AC and DC fields; electric AC and DC fields; acoustic influence; pressure/water depth; seismic influence; and the gradients of magnetic fields.

The range can be configured for use either as a portable range, a fixed range, or for use with exercise mines.

The control operation is divided into two phases: measurement from a small craft involving three runs with a duration of 30 minutes for collection of data followed by a 10 minute phase for the checking of the measurements and data transfer on to magnetic medium for analysis on board the parent ship. The analysis phase on board the parent vessel involves analysis of the data on a work station and comparison with previously recorded measurements.

The outboard equipment comprises a Thales Underwater System TSM 3207 multi-influence sensor and a set of cables with drums. Inboard equipment consists of a power generator, an interface electronic unit, DGPS (Differential GPS), and a workstation.

Various options are available including: additional cable; mechanical protection against shocks (titanium construction); a non-magnetic releasing system; additional sensors and software for modelling; and data transmission via radio link.

Specifications
Sensors

Type	Technology	Bandwidth
DC magnetic field	3-axis fluxgate	DC to 5 Hz
AC magnetic field	3-axis fluxmeter	5 – 3,000 Hz
LF electric field	3-axis silver/silver chloride electrodes	0.01 – 5 Hz
AC electric field	3-axis silver/silver chloride electrodes	5 – 3,000 Hz
Acoustic influence	Piezoelectric hydrophone	10 Hz - 10 kHz
Depth/pressure influence	Absolute sensor	DC to 2 Hz

Physical characteristics
Operating depth: <50 m
Multicoaxial cable: Length 100 m
Inboard equipment: Weight 100 kg

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

International

FACDAR

Type
Transportable magnetic and acoustic signature measurement range.

Description
The FACDAR (Forward Area Combined Degaussing and Acoustic Range) is designed to provide ships with protection against influence mines. The range is based on the highly successful transportable degaussing range used in the 1990-91 Gulf War by all the allied navies.

The range comprises the former Alliant Techsystems' Marine Systems (subsequently Hughes Aircraft, Naval and Maritime Systems, now part of Raytheon) acoustic instrumentation and power distribution system combined with Ultra Electronic's Transmag degaussing system.

The system, which is housed in three standard ISO containers, is designed to measure accurately a ship's magnetic and acoustic signatures using proven, reliable, COTS and non-development equipment. It features a single, digital, dual-fibre optic range-to-shore cable and a Differential Global Positioning System (DGPS)-based, real-time vessel-tracking capability.

There is capability for additional sensors, including Underwater Electric Potential (UEP) and Alternating Magnetic (AM).

FACDAR measures a ship's magnetic, acoustic and pressure signatures as it passes over an undersea sensor array. The signature data is analysed and displayed on IBM-compatible computers in the system's portable range house. Recorded in digital format, the data can be archived and retrieved for future analysis.

The signature analysis allows a ship to:

- set the onboard degaussing system to minimise the magnetic signature
- check for satisfactory operation of the degaussing coil system
- set up the vessel for operation at any global location
- adjust the onboard system to accommodate failed or faulty individual coils
- measure the noise-radiated acoustic signature of the vessel
- compare the vessel's acoustic database to monitor degradation
- complement any onboard vibration monitoring and analysis system
- identify any item of equipment that causes the vessel to be out of its acoustic radiated noise specification.

Operational status
A contract was awarded for one prototype FACDAR and five production units, including spares and tracking equipment. One unit is deployed at Sasebo, Japan and a second at Panama City, Florida. Four other units are in storage at Norfolk, Virginia.

Specifications
Magnetic sensor
Dynamic range: 0 to ±100,000 nT
Accuracy: 0.5 nT or 0.5% (whichever is greater)
Bandwidth: DC to 15 Hz
Resolution: ≤3.05 nT @ ±100,000 nT; ≤0.76 nT @ ±25,000 nT; ≤0.095 nT @ ±3,125 nT

Acoustic sensor
Max signal level: 160 dB re 1μPa
Accuracy: 0.5 dB
Bandwidth: 2 Hz to 30 kHz
Resolution: 0.1 dB max from full scale to 51 dB below full scale

Pressure sensor
Dynamic range: 10 bar
Resolution: <300 Pa 0.1 dB maximum

Contractors
Ultra Electronics, PMES Hednesford, Cannock, Staffordshire, UK.
Raytheon Systems Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

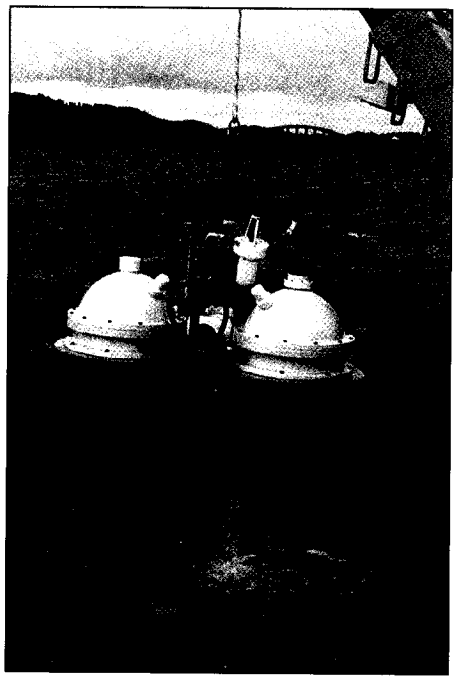
UPDATED

LUNDAR

Type
Multiple sensor platform.

Development
Development of LUNDAR (Littoral Underwater Data Acquisition Rover) began in 1998 under a bilateral co-operation project between the Norwegian Defence Research Establishment (FFI) and GESMA (Group d'Etudes Sous-Marines de l'Atlantique) of France. Under the project, two prototype vehicles have been built, one for FFI and one for GESMA.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com



The FFI-owned LUNDAR being deployed from the Norwegian mine warfare vessel KNM Tyr
0111207

Description
The LUNDAR environmental data buoy is a mobile multisensor system which can be deployed from a MCMV or research vessel to monitor influences from surface vessels. The sensor data gathered is used to assess the effect of the environment on signature propagation, environmental noise characterisation, signature assessment of target vessels in the field, and signature control of influence sweeps, and so on.

The system comprises an undersea-deployable instrumentation platform that communicates with a shipboard unit via an acoustic link. The vehicle incorporates expanded sensor capabilities to enable nine physical states to be measured. These comprise: magnetic, electric, seismic, pressure, water velocity, acoustic (from 4 Hz to 3.2 kHz and from 700 Hz to 100 kHz), conductivity, temperature and sound velocity. The platform also measures its own attitude and features a clock function that synchronises the sensor operations.

The vehicle has an autonomous endurance of up to 30 days and can be deployed at depths to 100 m.

Other features of the system are: flexibility of programming, data storage, and controlled mode of operation intended for target signature acquisition.

Among the tasks for which LUNDAR can be used are:
- MCM
- Environmental research
- Mobile test and ranging
- Area mine threat assessment
- Covert data gathering

Operational status
Two units are being used, one by the Norwegian FFI and the second by the French GESMA. The FFI unit will eventually be handed over to the Norwegian Navy for use when deploying overseas.

Specifications
Triangular size: 1.8 m
Height: 1.9 m
Weight: 400 kg (in water), 1,500 kg (in air)
Operating depth: 100 m
Endurance: 30 days (autonomous)

Sensor	Features	Bandwidth	Range (max)	Total dynamics/ resolution
Magnetic	Tri-axial	5 mHz – 500 Hz	±70 μT	140 dB
Electric (UEP)	Tri-axial	5 mHz – 500 Hz	±3 mV/μ	160 dB
Seismic	Tri-axial	1 – 100 Hz	±8 mG	100 dB
Pressure	Omni	DC – 2 Hz	1.38 Mpa	111 dB
Water velocity	Tri-axial	DC – 2 Hz	6 m/sec	76 dB
Acoustic I	Omni	4 Hz – 3.4 kHz	178 dB	146 dB
Acoustic II	Omni	700 Hz – 100 kHz	181 dB	136 dB
Conductivity		DC – 2 Hz	0.2 – 7.4 Siemens	Res: 0.001 Siemens
Temperature		DC – 2 Hz	–5 – +45° C	Res: 0.01°
Sound velocity		DC – 2 Hz	1,380 – 1,580 m/s	Res: 2 m/s
Attitude	Compass Inclination	DC – variable (1 Hz nominally)	-	-

Contractors
FFI, Oslo, Norway.
GESMA

UPDATED

Norway

Herdla

Type
Multi-influence test range and training facility.

Description
The Herdla test range is sited in a wide open sea area of a fjord near Bergen in Norway and provides the Norwegian Navy with a very versatile and important tool in developing the target simulation mode concept for influence sweeping, as well as training for operators involved in MCM tasks. It has been established chiefly for the evaluation, maintenance and control and studies into the passive physical signatures of ships, weapon systems, ROVs and divers.

The range comprises four seabed mounted clusters of sensors at water depths ranging from 25 to 90 m some 800 m off the nearest coast. Each sensor group within the cluster is hard wired and connected by underwater cables to a joint power/communication module (PCM) on the seabed. While servicing all the sensors the PCM receives power and communicates to the land station on a single power and signalling optical fibre cable.

The clusters are arranged so that the various signatures of target ships and MCMVs can be measured at various propagation angles, distances and depths as the ships pass through the range. The clusters of sensors are used to measure acoustic, seismic, hydrodynamic, magnetic and UEP signatures the measurements being complemented by object tracking data and sensor data relayed back to the vessel.

The shore station incorporates a communication and data acquisition computer that provides the complete instrumentation for the system, including reference sensors ashore and navigational information, display status and recording of data. A high bandwidth radio link relays data to receiving stations on the vessels. Laser, GPS or radar tracking data is available through the measurement process.

The instrumentation equipment, data acquisition architecture and auxiliary function of the test facility are tailored to provide:
- Test and evaluation of vessel and weapon system passive signatures.
- Maintenance/control of signatures of vessels, weapon systems, ROVs and divers.
- Tactical training with MCM assets.
- Studies into underwater signature generation and propagation (of ships and weapon systems).
- Studies/evaluation of environmental impact on signature behaviour.

Operational status
The range became operational in 2001 and as well as providing facilities for the Norwegian Navy can also be made available for tactical training and evaluation purposes for other NATO members.

Specifications
Sensor Specifications

Sensor	Features	Bandwidth	Range (max)	Dynamics (max)	Remarks
Magnetic I	3-axial	DC – 20 Hz	100	120 dB	SM-platform
Magnetic II	3-axial	5 mHz – 500 Hz	70	140 dB	EM-platform
UEP	3-axial	5 mHz – 500 Hz	3 mV/m	160 dB	EM-platform
Seismic	3-axial	1-100 Hz	8 mG	100 dB	CPA-platform
Pressure	Omni	DC – 2 Hz	1.38 Mpa	111 dB	CPA-platform
Water velocity	3-axial	DC – 2 Hz	6 m/s	76 dB	CPA-platform
Acoustic I	Omni	4 Hz – 15 kHz	178 dB	146 dB	One sensor group only
Acoustic II	Omni	700 Hz – 100 kHz	181 dB	136 dB	
Attitude	Compass inclination	DC – variable (1 Hz nominally)			Only for sensor reference information

Contractor
FFI, Horten.

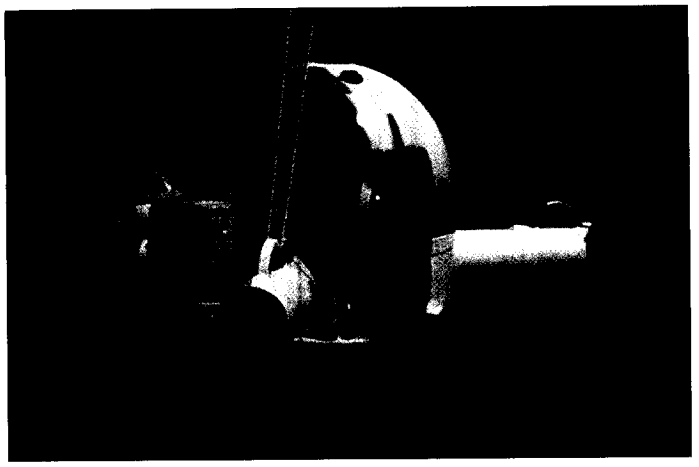
NEW ENTRY

Sweden

BMP 200

Type
Underwater data acquisition platform.

Description
The data acquisition platform BMP 200 is made for underwater surveillance and the recording of different signals from vessels and/or minesweep and/or environment influence. It is designed for easy operation, versatile use and can be equipped with a variety of sensors depending on use and customer demand.



BMP 200 system 0009856

BMP 200 is autonomous and can be placed on the seabed for long periods. The storage of data from the sensors is controlled remotely by means of an acoustic link. Recovery is also remotely initiated by the acoustic link. After recovery, all collected data can be transferred to other systems for evaluation.

Operational status
In production.

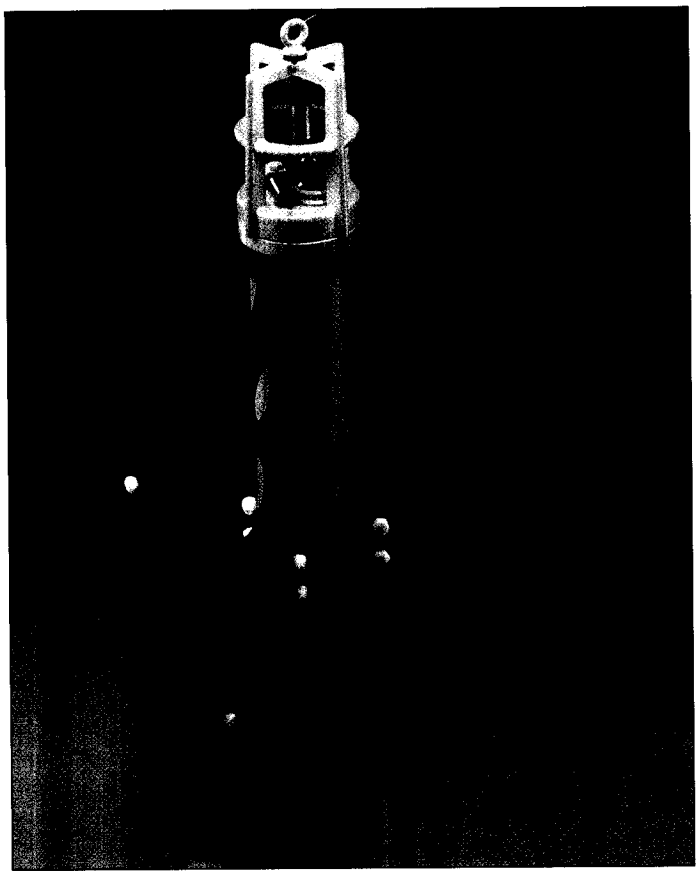
Specifications
Length: 2,500 mm
Width: 2,100 mm
Height: 1,300 mm
Weight (in air): 700 kg
Operating depth: 10-200 m

Contractor
Saab Bofors Dynamics AB, Karlskoga. ***UPDATED***

BMP 201

Type
Underwater measuring platform.

Description
The BMP 201 platform is designed for underwater measurement of magnetic, acoustic and pressure signatures of minesweeps and surface vessels. It also registers the static water pressure at the sensor's position. The system consists of a sea module and a land module to which the sea module is connected via a cable. To every land module, it is possible to connect four sea modules. The gathered data is transferred from the sea module via the land module to a standard PC where it will be recorded and evaluated. The algorithms in the PC evaluate signatures of surface vessels, the effectiveness of minesweep against various types of mine and can also evaluate seamine algorithms as well.



BMP 201 platform 0038678

Operational status
In production.

Specifications
Length: 700 mm
Width: 700 mm
Height: 700 mm
Operating depth: 5-200 m
Weight (in air): 85 kg
Cable length: >2,000 m

Contractor
Saab Bofors Dynamics AB, Karlskoga. ***UPDATED***

BMP 202

Type
Underwater data acquisition platform.

Description
The rugged and easy to handle BMP 202 sensor is a multimodular underwater data acquisition platform. The unit can be configured in various ways depending on requirements. It is simple to assemble and disassemble. The difference between the various configurations is the number of connected underwater data acquisition platforms and their sensor contents, together with the make-up of the shore-based analysing equipment.

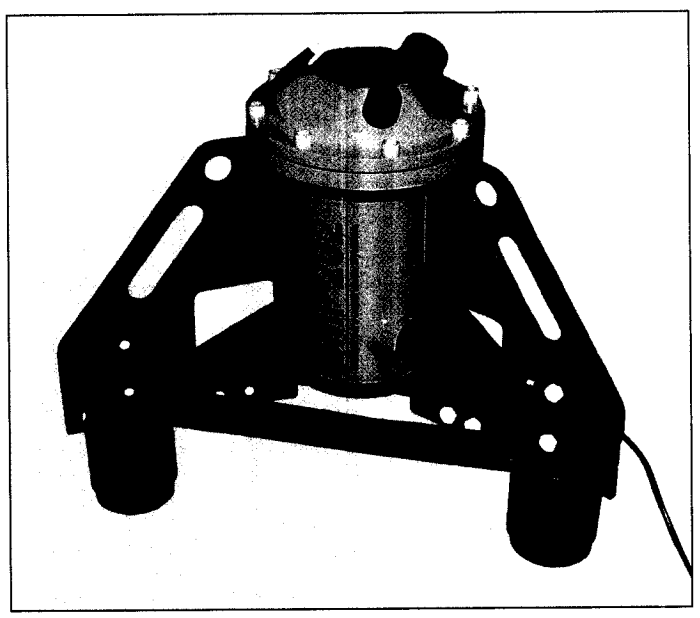
These features offer numerous possibilities for solving the most varied of underwater acquisition requirements, from single-point surveillance to advanced area surveillance, or extremely specialised high-speed real-time analysis of acoustic, magnetic, or electrical fields. Furthermore the BMP 202 system is very suitable for use in network-centric underwater warfare solutions which will provide valid sensor data, target tracks and so on to decision makers and other users (see also UDAS entry).

Operational status
In production for the Swedish Defence Material Administration. Delivered in 2001.

Specifications
Length: 850 mm
Width: 700 mm
Height: 700 mm
Weight: 50 kg (in air)
Operating depth 5 to 200 m
Operating temperatures: –2 to +40°C

Contractor
Saab Bofors Dynamics AB, Karlskoga.

VERIFIED



BMP 202 acquisition platform (Saab Bofors Dynamics AB) 0099764

UDAS

Type
Mobile Underwater Data Acquisition System (UDAS)

Description
UDAS is a mobile underwater range that is designed to register a variety of ship signatures. It comprises a chain of submerged and independent BMP 202 sensors that will simultaneously detect acoustic, magnetic, pressure and electric field signatures from passing vessels. The signatures are transmitted via a fibre optic cable to a land-based storage and evaluation system that is mounted in a climate-controlled container with its own diesel power generator. (See also BMP 202 entry.)

Operational status
Delivered to the Swedish Defence Material Administration in 2001 and in service.

Contractor
Saab Bofors Dynamics AB, Karlskoga.

VERIFIED

United Kingdom

MERS

Type
Signature measurement range and evaluation mines.

Description
MERS (MCM Evaluation and Range System) is a dual role transportable system providing a cableless underwater signature measurement range and an MCM evaluation range. The measurement range allows multi-influence signature measurement and modelling of vessels and sweeps. The range sensor units are themselves Versatile Exercise Mines, which provide the system with an evaluation mine facility for assessment and training of MCM against simulated threat mines.

The system is transportable, allowing forward area use, with operation from a small vessel or MCMV. It can be rapidly deployed, recovered and turned around on deck without diver support and with no cables to be laid. The system allows measurement of all potential threat mine influences – static/alternating magnetic, acoustic, seismic, pressure, static/alternating electric (UEP/ELFE). These influences are all recorded on a single transit of the ship being measured, and with no equipment fitted to the ship.

The system also provides all of the functions of the Versatile Exercise Mine System (VEMS), with the addition of alternating magnetic and static/alternating electric field sensors.

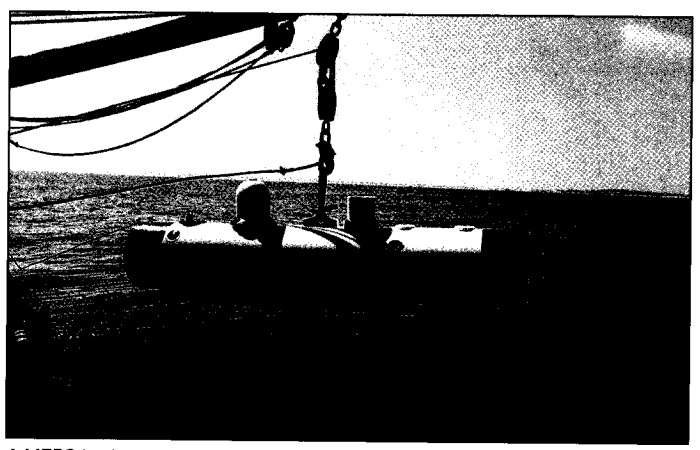
MERS is a dual role system that provides:

- a mobile multi-influence signature modelling range and
- evaluation mines for the assessment and training of MCM forces

For signature measurement, three sensor bodies form the sensor array. These are designed for accurate measurement of multi-influence signatures, and are capable of emulating in real time the fire control mechanism of known threat mines. Each sensor body is fitted with an INTEL 486-based processor with multiple Motorola 56000 series digital signal processors. An acoustic link allows communication with the sensor bodies on the seabed and indicates simulated actuations in real times. Signatures of vessels or target simulation influence sweeps can be measured and modelled, and no equipment needs to be fitted on the ship or sweep being measured.

The on-board control and analysis system comprises a PC, a ship transponder unit and differential GPS. These are used for programming prior to laying, controlling the acoustic link, unloading data after recovery analysis of recorded data and modelling ship or sweep signatures.

Signature modelling software allows the 3-D influence fields of the ship to be modelled using data measured on the single ship transit. These models allow prediction of the ship's fields at different depths and distances.



A MERS body ready for deployment 0009859

Operational status
In service with the Belgian Navy. A new variant is being developed to meet the requirements of an overseas Navy.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

VERIFIED

MUWS Family

Type
Multi-influence sensors.

Description
The MUWS family of sensors is designed to measure various influences in a sea environment relating particularly to disturbances to the environment created by passing vessels. The sensors are normally supplied as part of the TRANSMAG measurement range system.

The MUWS 3 and MUWS 9 are magnetic anomaly detectors whereas the MUWS 10 is a true multi-influence sensor.

MUWS 3
The MUWS 3 magnetometer is a gimballed, 3-axis analogue output, fluxgate magnetometer mounted in an underwater housing. The design features high stability and medium to low noise performance at moderate power levels. The unit is available with an optional pressure transducer fitted to the upper surface.

MUWS 9
The MUWS 9 is a 3-axis analogue output, fluxgate magnetometer mounted in an underwater housing. The design features high stability and medium to low noise performance at moderate power levels. The unit features very low interaction compensation windings with a range of ±100,000 nT and lightning surge protection. The left-hand end of the unit houses the titanium underwater connector. The electrical connections go to three circular PCBs containing the lightning surge protection components. After passing through the lightning surge protector, the connections go to the magnetometer PCB via a flexible PCB. At the right-hand end of the unit the three sensor elements are mounted on a triaxial fluxgate block on an end cap and connect to the magnetometer PCB via another flexible PCB.

Each end cap has a double O-ring seal to maintain watertight integrity.

MUWS 10 Series
The MUWS 10 Series is a multi-influence underwater sensor designed to measure static magnetic, alternating magnetic, static electrical potential, alternating electric potential, pressure and acoustic influences. It is a compact multi-influence sensor with a housing of the same dimensions as the MUWS 3. It is designed to be installed in a tripod support or other similar arrangement on the seabed. It features analogue voltage outputs for the measured influences for capture by a suitable nearby external measuring/recording system, and a digital link to allow sensor calibration data to be read from internal sensor memory. The digital link can be powered down when the sensor is making sensitive influence measurements, to eliminate any noise pick-up.

The unit is generally intended to be connected to an underwater system consisting of several other MUWS 10 units and an underwater junction box on the sea bed, via its own underwater mateable connector and the host system's sea cables. The MUWS 10 requires power from the underwater junction box and requires the box to measure and digitise its outputs and read and control its digital link.

Operational status
All sensors are in production and in service around the world.

Contractor
Ultra Electronics, PMES Hednesford, Staffordshire.

UPDATED

TRANSMAG

Type
Multi-influence measurement range.

Description
TRANSMAG represents a family of ship signature measurement range systems.

The ranges are designed to measure ships' underwater signatures, to calibrate the ship's onboard countermeasures systems, to enable the settings for the countermeasures to be implemented and to check the effectiveness of the settings.

The TRANSMAG family, which can be transportable in containers or fixed, can be configured to measures a ship's magnetic (static and alternating), pressure, acoustic and electric (static and alternating) signatures.

A typical system comprises a number of major subsystems including:

- underwater sensor units (on mountings)
- underwater interconnecting cables
- underwater cable junction box/data concentrator
- cables to the shore unit
- data interface units together with control and analysis computers
- high-precision ship course/position tracking system
- communication radios
- system container (if portable)

The sensors, junction box and analysis software are configured according to the type of influence to be measured.

The computer system is used to process data to advise the ship of the optimum course to steer over the range to resolve the various signature components and predict coil current settings. It can also predict fields remote from the ship to give safe distance analysis and magnetic anomaly detection effects.

In the magnetic signature check mode, the ship is sailed over the range on a pair of reciprocal headings. From the data acquired during these runs, the permanent and induced components of the ship's magnetic signature can be isolated and resolved into longitudinal, athwartship and vertical components.

Should the permanent components be found greater than those which can be comfortably controlled by the onboard degaussing coils, or they are outside predefined limits, then the ship may be instructed to undergo magnetic treatment.

In the ship's calibration mode, a coiled ship can carry out a number of passes with its coils either on or off. Providing this is performed in a controlled sequence, the effect on the signature of the ship by energising each coil can be determined. In this way, a ranging can be implemented with onboard degaussing coil currents being predicted to reduce the magnetic signature down to the lowest possible value.

Static electric field measurement is carried out using a single electrode mounted in the sensor housings to measure the potential voltage in the sea. This sensor is much smaller than the previously used electric field sensor that directly measured the static electric field signature and requires no alignment as did the electric field sensor.

The standard system consists of five magnetic sensors each carrying a voltage potential sensor and two acoustic sensors. Signature analysis is carried out on Pentium 2 PCs running under Windows NT or 98.

The newest addition to the range is the TransmagPlus. This system gathers a wide range of data for a variety of influences and over a range of bandwidths. Typical influences are shown in the table below, others may be added as requirements demand.

Influence
Static Magnetic (SM)
Static Electric (SE)
Pressure
Alternating Magnetic (AM)
Alternating Electric (AE)
Acoustic

Using modern high-speed desk top and laptop PCs acoustic and ELFE measurements can be carried out during a degaussing range process without increasing the ship time spent on range. Signatures are obtained during ranging runs which cover several minutes in time. Background noise runs can also be made. While signatures can be viewed in time mode, the data has to be converted to frequency measurements in order for valuable data to be extracted. Raw analogue data is converted to digital data underwater and then filtered before passing to a discrete Fourier transform for conversion into frequency data. Various processing options are available to aid signature analysis in the frequency spectrum.

The analysis software in the TrasnmagPlus uses a common software interface across all acoustic and alternating influences. In addition an increased diagnostic capability of ELFE signatures is gained by applying standard acoustic processing methods.

The whole data gathering and processing/analysis software runs under Windows with a user-friendly graphics user interface based on Windows functionality.

Operational status

Members of the TRANSMAG family of measurement ranges are in service with many navies around the world.

Contractor

Ultra Electronics, PMES, Hednesford, Cannock, Staffordshire.

UPDATED

DEGAUSSING SYSTEMS

Finland

FDS-700 Series

Type
Onboard degaussing system.

Description
The FDS is an advanced modular degaussing system that can be used aboard a wide range of ships. The solid state power units are PLC controlled switching mode current amplifiers with high accuracy and efficiency. The system has several different control and back-up modes.

The FDS 700 Series onboard degaussing equipment is based on industrial and marine grade commercial off-the-shelf (COTS) products. The COTS standard power amplifiers are controlled by the COTS programmable logic controllers (PLC) (type Siemens S7-300) that are connected to each other and to the operator's console by a Profibus field bus. The PLCs and the power amplifiers are located in the power cabinets (DCU) in the equipment room. The operator's console is typically on the bridge or in the machinery supervision room.

The console is a ruggedised workstation which operates under standard MS Windows NT and is integrated in the sweep officer's workstation on the bridge. The MMI interface allows system configuration and start/stop, the entry of calibration parameters, manual control over the system, and gives system alarms with clear descriptions. There is also a special approximation software which calculates an estimate of the local magnetic field based on the position of the ship. In the normal mode the operator's console supervises the power controllers and gives indicative figures of the system status without any input from the operator.

The coil current control is based on a modern multiparameter DG (MPDG) control algorithm which uses the information from several different sources such as magnetometers, gyrocompass, pitch/roll sensors and the ship's navigation system. The current control mode is either automatically or manually selected by the operator. The manual heading control with the local earth field approximation is always available for the operator. Several calibration parameter sets can be stored into the system's memory and be recalled when the ship's load state is changed.

The system features built-in diagnostics with clear alarm functions and fault-tolerant distributed architecture. All calibration parameters are stored in non-volatile memories both in the PLCs and the operator's console. In the event of major damage the system can change the coil current parameters into reduced magnetic silencing with only part of the power cabinets working. The field bus is not vital to the system; the PLCs will maintain full functionality if the connection to other DCUs or the operator's console is lost. Multiple back-up modes assure high system availability. The equipment may also contain uninterruptible power supply for signature reduction in a blackout situation.

Multiple automatic control modes are available allowing the system to be used in: magnetometer control; magnetic map control with and without gyro; and different manual control modes.

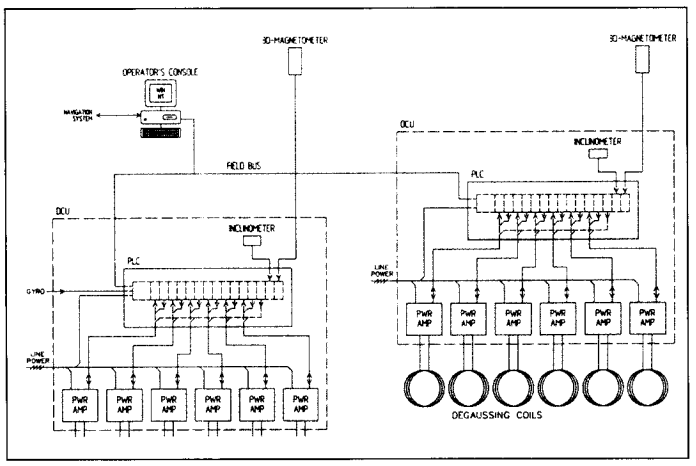
The FDS 700 Series onboard degaussing systems are based extensively on COTS hardware, which ensures cost-efficient maintenance over the system lifetime.

Elesco's services also include design and consultation in magnetic silencing.

Operational status
Since 1980 over 20 FDS systems have been delivered. Nine of the above described FDS-700 systems have been delivered since 1998. The FDS-700 equips the six newly upgraded Kuha class MCMVs and the new FACs of the Finnish Navy. One more system is on order for delivery in 2005 for the latest new FAC for the Finnish Navy.

Contractor
Elesco Oy, Espoo.

UPDATED



Block schematic of FDS-700 0017881

France

Magnetic treatment systems

Description
Thales Underwater Systems manufactures magnetic treatment facilities which are used to reduce and/or normalise permanent magnetic signatures using a deperming system. These systems are of particular use for vessels lacking onboard degaussing equipment. Stations can be of the static type, or dynamic, in which the vessel to be depermed makes a run over the range.

Operational status
Systems have been sold to the Norwegian Navy.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Germany

Deg Comp Mod 1

Type
Shipboard degaussing system.

Description
The Deg Comp Mod 1 is designed to compensate for the permanent, induced and – in its optimum configuration – the eddy current magnetic interference fields of naval vessels, to specified target signatures. The non-magnetic design of the system makes it suitable for use on MCMVs and non-magnetic submarines.

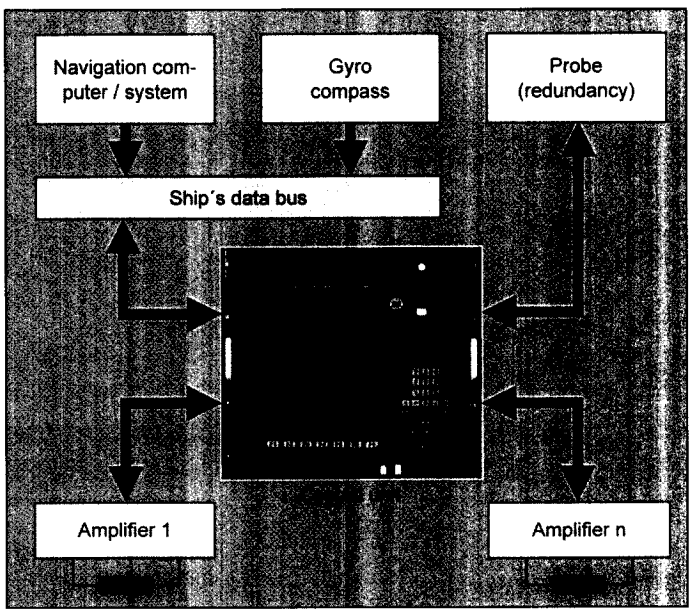
The decentralised modular system is computer-controlled and works on the sum current principle. That is at any given moment during operation each coil carries the aggregate current load as required for compensation of the permanent, induced and, if required, eddy current content of the magnetic interference field. This requires separately controllable power supplies for the individual coils, which is achieved using independent power amplifiers.

The system features selectable automatic control in master-slave mode, with inputs coming either from a tri-axial magnetic probe system or from the ship's navigation system. In emergency mode relevant control data is entered manually.

The system features a user-friendly MMI with data input and monitoring via display, keyboard and softkeys. Hierarchically organised menus for interactive control are provided for the different operational modes.

The heart of the system is the computer-based degaussing control unit that accommodates the MMI and interfaces to the other main system components. For control and monitoring standard interfaces are provided.

In automatic mode the control unit receives the actual magnetic earth field data either from the magnetic probe system or by calculations derived from a geophysical model as database, and inputs from the vessel's navigation system.



Deg Comp Mod 1 system configuration (SAM Marine Electronics) 0131879

For this the unit is equipped with a suitable memory that contains the algorithms of the geophysical model for generation of the magnetic earth field data. In emergency mode, the navigation data can be manually input.

At any given moment the system automatically calculates the required sum current for each degaussing coil, which is composed of the permanent, induced and, when required, eddy current content.

On the basis of this calculation, each degaussing power amplifier generates the required DC sum current to feed the related connected coil. Menu controlled interactive communication between the user and the control unit is affected via a display with attached keyboard and functional soft keys.

Error messages are generated in case specified limits are exceeded, or undesired operational conditions prevail.

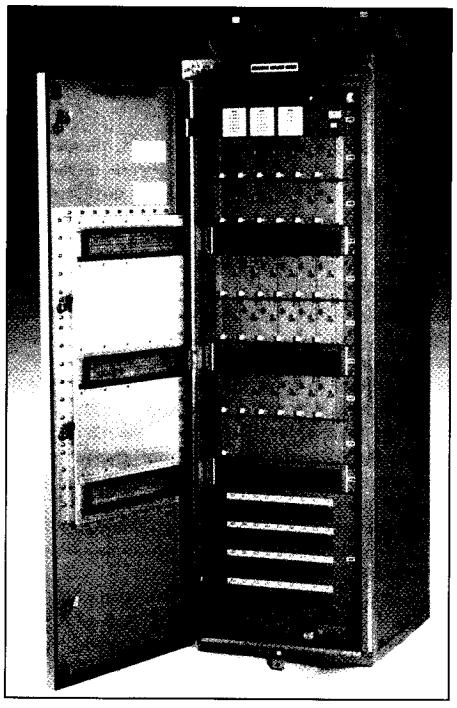
Depending on the respective type of vessel the degaussing system makes use of two different coil supply concepts:

- The centralised coil supply concept, which is intended for vessels having a low power demand per coil (for example MCMVs and non-magnetic submarines). This allows the power amplifiers for the individual degaussing coils to be arranged in a centrally located amplifier cabinet.
- The decentralised coil supply concept, which is intended for vessels having a higher power demand per coil (for example steel hulled surface combatants and logistics vessels). These vessels make use of individual degaussing power amplifier units arranged near the connected coil.

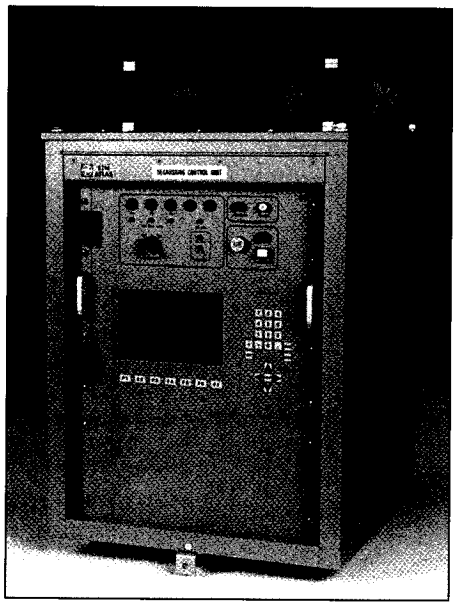
Both power supply concepts use a family of current controlled amplifiers of different configuration and power rating, each suitable for the direct supply of the respective sum current to the connected degaussing coil.

The robust and compact power amplifiers intended for use with the centralised power supply concept are available in the power range between 60 and 500 W. They are designed as modular plug-in units and are accommodated in a common amplifier cabinet.

Degaussing systems for large steel vessels using the decentralised power supply concept use a number of degaussing power amplifier units to energise the connected degaussing coils. The power amplifier units, designed as stand-alone units, are of identical design, and differ only with regard to their power rating. Depending on the coil design maximum power ratings of approximately 9 kW is feasible.



Degaussing amplifier cabinet
(SAM Marine Electronics)
0131880



Degaussing control unit
(SAM Marine Electronics)
0131878

Contractor
SAM Marine Electronics GmbH, Hamburg.

VERIFIED

United Kingdom

FEMAP

Type
Analysis, prediction and design software.

Description
FEMAP (Finite Element Magnetic Analysis Package) is a suite of computer modelling routines designed and assembled for use in conjunction with other packages to design shipboard degaussing coil systems. The design aim is to provide a coil layout in order to achieve a target ship's signature.

The resulting design is usually matched to a suitable set of coil drivers. Ultra Electronics can provide shipbuilders with a complete service from design start (hull drawings) to signature ranging acceptance.

The company can undertake similar analysis and design work for Impressed Current Cathodic Protection (ICCP) and the associated electric fields and corrosion related magnetisation.

Operational status
FEMAP is commercially available and has been procured by a number of users.

Contractor
Ultra Electronics, PMES, Hednesford, Cannock, Staffordshire.

UPDATED

OBDG

Type
Onboard degaussing and signature management system.

Description
OBDG is a system comprising controlled power supplies and magnetic field producing coils. The coils are arranged within the ship's hull in such a way as to envelop as much of the hull as possible. The location, power and routes for the coils (degaussing coils/loops) are critical in reducing the ship's own magnetisation to (mine) safe levels or signature targets. DG coil current settings are chosen (following magnetic signature ranging) to counteract both the ship's own natural magnetic field and the effect of earth's magnetic field.

The way in which the DG coil currents are controlled is critical to the performance of the system. The system controller is therefore a sophisticated unit with embedded control algorithms and a geomagnetic map. The ship's local earth's field may be measured by an optional masthead magnetometer – the controller can accept this information. The ship's own data such as its latitude, longitude and heading are required inputs to the controller.

The control software can be configured to meet client specific requirements.

The coil driver units can be housed in cubicles located to suit the vessel's design or individually near the degaussing coils.

Systems are available to combat ship corrosion and electric field – Impressed Current Cathodic Protection (ICCP). The complete control of underwater electromagnetic signatures is achieved by the integration of active shaft grounding (ASG).

Ultra Electronics supports all of the signature management activities with system design and computer-based analysis (FEMAP). The analysis includes degaussing coil design and cathodic protection.

Operational status
Various systems are currently in design, manufacture and installation/service with a number of navies around the world, including the Royal Navy T45 and Astute classes.

Contractor
Ultra Electronics, PMES, Hednesford, Cannock, Staffordshire.

UPDATED

United States

Advanced Degaussing Technology

Type
Degaussing technologies.

Description
This US Programme is aimed at reducing the magnetic signature of existing steel-hulled vessels by about a half and of future steel-built vessels and MCMVs by up to a quarter of current levels. In pursuance of these goals a variety of technologies will be used including:

- Corrosion current control
- High field deperming
- Closed-loop degaussing (for steel-hulled vessels)
- Standard degaussing power amplifier
- Reduction of eddy current magnetic field
- Reduction of stray magnetic field reduction
- Degaussing system calibration algorithms

Operational status
Technologies are currently under development. Scheduled for application to San Antonio (LPD-17) class amphibious warfare vessels, Arleigh Burke class Flight IIA destroyers, DD-21 and CVX. The technologies will also be retrofitted to US MCMVs.

VERIFIED

ACOUSTIC CONTROL

France

QSUA-4

Type
Acoustic self-noise monitoring system.

Description
The QSUA-4 self-noise monitoring system and cavitation detector is especially dedicated to submarine applications.

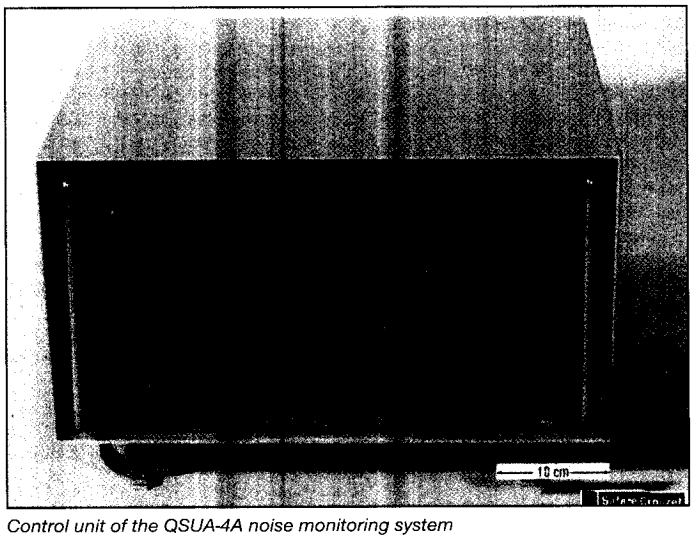
The system provides simultaneous monitoring of the boat's machinery and hull vibrations through accelerometers, self-noise measurements using hydrophones, and cavitation detection and survey using hydrophones. In addition, the system provides rms level measurements, and alarm capability and built in test. Other features include a 2-channel recording/processing capability and the possibility of being connected to an external computer/analyser as well as connections to a multitrack recorder. An RS-422 datalink is also available.

The QSUA-4 has an operating bandwidth between 20 Hz to 15 kHz, and is usable down to 3 kHz. Both broadband and narrowband (scanned) measurements are carried out and programmable thresholds for display and alarms (at broadband level) are provided. Sensor signals are available for external analysis and recording. The baseline unit offers up to 20 sensors while extension units can provide an additional 16 sensors per unit.

Operational status
In service with the French Navy.

Contractor
Thales Safare, Sophia Antipolis.

UPDATED



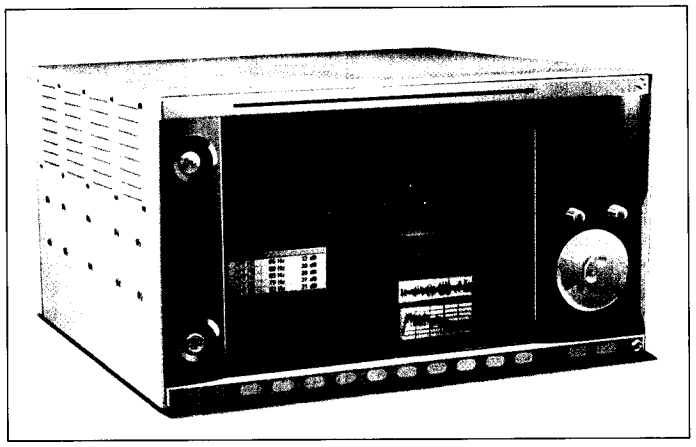
Control unit of the QSUA-4A noise monitoring system

SNM 40/120

Type
Self-noise monitoring system.

Description
The SNM (Self-Noise Monitor) system monitors the vibrations of the hull and noise from the machinery to ensure silent and safe navigation. The modular integrated system uses C-PCI hardware technology and ICP sensors. The SNM 40 features 20 to 40 sensors and the SNM 120 up to 120 sensors. The system can be installed either as a stand-alone system, fully integrated into the sonar system or as an integrated and stand-alone system. The system features a powerful processing capacity and ensures real time simultaneous monitoring and analysis of signals from a wide range of different types of sensor (accelerometer, hydrophone, microphone or tachometer).

Data is presented on a 15 in XGA screen with operator management exercised using a thumbwheel and keyboard. The MMI features data recording and automatic generation of thresholds, analysis and adjustment of alert and pre-alert thresholds, immediate localisation of alerts, breakdowns and diagnostics, and instantaneous or averaged spectral analysis of raw or filtered signals. Signal analysis features: bandwidth selection of raw or filtered signals, spectral analysis of



Display unit of the SNM 40/120 (Thales Safare) 0593005

instantaneous, averaged or DEMON, event recording of sensor numbers, dating, raw signals from sensors, and sound and threshold levels.

The system can connect to external units such as a CPU via a fast Ethernet 100 TX base, a sonar system using a fast Ethernet 100 TX base, a navigation system via serial link and to external analysers via a quayside maintenance connection.

Operational status
Available for installation on submarines and surface vessels.

Specifications
Weight: 35 kg
Dynamic range: 120 dB
Resolution: 24 bits
Input signal range: ±10 V
Sampling frequency: 44.1 kHz
Bandwidth: 5 Hz to 14.4 kHz (optional upgrade to 20 kHz for specific sensors)

Contractor
Thales Safare Sophia Antipolis.

UPDATED

Israel

ANC

Type
Adaptive noise cancellation system.

Description
The adaptive noise cancellation system is designed to improve the performance of submarine flank array sonars by providing real-time reduction in self-noise received by the sonars. This in turn results in a substantial increase in target detection ranges together with improved target classification and identification.

The system uses advanced real-time algorithms and state-of-the-art technology to remove self-radiated noise from other signals received by the flank array.

The equipment comprises a number of accelerometers mounted along the submarine's hull which are used to detect vibrations in the submarine's hull caused by self-radiated noise.

The ANC can be integrated into any flank array sonar and, the manufacturers claim, can improve self-noise factor by 15 to 30 dB.

The equipment is available for new build sonars or to upgrade existing submarine sonar systems.

Operational status
Carried on board Gal class submarines of the Israeli Navy. These submarines have been withdrawn from service and are for sale. The system has also been exported.

Contractor
Rafael, Armament Development Authority Ltd, Ordnance Systems Division, Defense Directorate, Acoustic Systems, Haifa.

VERIFIED

United Kingdom

Acoustic tiles

Type
Noise suppression tiles.

Description
Decoupling tiles are applied to surface ship and submarine hulls to reduce their radiated noise levels and provide a similar level of performance to the Prairie/ Masker system. In a submarine the most vulnerable areas to detection by sonar are the sail and other flat surfaces such as the hydroplanes and rudder as well as the region around the machinery compartment.

No single material meets all conceivable restraints and performs well in all scenarios. Echo reduction varies with frequency when operating temperatures and depths change and also when material stiffness or thickness changes. Hence the resulting treatment has, of necessity, to frequently be a compromise. To arrive at the best affordable solution, W & J Tod has developed a software code,TRANS, using established theory to predict transmission, reflection and absorption for individual and multilayered structures at all angles of incidence.

For viscoelastic materials this code uses dynamically measured material properties to predict the temperature, frequency and pressure dependant performance.

Decoupling tiles for signature reduction are used to decouple a submarine's internally generated sound signature from the surrounding sea water thus reducing its energy transmission. Theses tiles are made out of polymers (in some cases urethane-based polymer technology) and rubber compounds that absorb acoustic energy and create an impedance mismatch. This mismatch brakes the sound path into the ocean in the same way that the air layer along the hull does in the Prairie/ Masker system. In addition to providing this mismatch, decoupling tiles also scatter active sonar transmissions resulting in a poor return to the sonar receiver in the hostile vehicle. Standard tile size is 305 mm² and 25 mm thick.

Anechoic echo reduction tiles operate in the same way and use the same techniques as radar absorbent material, absorbing the sonar transmission at discrete frequencies. In the same way as RAM, anechoic tiles are available in both dual band and triple band versions. Anechoic tiles measure approximately 305 mm² in area and are around 100 mm thick. They are attached to the outer hull by use of an adhesive. Alternatively some anechoic materials can be cast directly onto the hull or sprayed on. Anechoic tiles from W & J Tod Ltd are manufactured with a nominal density of 1.6 providing efficient energy absorption through a nominal frequency range of 2 to 100 kHz.

Both types of tile are applied to those areas of the hull which are most vulnerable from a target strength point of view.

In service, several different types of tile are likely to be applied to different areas of the hull possibly in combination, depending on the type of protection deemed necessary. Using transmission loss materials next to the hull of a submarine acts as an efficient internal reflector, and the application of an anechoic tile on top of this absorbs externally generated acoustic signals (sonar signals from torpedoes, submarines, surface ships, sonobuoys, dipping sonar and so on) preventing any echo being reflected back to the seeker. Generally materials are tuned to counter the anticipated threat frequencies and optimised for the depth and temperature of the operating environment. As temperature rises, anechoic material softens and its optimum performance shifts to the lower frequencies. Likewise the effect of depth changes the performance of the tiles. Anechoic tiles are of cellular construction to maximise energy loss. As depth increases so the tiles are compressed and, to overcome this effect, tiles must be of stiffer material in order to maintain their operating frequency, or of softer material to reduce the frequency at which they operate. In addition to anechoic tiles and signature reduction tiles, RhoC acoustically transparent materials in tile form are used as acoustic windows around sensors mounted in the boat's sail, bow and along the hull. These tiles provide stand-off layers between turbulent flow noise and the sensor, thus improving the acoustic sensitivity of the sensor.

Operational status
In service on many classes of submarine and surface ship worldwide. The 'Collins' class is undergoing flow noise treatment under the upgrade to reduce turbulent flow noise. Other classes of submarine which have been treated include: 'Gotland', 'Victoria', 'Walrus' 'Sea Dragon' classes and on the Royal Navy S & T Upgrade.

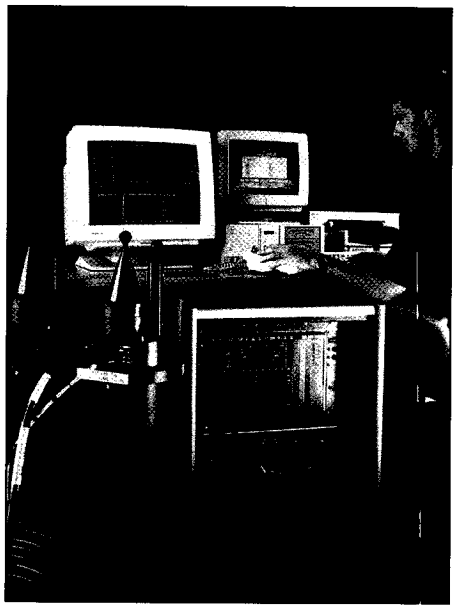
Contractor
W & J Tod Ltd, Crewkerne, Somerset.

VERIFIED

ATARS

Type
Transportable acoustic noise range.

Description
The ATARS System is designed as a transportable acoustic ranging facility, used to measure and analyse underwater radiated noise from a wide variety of platforms including warships, auxiliaries, ROVs and weapons. Its primary purpose is to obtain



Units of the ATARS system

the underwater acoustic characteristics of the vessel to determine the probability of detection by mines and passive sonars.

The system comprises two underwater acoustic sensors, one mounted along the track of the vessel and one which is separated from the track by about 25 m to allow measurement of the beam signature. Sensors are easily deployed from a small craft.

The beam sensor is connected to the acoustic track sensor by a multiway copper cable. The track sensor has a fibre optic cable to the shore.

A signal processing system provides frequency domain analysis of the vessel noise characteristics and allows the processed data to be stored on floppy disk for subsequent retrieval and comparison.

A high-resolution colour display is provided for display of the processed data, and control of the system is via a computer workstation. The operator interacts with the system via a standard keyboard and trackball. All system commands are selected and executed using the trackerball via the displayed menus.

Ship tracking is achieved by means of a laser tracking system and a reflecting prism. As each ranging run is executed, all data is both displayed in waterfall format, and retained in high-capacity hard disk for temporary storage. Before the vessel enters the data collection area, the tracking system is 'locked on' to the vessel by the operator.

On successful completion of ranging, the processed data is archived to floppy disk. Processed data is displayed in several formats designed to assist the operator in identifying the nature and cause of possible extraneous acoustic noise sources. Display formats include both narrowband spectra, derived using FFT techniques, and true one-third octave broadband responses. The acoustic frequency range covered is 10 Hz to 56 kHz.

The whole system can be supplied in a 6 m ISO container which may be fitted out as a ranging control office and also used to store the cable and sensors when not in use.

Operational status
ATARS systems have been delivered to the Middle East and are in service in Asia.

Contractor
Ultra Electronics Ocean Systems , Weymouth, Dorset.

VERIFIED

TONES

Type
Transportable acoustic noise range.

Description
TONES (Transportable Overside Noise Evaluation System) provides the capability for a vessel to measure its own radiated noise within a matter of 2 to 3 hours. This may be particularly useful if the vessel is operating away from fixed ranging facilities.

TONES comprises two self-contained units, a wet end unit and a shipborne unit.

The wet end unit is deployed in the sea when the system is in use. It comprises a free-floating buoy (either a recoverable, reusable buoy or an SSQ 906 type sonobuoy) with a suspended hydrophone. The radiated noise received by the hydrophone is transmitted by radio to the shipborne unit using one of 40 channels in the 136 to 174 MHz frequency band. After use the wet end unit is brought back on board.

The shipborne unit is typically carried as a temporary installation on the vessel to be ranged, although it can alternatively be a permanent installation or can be operated from an escort. The unit incorporates a radio receiver, signal analyser and



Self-contained shipboard unit of TONES

a VGA flat screen monitor. The monitor displays the analysed noise in the form of a narrowband spectrum, or a one-third octave analysis.

The system is straightforward in use with the minimum of operator input being required. The operator is required to initiate an event mark when a specific point on the ship passes the wet end unit buoy a few tens of metres abeam.

The data is analysed in real time, and the resulting plots displayed and stored. The stored plots can be printed out when required.

TONES will measure radiated noise in the acoustic band 20 Hz to 20 kHz, over a dynamic range of 60dB/1 µPa with a 1 Hz resolution. It will perform narrowband (FFT) and one-third octave analysis in real time on the incoming data.

The hydrophone may be set at any depth between 10 and 60 m, and the analysis software will automatically reference the data to the separation set by the operator. The standard deployment is at 10 m.

Operational status
In service with a Middle East customer. In a collaborative venture Ultra and the DRA are jointly to develop, market and sell TONES. TONES has been supplied to a number of navies and has been proven during acceptance testing on the DRA/DTEO Loch Goil facility.

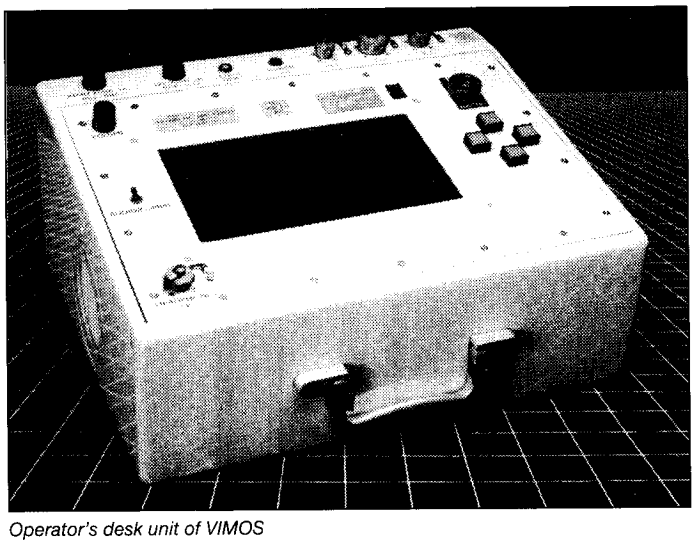
Contractor
Ultra Electronics Ocean Systems , Weymouth, Dorset.

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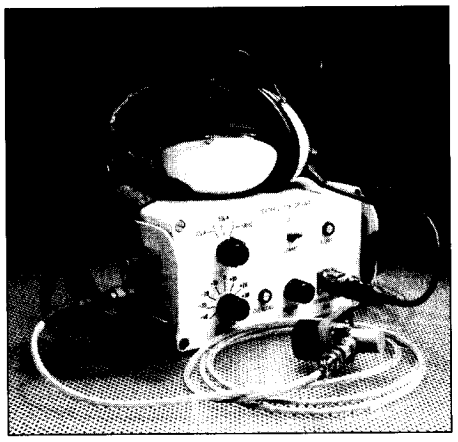
VIMOSPlus monitoring system

Type
Vibration and noise monitoring system.

Description
VIMOSPlus is a computer-controlled vibration and noise monitoring system designed to enable the continuous measurement of radiated noise levels at selected positions throughout the ship. In warships, for which the system was originally designed, this allows the increase in these levels to be detected before they adversely affect the ship's sonar capability or increase the risk of detection. Applications include use by the ship's sonar operators and monitoring of machinery wear and of detection.



Operator's desk unit of VIMOS



VIMOS portable monitoring equipment

By measuring hull and equipment vibrations via sets of distributed sensors, VIMOSPlus performs a unique combination of spectrum analysis and data processing, providing an ability to quantify self-generated radiated noise, continuously monitor structure-borne noise and monitor machinery health.

A combination of accelerometers and hydrophones, placed at requisite internal and external points, is employed, from which signals are transmitted through amplifiers and switch equipment to a central processing unit based on a central processing unit 486 PC, modified to interface to a Thales Underwater Systems DSP board featuring the former Lucent Technologies DSP32C hosted by the INMOS T802 transputer. These give data acquisition and signal switch control, Fast Fourier Transform (FFT) signal processing providing both narrow and broadband analysis and back-up facilities.

Results are displayed using Windows technology and pull-down menus.

A typical surface vessel system would deploy around 216 individual sensors grouped into nine arrays. In addition, a portable hand-held sensor is available for specific tracking of noise sources.

Operational status
VIMOS systems have been supplied to the UK MoD for the Royal Navy Type 23 frigates, Sandown class minehunters and Fort Victoria class Fleet Auxiliary vessels. Three earlier versions of this system, Hull Vibration Monitoring Equipment (HVME) Mk 1, were delivered to the Royal Navy in 1985.

The system is fully operational in the Canadian Forces Maritime Command, Royal Navy and Royal Saudi Navy. During 1995 the company won a contract to supply VIMOSPlus to HDW in Germany for equipping submarines.

Contractor
Thales Underwater Systems, Cheadle Heath, Stockport.

VERIFIED

United States

EMTC

Type
Acoustic signature reduction technology.

Description
The electromagnetic turbulence control (EMTC) technology being developed by the US Defense Advanced Research Projects Agency (DARPA) and Naval Undersea Warfare Center (NUWC) is designed to reduce the acoustic signatures of submarines and possibly surface ships.

The technology uses an electromagnetic field that controls the boundary layer around the hull of the vessel that reduces drag-induced noise,

Tests have shown that it is possible to counteract turbulence using an array of magnets and electrodes embedded in the hull. It has been suggested that the viscous drag of the hull could be reduced by as much as 45 per cent using this technology.

It is also possible that EMTC could be applied to propellers to reduce cavitation.

Operational status
Under development.

Contractor
DARPA, Arlington, Virginia.

VERIFIED

MESA

Type
Fibre optic undersea acoustic tracking range.

Description
MESA (Multiplexed Extended Sensor Array) is the first US Navy fibre optics undersea acoustic tracking range and was installed in AUTEC in August 1996. MESA makes use of Common Undersea Platform (CUP) components to provide a fully digital, time division multiplexed, wide bandwidth sensor system based on 12 tethered hydrophones. Each hydrophone is attached to a sensor node assembly. The node assembly is used to format and transmit via the fibre optic link data to the shore station. The telemetry architecture is based on the SONET standard that supports data rates that allow the hundreds of sensor channels to be placed on a single optical fibre. MESA is a 20 year life system with fully undersea qualified redundant lasers. Also for redundancy, the design includes optical and power bypass features which allow for up to two consecutive multiplex/repeaters nodes to be bypassed without failure of the system. The system can be deployed to depths of 5,500 m. The frequency range covered by the hydrophones is 50 Hz to 50 kHz with a dynamic range of 80 dB. The lower frequency is used to receive and measure LF ambient and other noise sources as well as tracking and communication signals from pingers and active sonars of weapons.

MESA also includes a power and demultiplexer shore- or ship-based subsystem that provides power to the undersea cable and sensor subsystem and provides both digital and analogue data output for all sensors. A display panel continuously monitors the state of the undersea system with regard to laser operation, bypass status, and system current and voltage. The panel also allows for the operator to communicate to each sensor node through a supervisor channel allowing for greater flexibility in node status and control.

Operational status
The prototype MESA I is installed in the weapons range part of the AUTEC range. A MESA II project is being developed to replace the original hydrophone arrays.

Contractor
Lucent Technologies, Advanced Technology Systems, Greensboro, North Carolina.

UPDATED

Prairie/Masker

Type
Radiated noise suppression system.

Description
The Prairie/Masker radiated noise suppression system is designed to create an impedance mismatch around the parts of the hull which are inherently noisy. Through this mismatch the sound path from the hull or propeller to the surrounding water is blocked or distorted resulting in a very much reduced level of radiated noise or a noise which is very difficult to detect and identify because of its distorted nature.

In sensitive areas such as the region surrounding the machinery compartment, the Masker system is used to disguise LF noise emanating from machinery that radiates through the hull by blowing air through a series of small nozzles mounted in the hull at about 12 psig. The air supply is bled off from the ship's high-pressure gas turbine (if fitted) or supplied by dedicated compressors. The bubbles so created remain trapped along these sensitive regions of the hull and mask the noise that would otherwise be directly radiated into the ocean from the vibrating hull plating.

The other area where noise is a major problem is the propeller. In this case the Prairie system feeds air down the propeller shaft and through small holes in the propeller's leading edge to delay the onset of cavitation. Each machinery compartment has its own Prairie system to supply air to its associated propeller. Prairie also feeds air to the leading edge of the ship's stabilisers to reduce the onset of cavitation. In both systems the air is cooled to reduce to a minimum any possible IR signature.

The disadvantage of this noise suppression system is that at lower speeds the layer of bubbles tends to rise to the surface rather than remain entrained along the hull. A similar effect occurs when the ship experiences a heavy seaway and the bubbles are sheared off by the violent pitching of the hull. In addition the bubbles contribute more noise to the ship's wake, which can increase its vulnerability if it is likely to be attacked by wake homing torpedoes or increase risk of detection by passive sonar systems.

Operational status
Mounted on many surface warships in many navies.

VERIFIED

ENVIRONMENTAL MEASURING SYSTEMS

Introduction

All forms of warfare are governed by the surrounding environment, and nowhere is this more true than in the case of underwater warfare. The ocean is the largest of all environments and covers some 70 per cent of the earth's surface. At its deepest it reaches 11,000 m, with an average depth of 3,850 m. The ocean environment is the most difficult of any in which to conduct warfare, and its vagaries are such that even today there is a great deal that still remains unknown about how the sea behaves and how it is affected by the land and air within and above it. Yet, upon our understanding of how the oceans change, and what environmental conditions affect those changes, depends the success of the conduct of any form of naval operation. Every aspect of underwater warfare — submarine operations, anti-submarine warfare, mine warfare, diver operations and so on — is subject to the behaviour of the sea. It is for this reason that the science of oceanography has become so important to many of the world's navies.

It is impossible for navies to survey all the potential maritime areas where crises may develop, especially the littoral regions, and so it is essential for the successful conduct of maritime operations that a navy has the capability to assess the behaviour of an environment in an unfamiliar area.

It is the littoral and inshore regions, which are now the focus for any battlespace operations. Environmentally these are the most complex regions in which to conduct naval operations, particularly underwater operations. In the deep ocean certain characteristics such as seabed topography are not significant to ASW and MCM operations, but the knowledge of such features are of paramount importance in the littoral and inshore region.

The underwater environment differs in many ways from the land and air environments and is subject to quite different forces. For example, in seawater, radiation of certain parts of the electromagnetic spectrum is severely limited. This greatly restricts the use of visual, radar or other detection systems which use that part of the spectrum.

Conversely, sound waves can travel and be detected over very long distances underwater and are therefore the most important factor relating to underwater warfare, for they form the primary means of detection. Certainly this is true at long range, although at a relatively short range other phenomena such as magnetism and electric potential phenomena are also very important, particularly in mine warfare.

The physical properties of the sea, and how they affect radiation, play a vital role in underwater warfare. For example, geographical considerations, local atmospheric conditions, the season, and the composition of the seabed (is it smooth or rough, does it undulate and by how much, what is its underlying structure, is it rock or is it a sediment of mud or sand?) all affect very considerably the nature of the environment and how it behaves. Knowledge of how the oceans are conditioned by the atmosphere above, how the masses of ocean water move, and how temperature and salinity are affected, for example, is essential to assess how the propagation of sound in water will be affected. Other factors affecting sound propagation in water relate to boundary layers, both in water movement (in different parts of the ocean, currents running in opposite directions can be found one above the other) and temperature boundaries (as opposed to gradients), scattering effects, and ambient noise, such as noise from shrimps, whales, dolphins and so on, is a constant source of interference.

Knowledge of how sound propagation is affected in the ocean environment can be used to exploit methods of detection, or to avoid detection and to limit the effects of uncontrollable noise generation. Using such knowledge, it is also possible to predict how sound propagation will be affected in a given set of circumstances, hence the probability of detection under those conditions can be predicted.

In mine warfare other phenomena such as magnetic fields, electric potential and so on are also subject to variations in the surrounding natural environment. Again the effects caused by the natural environment need to be known in order for sensors operating in these domains to be effectively used.

Various methods and equipment are available with which to investigate and measure the various physical factors which affect the underwater environment.

Of increasing use in the presentation of metocean data, is the use of 3-D imaging techniques now available. The use of these techniques in the underwater environment will become increasingly important in the understanding of how various natural factors affect operations underwater, such as the build-up of the underwater picture from a moving sensor, as an aid to assessing the probability of detection and being able to forecast changes in the environment and how those changes could affect the conduct of operations.

VERIFIED

Canada

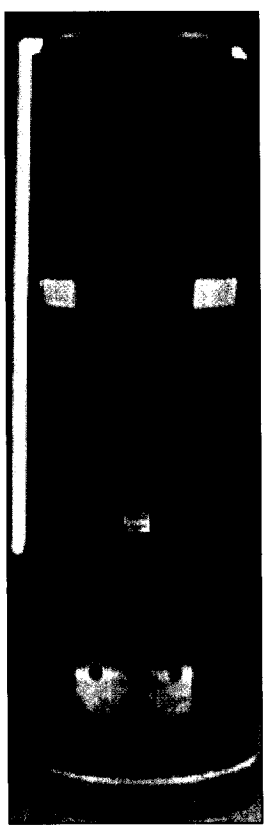
AN/SSQ-536G

Type
Bathythermal buoy.

Description
The AN/SSQ-536G is a 'G' size bathythermal buoy that allows an ASW operator to obtain an extremely accurate plot of sea temperature versus depth. The buoy is configured for gravity launch and can be deployed from a wide range of airborne and shipborne platforms. The buoy is fitted with an EFS function that allows the operator to select one of 99 VHF-FM channels to uplink the data.

A complete temperature profile down to 800 m can be obtained within 10 minutes of entry into the water.

The buoy uses five polycarbon monofluoride BR-2/3A lithium cells as its power source.



AN/SSQ-536 bathythermal buoy (Ultra Electronics Maritime Systems)
0594881

Operational status
In service.

Specifications
Length: 419 mm
Diameter: 124 mm
Weight: 3.9 kg
Transmitter frequency: 136 - 173.5 MHz
RF power: 0.25 W
Operating depth: 800 m
Descent rate: 1.5 m/s
Descent time: 525 s
Operating life: 12 min (max)
Sensor temperature: –2 to +35°C
Temperature accuracy: ±0.56°C
Launch altitude (max): 9,144 m
Launch speed (max): 370 k @ 564 m

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.

UPDATED

AN/SSQ-937C

Type
Bathythermal buoy.

Description
The AN/SSQ-937C is an 'F' size bathythermal buoy designed, built and qualified for the UK MoD. It provides an ASW operator with a highly accurate plot of sea temperature versus depth. The buoy is configured for gravity launch from aircraft and helicopters.

The microprocessor controlled buoy provides a temperature versus depth profile down to 610 m within 7 minutes of entry. An 800 m probe can be supplied as an option. The buoy activates within 30 seconds of entry into the water.

The buoy incorporates an AFS (Autonomous Function Select) capability that allows any one of 99 FM VHF telemetry channels to be selected prior to launch.

Five poly-carbon monofluoride lithium cells power the buoy.

Operational status
In service aboard aircraft of the United Kingdom RAF and Royal Navy.

Specifications
Length: 305 mm
Diameter: 124 mm
Weight: 3.76 kg
Transmitter frequency: 136-173.5 MHz
RF power: 0.25 W
Transmission channels: 99
Operating depth: 610 m (optional 800 m probe)
Descent rate: 1.5 m/s
Descent time: 307 s (to 460 m)
Operating life: 12 min (max)
Sensor temperature: –2 to +35°C
Temperature accuracy: ±0.56°C
Launch altitude (max): 45-9,144 m
Launch speed (max): 50-370 kt @ 564 m

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.

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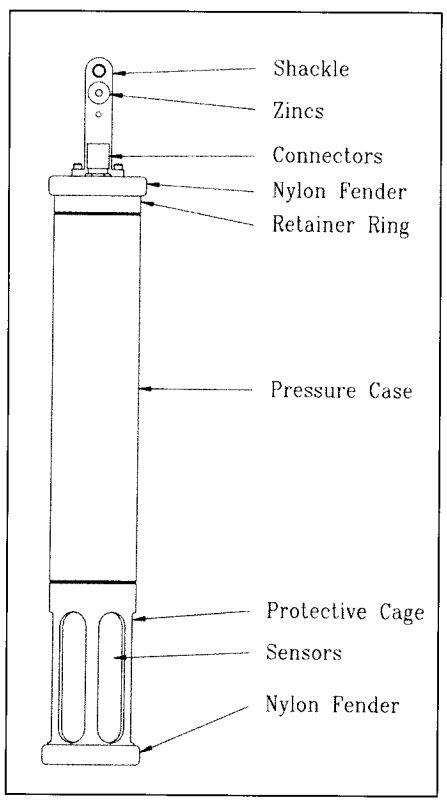
CTD-12 plus

Type
Miniature conductivity, temperature, depth probe.

Description
The CTD Plus is a rugged, intelligent CTD designed for precision measurements of conductivity, temperature, and depth. The instrument is normally used for vertical profiling and in-situ applications. The CTD Plus is delivered ready-to-use, and includes a shipping case, batteries, and data cabling.

Recently updated, the new version of the CTD Plus offers a USB port to enable rapid data download. The revised instrument also provides the user with plug-and-play capability on all remote sensors (optional, including turbidity, pH, dissolved oxygen, chlorophyll A, rhodamine, PAR, redox, transmissometer). This plug and play capability allows remote sensors to be plugged into any instrument connector on any one of a number of Applied Microsystems instrument models, giving the end-user a greater ability to self-configure the instrument ideal for their specific application.

Other new features include upgraded pressure sensors (including an optional 0.01%FS sensor), instrument availability in Delrin, and communications improvements.



Elements of the CTD-12 Plus
0099446

Specifications
Length: 675 mm
Diameter: 102 mm
Weight: 3.5 kg (in water), 9 kg (in air)

Pressure
Type: Semiconductor bridge strain gauge
Range: Various to 6,000 dbar
Resolution: 0.05%FS (0.01%FS optional)
Accuracy: 0.15%FS

Conductivity
Type: Conductive
Range: 0-7 S/m or 0-70 mS/cm
Resolution: 0.0003 S/m
Accuracy: 0.01 mS/cm; 0.005 mS/cm precision

Temperature
Type: Thermistor
Range: –2 to 32°C
Resolution: 0.001°C
Accuracy: 0.005°C

Contractor
Applied Microsystems Ltd, Sidney, British Columbia.

UPDATED

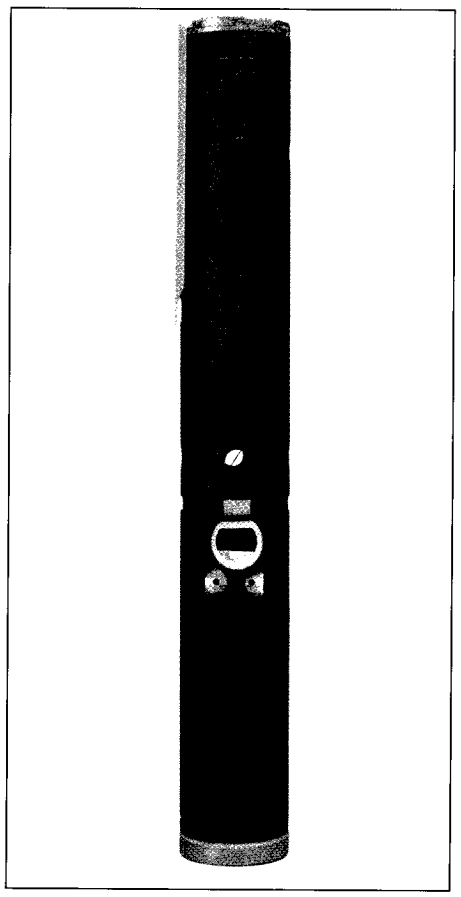
International

AN/SSQ-36B

Type
Expendable bathythermograph.

Description
The AN/SSQ-36B bathythermograph provides vertical temperature profiles of the ocean layer for research purposes, and for ASW evaluates local effects of seawater temperature on sonar propagation and acoustic range prediction.

The 'A' size buoy provides temperature profiles to depths in excess of 800 m and data can be transmitted on any one of 99 VHF- FM channels. Thermistors located in the probe measure the changes in seawater temperature during the buoy's descent from the surface. A RF transmitter sends this data to the launch aircraft. On board the aircraft the data is processed and displayed as a temperature versus depth display. The buoy is compatible with the following radio receivers: AN/ARR-52A, AN/ARR-72, AN/ARR-75, AN/ARR-76 and with the following



The AN/SSQ-36B bathythermograph buoy
(Ultra Electronics)
0089215

processors: AN/AQA-7, AN/AQA-7(V), OL-82, OL-320, OL-5004, UYS-1, UYS-2. The antenna directivity is omnidirectional within ±1 dB in the horizontal plane. The buoy is activated within 30 seconds of splash down and the entire water mass temperature profile is completed 10 minutes after entry into the water.

The bathythermograph can be air launched at air speeds of 0 to 370 kt and at altitudes up to 9,144 m. Air descent is controlled and stabilised by a parachute that deploys when the buoy exits the aircraft.

Power is provided by five polycarbon monofluoride lithium cells, which offer improved operational capability in sub-zero temperature seawater.

Operational status
In service with the US Navy.

Specifications
Size: 'A'
Length: 91.44 cm
Diameter: 12.4 cm
Weight: 7.3 kg
Descent rate: 1.5 m/s
Descent time: 525 s
Sensor temperature range: –2 to +35°C
Temperature accuracy: ±0.56°C
Channels: 99 RF
RF Power: 0.25 W
Operating depth: 800 m
Operating life: 12 min (max)

Contractors
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia, Canada.
Sparton Electronics, DeLeon Springs, Florida, USA. ***UPDATED***

AN/SSQ-937C

Type
Bathythermal buoy.

Description
The AN/SSQ-937C is an 'F' size bathythermal buoy designed, built and qualified for the UK MoD. It provides an ASW operator with a highly accurate plot of sea temperature versus depth. The buoy is configured for gravity launch from aircraft and helicopters.

The microprocessor-controlled buoy provides a temperature versus depth profile down to 457 m within six minutes of entry into the water. The buoy activates in less than one minute of entry into the water.

The buoy incorporates an AFS (Autonomous Function Select) capability that allows any one of 99 FM VHF telemetry channels to be selected prior to launch.

Five polycarbon monofluoride lithium batteries power the buoy.

Operational status
In service aboard aircraft of the UK RAF and Royal Navy.

Specifications
Length: 304.6 mm
Diameter: 123.8 mm
Weight: 3.76 kg
Transmitter frequency: 136-173.5 MHz
RF power: 0.25 W
Transmission channels: 99 (preselectable)
Operating depth: 457 m
Operating life: 12 min (max)
Sensor temperature: –2 to +35°C
Temperature accuracy: ±0.56°C
Launch altitude (max): 45-9,200 m
Launch speed (max): 50-370 kt

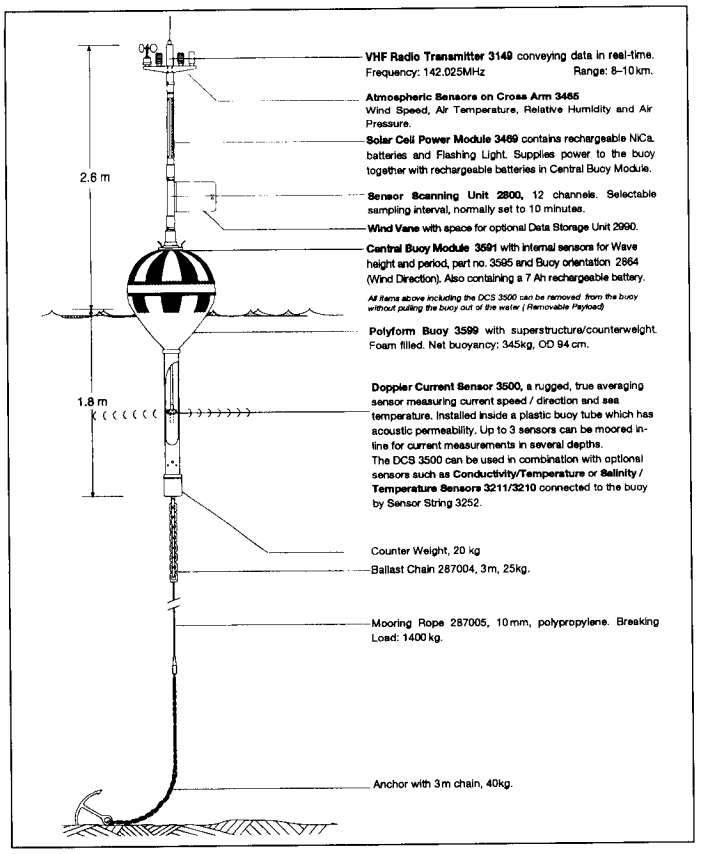
Contractor
Ultra Electronics, Sonar and Communications Systems , Greenford, Middlesex, UK.
Ultra Electronics Maritime Systems,, Dartmouth, Nova Scotia, Canada.
UnderSea Sensor Systems Inc, Columbia City, Indiana, USA.

UPDATED

Norway

CMB 3280

Type
Coastal monitoring buoy.



CMB 3280 buoy

Description
The rugged, lightweight and compact moored data buoy is intended for use along the coast and near off-shore platforms. It is designed to measure wave height, wave period, current speed, current direction and sea temperature, as well as the most important meteorological parameters (windspeed and direction, air temperature, relative humidity and air pressure) and to transmit the information to the user in real time via VHF radio.

The device consists of a foam-filled polyform buoy with a payload carrying the entire measuring system as well as all the sensors and the VHF radio transmitter. The payload can be removed from the buoy for service and maintenance without lifting the buoy out of the sea.

The buoy, which is moored in a fixed position, operates on solar cells. Its operation is controlled by the sensor scanning unit. An internal clock starts the measuring cycle every 10 minutes, reads the sensors and transmits the readings by radio in real time to the shore station or to a platform.

At the receiving end, the computing unit 3015 converts the raw data signals to engineering units which are subsequently displayed on an LCD or screen. On the screen, data are presented as a diurnal picture, which contains the last readings, the 3 hour average, and 24 hour maximum, minimum and average readings for all the parameters. Further relaying of data can be carried out by telephone both digitally and as a voice message.

Contractor
Aanderaa Instruments, Bergen.

VERIFIED

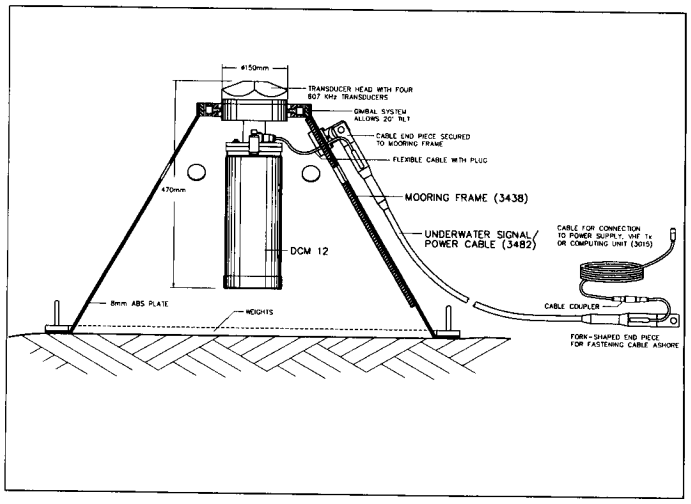
DCM 12

Type
Doppler current meter.

Description
The DCM 12 current meter is designed specifically to measure currents in shallow harbour and coastal waters. The high-technology device is easy to use and handle and can be deployed without the need for divers, underwater foundations and heavy installation equipment.

The meter measures current speed and direction at the surface and five other depths, as well as measuring the depth of water and significant wave height.

The unit consists of an acoustic transducer head fitted on top of a recording unit for measuring the horizontal speed and direction of current. The transducer head has four acoustic transducers angled 30° in 90° azimuthal increments for measuring the horizontal speed and direction of current. A central transducer transmits data to a hydrophone on the surface or shore. The recording unit, housed in a pressure case, contains the main electronics, data storage unit, battery and a compass which enables current direction measurements to be referred to magnetic north.



DCM 12 current meter

The unit is installed in a self-levelling mooring frame that automatically ensures correct installation on seabeds with up to 20° inclination.

The unit samples over a 10 minute period before data is presented. Oppositely located transducers work together, one transducer pinging two seconds after the other. Three seconds later the same cycle is repeated by the other pair of transducers. As the ultrasonic pulses travel towards the surface, echoes from particles and organisms in the water are scattered back to the transducers. Echoes received from the scatterers change frequency due to their movement in correlation with the sea current. By measuring this frequency change (the Doppler shift) the unit can calculate the speed of the particles, and hence the speed of the current.

When 240 samples of the current speed have been taken data is calculated, transmitted or stored. The calculation takes place internally and the DCM presents the vector average speed and direction as two 10-bit binary words for the surface and each of five uniform segments called depth cells. These cells overlap each other by 50 per cent. The cell size is one third of the DCM's deployment depth minus illegible zone of 4 m or 2 m for depths above or under 15 m. The pulse energy is set by a three-position depth setting switch relative to the deployment depth.

Simultaneously with the current measurements, an internal pressure sensor measures once each second the hydrostatic pressure in the water column above the instrument. Based on these measurements, the instrument calculates the water level and the significant wave height on the surface. Data is transmitted in real time via underwater cable or acoustically to a receiving station on shore or on board a ship for immediate display. Power can be supplied via underwater cable or by batteries. Data may also be stored by the meter in a data storage unit.

Total weight of the instrument with mooring frame is 38.9 kg in water.

Operational status
Over 80 units have been supplied worldwide since its launch in May 1994.

Contractor
Aanderaa Instruments, Bergen.

VERIFIED

RCM 9 Mk II

Type
Recording current meter.

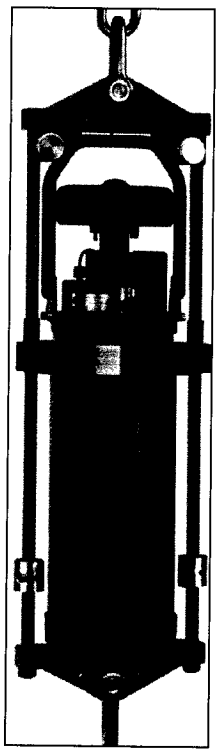
Description
Designed for use in both salt and fresh water, the RCM 9 Mk II recording current meter is based on Aanderaa's Doppler Current Sensor (DCS) which measures horizontal current speed and direction. The unit incorporates a Hall-effect compass and a two-axis tilt sensor which permits accurate measurements at inclinations up to 35° from the vertical.

The unit is free from electrodes which are easily fouled, and features very low power consumption and measures current outwards from the sensor, reducing influences created by turbulence shed from flow around the instrument. The unit also features sensors for the profiling of temperature, conductivity, instrument depth and turbidity along with user selections for fresh water conductivity and Arctic temperature ranges. An optional sensor to measure, for example, dissolved oxygen may also be installed.

The RCM 9 Mk II can be deployed at depths of 2,000 m and will operate unattended for more than two years at 60 minute recording intervals.

Data is stored internally in a standard data storage unit (DSU 2990) or transmits data in real time via cable or acoustic telemetry.

The most common way to use the RCM 9 Mk II is in an in-line mooring configuration. As it operates under a tilt up to 35° from the vertical, it has a variety of in-line mooring applications using surface buoys or subsurface buoys. The instrument is installed in a mooring frame that allows easy installation and removal of the instrument without disassembly of the mooring line.



Recording current meter RCM 9 Mk II
(Aanderaa Instruments)
0099443

It is intended that the RCM 9 Mk II will, in time, replace mechanical rotor-type current meters.

Contractor
Aanderaa Instruments, Bergen.

VERIFIED

SD204

Type
STD/CTD.

Description
The model SD204 measures, calculates and records seawater conductivity/salinity, temperature, depth (pressure) and sound velocity/water density. Sensors for dissolved oxygen and fluorescence/turbidity are optional. The SD200W software combines both the communication and data processing functions. On-line reading by cable, and remotely via telephone or satellite terminal is possible.

The electronic and other components are vacuum moulded in solid polyurethane. On/Off-switching is by a magnetic key or from the keyboard. The unit is powered by two 3.6 V lithium replaceable C-cells housed in a sealed battery compartment. In practical operation the battery capacity is sufficient for continuous year-round operation.

Data is recorded using a real-time clock (accuracy ±2 s/day) with recording intervals of 1 second to 180 minutes.

The SD204 is widely used for calibrating acoustic systems, both by sonar equipment manufacturers and their customers.

Operational status
In service with the Norwegian Navy aboard the 'Oksøy' class minehunters, and at the FORACS NATO test field at Stavanger.

Specifications
Conductivity
Type: inductive cell
Range: 0 to 70 mS/cm
Resolution: 0.01 mS/cm
Accuracy: ±0.02 mS/cm

Salinity
Type: calculated from C,T and D
Range: 0 to 40 ppt
Resolution: 0.01 ppt
Accuracy: 0.02 ppt

Temperature
Type: Thermistor (Fenwall)
Range: –2 to +40°C

Resolution: 0.001°C
Accuracy: ±0.01°C
Response time: < 1 s

Pressure
Type: Piezoresistive (Keller)
Ranges: 500, 1,000, 2,000-6,000 m
Resolution: 0.01% of range
Accuracy: ±0.02% of range

Sound velocity
Type: calculated from S,T and D
Range: 1,350 to 1,550 m/s
Resolution: 5 cm/s
Accuracy: ±10 cm/s

Dimensions
Length: 400 mm
Diameter: 60 mm
Weight: 2.5 kg (in air), 1.3 kg (in water)

Contractor
Saiv AS, Bergen.

UPDATED

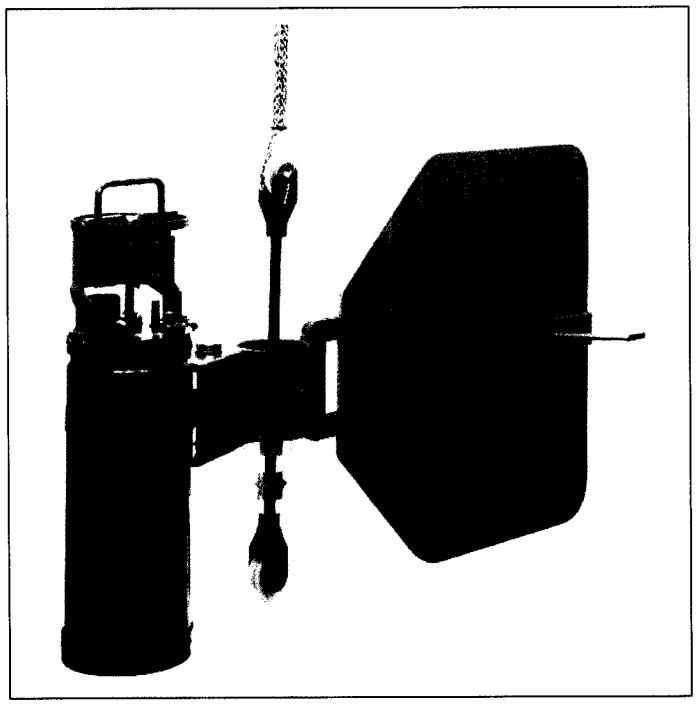
Series 7

Type
Series of oceanographic instruments for data collection.

Description
This range of instruments consists of the recording current meter model RCM 7, water level recorder model WLR 7 and temperature profile recorder model TR 7.

The RCM 7 and RCM 8 are self-contained instruments for recording speed, direction, temperature, pressure and conductivity of ocean currents. The RCM 7 can be moored to the seabed and record ocean data. It comprises a recording unit and vane assembly which is equipped with a rod that can be shackled to the mooring line. This arrangement allows the instrument to swing freely and align itself in the direction of the current. The recording unit contains all sensors, monitoring systems, battery and a detachable, reusable solid-state data storing unit. A built-in clock triggers the instrument at preset intervals and a total of six channels is sampled in sequence. The first channel is a fixed reference reading for control purposes. Channels 2, 3 and 4 represent measurements of temperature (three selectable ranges between –2.46 and 36.04°C plus an Arctic range (–2.46 to 5.62°C to special order), conductivity (0 to 74 mmho/cm standard with two other ranges available on request) and depth (down to 2,000 m) respectively; channels 5 and 6 represent measurement of vector-averaged current speed and direction since the previous triggering of the instrument. The data are sequentially fed to the memory unit.

Simultaneously with the taking of the reading, the output pulse keys on and off an acoustic carrier transmitted by a transducer. This allows monitoring of the performance of moored instruments from the surface by a hydrophone and can be used for real-time telemetry of data.



The RCM 7 vector averaging current meter

The RCM 8 is similar to the RCM 7 in most respects except that it is a high-pressure model for measurement to depths of 6,000 m.

The RCM unit can be moored in one of two ways: a U-mooring which is best suited for use in relatively shallow water and the I-mooring involving the use of an acoustic release device which can be used at any depth. It is essential that a subsurface float is used to avoid wave-induced motion on the mooring line.

The WLR 7 water level recorder is a self-contained high-precision instrument which is placed on the seabed to record water level by precise measurement of hydrostatic pressure, as well as measuring temperature and conductivity. The WLR averages the pressure over a period of 40 seconds in order to eliminate fluctuation in water level due to waves. When this integration time is completed the data words are recorded. The first data word is a fixed reference reading followed by the temperature of the ambient water. Pressure is recorded as two 10-bit words and finally a 10-bit word for the conductivity (optional sensor). Data are transmitted via an acoustic transducer to a hydrophone receiver hung from a relay buoy at the surface. The buoy then transmits the received data via VHF link to a shore base or parent ship.

The temperature profile recorder TR 7 is a fully self-contained instrument for recording temperature profiles in the sea, lakes or fjords. The vertical temperature profiles are used by oceanographers to study internal waves and other physical phenomena. In some applications *in situ* recording of data is required, while for other applications telemetry of data to shore or ship is required, and both functions can be provided by the TR 7. The profile recorder consists of a 12 channel recording unit and a thermistor string. The thermistor string employs 11 temperature sensing thermistors embedded in a polyurethane cable. The thermistors are spaced throughout the cable which can be from 5 up to 400 m maximum in length. Four different temperature ranges are available.

Contractor
Aanderaa Instruments, Bergen.

VERIFIED

United States

HSCP-600

Type
Harbour Surveillance Current Profiler (HSCP).

Description
The HSCP-600 uses digital signal processing and wideband acoustic signals to measure water currents with high accuracy. The device is a real-time data gathering instrument, suitable for coastal, port or inland waterways applications where direct connection to the shore is required.

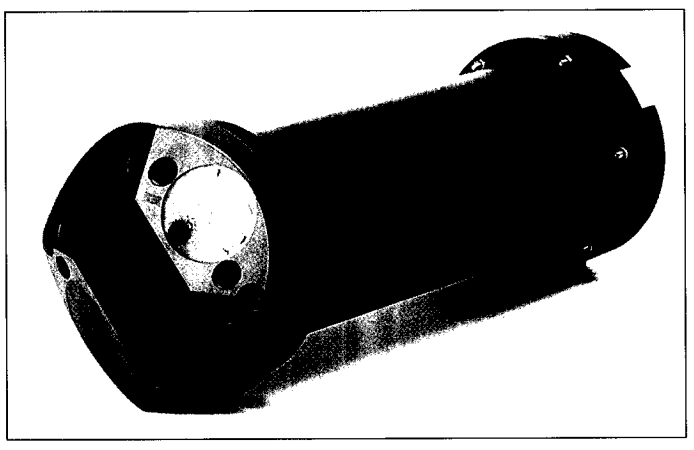
It is primarily designed for short-range, high-resolution applications, and with the addition of optional sensors, including a fifth vertical beam, it can also be configured to measure wave and tide variations, temperature and pressure.

The HSCP-600 uses a 600 kHz wideband signal with digital signal processing offering 50 m range, variable cell size and high resolution. It features a fast update rate (up to 4 pulses per second) and the transducer uses four beams each 3° in width at an angle of –30° from the vertical in 90° azimuthal increments. HSCP-600 also incorporates a temperature sensor.

The data acquisition cycle is versatile and adaptive and provides a binary data output.

The pressure housing/transducer is constructed of hard anodised aluminium, reinforced plastic composite or stainless steel coated with anti-fouling paint, and is suitable for long-term deployment in harsh environments.

Optional features include a pressure sensor, right angle transducer kit, flux gate compass and dual-axis tilt sensors.



Model HSCP-600 acoustic current profiler

Specifications
Profiling range: 50 m (85% of distance of bottom or surface interface)
Current speed range: ±10 m/s
Depth cells: up to 128
Precision: 1 cm/s with 4 m cell
Wideband signal: 600 kHz ±40 kHz bandwidth
Sound power level: 213 dB re 1μPa at 1 m, programmable

Contractor
EDO Combat Systems, Chesapeake, Virginia.

VERIFIED

Neptune RSVP/CTD-1020

Type
Sound velocimeter.

Description
The Neptune RSVP/CDT is a self-recording precision instrument for the direct measurement of sound velocity as well as conductivity, temperature and depth. The CTD measurements can be used for quality control of sound velocity measurements as well as for depth profiles of all parameters.

The RSVP/CDT uses the Ocean Data Equipment Corporation Model 1020 sing-around sound velocity sensor coupled with computer control for data logging and improved calibration, along with calibrated conductivity, temperature and pressure sensing.

The RSVP/CTD is packaged in a high pressure housing, with a standard 10,000 PSI/6,900 m capability. The system is entirely self-contained so that profiles with no electrical connections are possible. It includes 1/2 Mbyte of data storage and rechargeable NiCd batteries capable of 18 hours of profiling with 2 hours recharge. The Neptune RSVP/CTD is suited for high accuracy sound velocity and CTD profiles for swath sonar mapping and for oceanographic surveys. It allows comparison of directly measured sound velocity with sound velocity calculated from conductivity, temperature and depth measurements from its own sensors. It can be used with or without a winch, and with or without electromechanical cable for deep or shallow water profiling. The unit is self-powered and self-recording with menu-driven sampling and setup options. Data is easily downloaded via a serial port and displayed using standard spreadsheet software.

Operational status
The product was introduced in 1997.

Contractor
Ocean Data Equipment Corporation, E Walpole, Massachusetts.

VERIFIED

RO-308/SSQ-36 data recorder

Type
Bathythermograph data recorder.

Description
The recorder is an integral part of the US Navy P-3C Orion aircraft ASW system. The equipment converts seawater temperature information provided by the AN/SSQ-36 bathythermograph buoy transmitter set and AN/AAR-72 radio receiving set to two output forms:

(a) a permanent record of the vertical temperature profile (temperature versus depth) on a paper strip chart
(b) a parallel mode, eight-bit binary-coded data word for delivery to the AN/AYA-8B data processing system.

The buoy is dropped from an aircraft in the target area. Seawater is utilised as the activating agent and after an initial, predictable delay, the buoy releases a temperature sensing probe (TS probe). The TS probe is the variable element in a frequency generation circuit. A radio frequency signal transmitted by the buoy is modulated at a frequency correlated to the temperature of the water. On board the aircraft, the ARR-72 radio is tuned to the buoy carrier frequency. Water temperature information is converted to an audio frequency signal and delivered to the recorder.

Operational status
In service aboard P-3C Orion aircraft of the Japanese and US navies.

Contractor
Lockheed Martin, Archbald, Pennsylvania.

VERIFIED

SSXBT/SSXSV bathythermograph

Type
Submarine-launched expendable bathythermograph.

Description
Profiles of temperature and sound velocity versus depth may be obtained by a submerged submarine using the submarine-launched expendable bathythermograph/sound velocity (SSXBT/SSXSV) equipment. This is similar to the XBT/XSV system described previously except that the probes are launched through the signal ejector of the submarine and are carried to the surface by a float. The buoy releases the probe just before reaching the surface, and the probe then descends, measuring temperature or sound velocity on the way. The float then immediately scuttles. The SSXBT expendable probe senses the water temperature profile from the surface to a depth of 760 m and transmits this to the moving submerged submarine. The SSXSV sound velocity probe provides a profile of measured sound velocity down to 850 m. Temperature or sound velocity data are transmitted to the submarine, via the fine wire tether, for recording and display. A complete measurement cycle takes less than 4 minutes.

The breech door/cable feed-through assembly provides the inner door for the signal ejector. It allows the tether wire to pass through the door and provides a seal around the wire. At the end of probe deployment a guillotine in the assembly cuts the tether wire allowing the SSXBT components to clear the submarine and scuttle.

The AN/BQH-7/7A and Mk 8E recorders/processors provide temperature and sound velocity profiles. The processor can convert measured temperature to compute sound velocity based on a standard salinity of 35 psu.

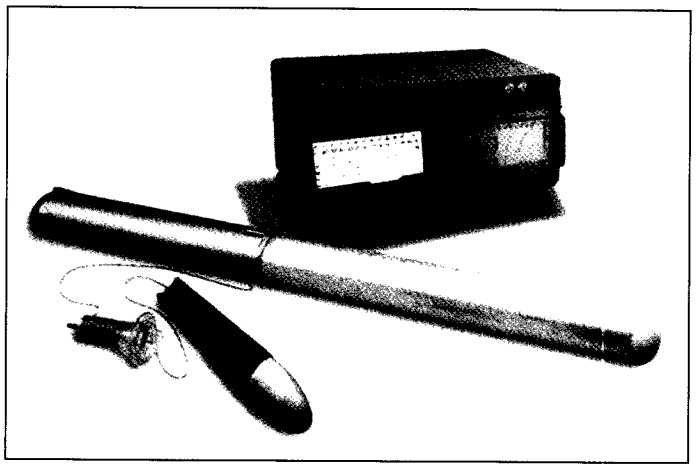
Operational status
In service.

Specifications
SSXBT
Range: –2.2 to +35.6°C
Accuracy: ±0.15°C
Depth range: 0-760 m
Depth accuracy: ±2%
Size: 97.6 × 7.6 cm

SSXSV
Range: 1,405-1,560 m/s
Accuracy: ±0.25 m/s
Depth range: 0-850 m
Depth accuracy: ±2%
Size: 97.6 × 7.6 cm

Contractor
Sippican Inc, Marion, Massachusetts.

VERIFIED



SSXBT system (Sippican Inc) 0538137

SSXCTD

Type
Submarine-launched conductivity, temperature and depth probe.

Description
An adaptation of the XCTD probe for launching from submarines. Salinity and density may be derived from the conductivity and temperature data. This is especially useful for submarine operations in areas where salinity is non-standard.

Operational status
In production.

Contractor
Sippican Inc, Marion, Massachusetts.

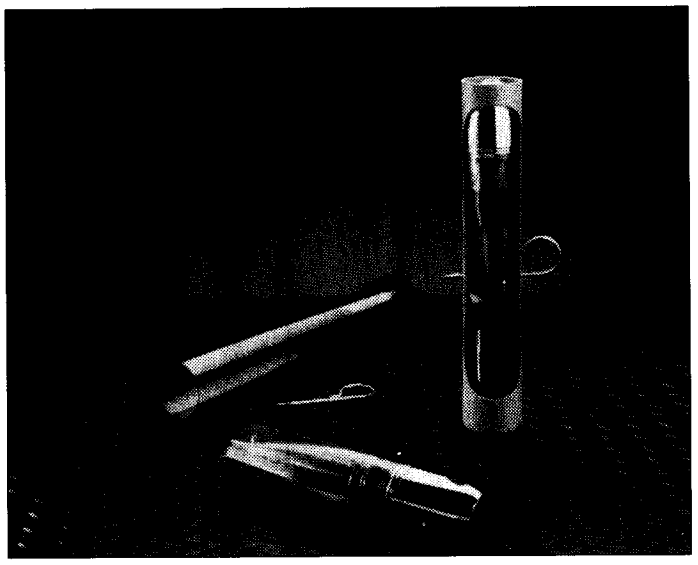
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XBT/XSV bathythermograph system

Type
Expendable temperature/sound velocity probes.

Description
The Sippican XBT/XSV system uses inexpensive, expendable probes to obtain vertical profiles of temperature and sound velocity. The temperature data obtained by XBT probes may be used to compute sound velocity, although the XSV probes measure sound velocity directly. Whether computed or measured directly, the sound velocity data obtained assists in the prediction of sound propagation and is crucial to the effective use of sonars. An XBT/XSV system includes XBT or XSV probes, a hand-held, deck-mounted or through-hull launcher, and a Mk 8 microprocessor-based data processor/recorder.

The nose of each probe is precision-weighted and the unit spin stabilised to assure a predictable rate of descent. From the rate of descent, probe depth can be determined to an accuracy of ±2 per cent.



XBT/XSV expendable profiling system

The temperature data obtained by the XBT may be used to compute sound velocity wherever salinity is constant. In areas where salinity may be highly variable, such as the Mediterranean and the Arctic, temperature data may not be sufficient to calculate velocity and to predict adequately acoustic propagation. In these areas sound velocity must be measured directly with the XSV probe. The XSV uses a unique sing-around transducer to obtain this direct measurement. The sound velocity is accurate to ±0.25 m/s at depths up to 2,000 m.

The XBT houses a precision thermistor in its nose, which is capable of recording temperatures with an accuracy of ±0.1°C.

Both XBT and XSV probes obtain data in real time. Following launch, data collection begins at the surface and as the probe descends, wire unreels from a spool located within the probe, as well as unreeling from another spool in the launch canister. This enables the ship to use the system without restrictions on speed or manoeuvrability.

The Mk 8E data processing system, US Navy nomenclature AN/BQH-7/7A, is linked to the descending probe by the hard wire link. The processor provides profiles of temperature or sound velocity to three outputs: digital data stored on magnetic tape, analogue chart paper trace, and RS-232 digital interface to external data systems.

These probes may also be used with the IBIS - Integrated Bathythermal Information System (see IBIS entry). This uses the Sippican Mk 12 data acquisition system in a ruggedised computer and is integrated with several prediction systems. This is in service with the Royal Navy as sonar 2090.

Operational status
In service.

Contractor
Sippican Inc, Marion, Massachusetts.

VERIFIED

Specifications

XBT	T-4	T-5	Fast Deep™	T-6	T-7	Deep Blue	T-10	T-11
Applications	standard probe used by the US Navy for ASW operations	deep ocean scientific and military applications	provides max depth capabilities at the highest possible ship speed of any XBT	oceanographic applications	increased depth for improved sonar prediction in ASW and other military applications	increased launch speed for oceanographic and naval applications	commercial fisheries applications	high resolution for US Navy mine counter-measures and physical oceanographics applications
Max depth	460 m	1,830 m	1,000 m	460 m	760 m	760 m	200 m	460 m
Rated ship speed*	30 kt	6 kt	20 kt	15 kt	15 kt	20 kt	10 kt	6 kt
Depth resolution	65 cm	65 cm	65 cm	65 cm	65 cm	65 cm	65 cm	18 cm

XSV	XSV-01	XSV-02	XSV-03
Applications	ASW application where salinity varies; naval and civilian oceanographic and acoustic applications	increased depth for improved ASW operation where salinity varies; naval and civilian oceanographic and acoustic applications	high-resolution data for improved mine counter-measures and ASW operations in shallow water, geophysical survey work, commercial oil industry support
Max depth	850 m	2,000 m	850 m
Rated ship speed*	15 kt	8 kt	5 kt
Depth resolution	32 cm	32 cm	10 cm

System depth accuracy = 4.6 m or 2% of depth (whichever is greater)

*All probes may be used at speeds above rated maximum. However, there will be a proportional reduction in depth capability

XCP profiler

Type
Horizontal ocean current profiler.

Description
The XCP (Expendable Current Profiler) is an expendable instrument capable of obtaining real-time profiles of horizontal current direction, speed and temperature

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juws.janes.com

down to depths of 1,500 m with an accuracy of ±1 cm/s RMS. The data acquisition and processing system samples eight parameters: north velocity component, east velocity component, temperature, rotational frequency, electric-field baseline, magnetic compass baseline, area ('tilt' correction) and velocity error. It may be deployed from either a surface or airborne platform since it uses an RF link to transmit data. Three channels are available for RF transmission: 170.5, 172 and 173.5 MHz (standard US Navy sonobuoy channels 12, 14 and 16). A complete XCP system includes expendable probes, a Sippican Mk 10 digital data interface, and any MS-DOS-compatible computer with IEEE-488 support.

The probe is deployed by hand over the side of any ship. A battery inside the buoy is activated when it enters the water and rapidly assesses the operating voltage required to power the buoy's electronics. Power is applied to the RF transmitter and to a training circuit. The surface buoy releases the probe after a 40 second delay and data sampling commences.

Data is telemetered to any receiver within line-of-sight of the XCP surface buoy via RF link. After the probe has completed its descent, the RF transmitter self-disables and the entire buoy assembly scuttles.

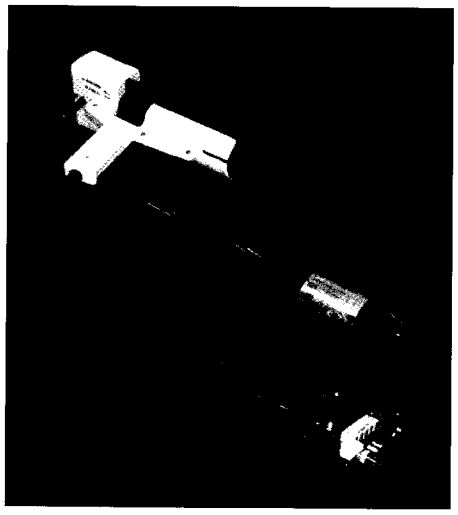
The XCP has been used in studies of the mixed layer, ocean fronts, Gulf Stream rings, mid-ocean eddies, internal waves and acoustic propagation.

Operational status
Developed under the auspices of the US Naval Oceanic Research and Development Activity (now the office of Naval Research, Stennis Space Center) — over 5,000 XCPs have been successfully deployed. XCPs have been used in a number of oceanographic programmes and experiments, by agencies such as the National Oceanic and Atmospheric Administration (NOAA), the Office of Naval Research (ONR), and the National Science Foundation (NSF). An aircraft deployed XCP is also available.

Specifications
Operating frequencies: US Navy sonobuoy channels 12, 14, 16
Operating depths: 1,500 m
Horizontal sheer current accuracy: –3% RMS
Velocity resolution: –1.0 cm/s RMS
Vertical resolution: 0.3 m
Temperature range: 0 to +30°C
Temperature resolution: 0.2°C
Sampling rate: 16 Hz

Contractor
Sippican Inc, Marion, Massachusetts.

VERIFIED



XCTD (Sippican Inc)
0538138

XCTD

Type
Expendable conductivity, temperature and depth profiling system.

Description
The XCTD is designed to collect salinity profiles up to 1,000 m, while under way, at ship speeds up to 12 kt. The system comprises an expendable digital probe that measures conductivity and temperature, the Sippican Mk 21 data acquisition system, which is an expansion card that can be inserted into PCs, and a launcher.

The system can collect conductivity measurements to 0.03 milli-Siemens (mS/cm) and temperature to ±0.035°C. These measurements are sampled at a rate that provides a vertical resolution of 80 cm at a depth accuracy of ±5 m or 2 per cent of depth, whichever is greater.

The XCTD probe contains a conductivity cell, a thermistor, electronics and a BT wire link to the surface. The conductivity cell is a high-purity, alumina ceramic tube wired to form a four-electrode conductivity sensor. The cell is potted in a glass-filled, rigid epoxy compound.

The temperature sensor is a very stable glass encapsulated, fast-response temperature-cycled thermistor. The cell electronics package converts the measured resistance on the thermistor and conductivity cell into a frequency which is sent up the BT wire as a coherent DPSK on a 800 Hz square wave to the acquisition circuitry in the Mk 21.

Included in the probe electronics are two precision calibration resistors which are periodically sampled and their output transmitted up the BT wire in conjunction with the temperature and conductivity data to compensate for any induced changes in the electronics during the deployment.

The digital XCTD is calibrated at three temperatures and three conductivities during manufacture. These co-efficients are stored in the probe and used internally to compute the temperature and conductivity prior to data transmission. The Mk 21 system processes and displays the conductivity and temperature profile in real time and provides a calculated salinity profile once data acquisition is complete.

Operational status
The XCTD has undergone extensive at-sea testing to verify its accuracy. The probe has been in full production since early 1994 and over 6,000 units have been deployed to date.

Contractor
Sippican Inc, Marion, Massachusetts.

VERIFIED

Specifications
XCTD-air launch version, AXCTD also available.

PERFORMANCE CHARACTERISATION

Nominal Accuracy to Standard*

Temperature		Conductivity		Depth		Vertical
Range	**Accuracy****	**Range**	**Accuracy****	**Range**	**Accuracy*****	**resolution**
-2.2-30°C	±0.2°C	0-70 mS/cm	±0.035 mS/cm	0-1,000 m	±5 m or 2% of depth	1 m

* Accuracy of temperature and conductivity standards used in XCTD calibration is ±0.005°C and mS/cm
** Nominal accuracy characterisation based on XCTD horizontal profiles against a calibrated transfer CTD (each comparison used 4 pt smoothing). 95% of tabulated data was within ±0.035°C and mS/cm of the transfer CTD
*** Drop rate characterisation has been conducted on vertical profiles referenced to a CTD. Maximum offset at 91% of full depth (910 m) for pairs of simultaneously launched probes was ±1.4%

PREDICTION SYSTEMS

France

Neptune

Type
Environmental tactical aid software.

Description
The modular Neptune system introduces a new concept of environmental tactical aid. The system contains different components, the complexity of which can be varied depending on a variety of customer requirements such as type of vessel (submarine, surface ship and so on); integration into a combat management system; stand-alone configuration.

Through an intuitive GUI-based interface, Neptune can enable the user to assess his acoustic superiority or risk in the face of one or more hostile threats or targets. Operating modes range from fully automatic to operator specification of all variables.

The components of Neptune include an environmental model (including measured, statistical and forecast data); ship and sensor parameters; acoustic confrontations (where the ship faces one or more threats in the current scenario); different ray tracing either in normal mode or using parabolic equation propagation loss models; and synthetic analysis of the acoustic situation from different graphical outputs — ray tracing, propagation loss (images and plots with panoramic views which are operator-selectable across various bearings) and signal to noise ratio and finally sophisticated tactical aid images. The propagation loss is displayed in global vision around the 'own ship' from which null points at all depths can be seen.

Among the various capabilities offered by Neptune are operator selectable depth contours covering the whole world; an international database and the ability to read messages from shore bases using datalinks.

The displays can show surface temperatures for any geographical location and the final version will be able to display temperatures at different depths. It will also incorporate sonar equations and ship characteristics to which changes can be input by the operator. Other features include three-dimensional (3-D) pictures of the seabed, which can be oriented in three directions, and the ability to zoom in and out of displays.

Neptune can be colour coded according to customer requirements. Neptune is available in several versions based on 486 PCs or multiprocessor workstations with 3-D graphic accelerators. The system supports UNIX (including Motif), and Windows (NT or 95), as well as leading graphic libraries (Open-GL, Xgl, PEX).

Operational status
A first prototype has been built.

Contractor
DCN, Paris.

VERIFIED

International

Type 2090/IBIS

Type
Recorder, processor and sonar prediction system for use with XBT, XSV and XCTD and submarine launched expendable probes.

Description
Designed jointly by Ultra Electronics Sonar and Communications and Sippican Inc (USA) to meet the Royal Navy's requirement for a powerful oceanographic data acquisition and sonar range prediction system (MoD designation Sonar 2090).

IBIS (Integrated Bathy Information System) interfaces directly with standard Sippican launchers and probes (XBT, XSV and XCTD and submarine equivalents). It may easily be installed in place of all Sippican processors.

Its key features include: data acquisition, display and recording with zoom and edit facilities, and reduced breakpoint algorithms; Wader — provides worldwide oceanographic database (with zoom) of bottom profile, and monthly temperature and salinity profiles and sound velocity data; Hodgson — range dependent high-speed propagation loss model; Mimic — very low frequency, range dependant, high speed propagation loss model, complementary to Hodgson.

Raw data may be processed to provide a simplified profile for sonar analysis and bathy reports. Raw profiles may also be uploaded via a serial link to an external computer. Bathy and surface observation reports are compiled automatically and printed in a standard format.

Operational status
Production units available and in service with the Royal Navy as sonar Type 2090 in surface vessels and submarines. The survey vessels *Scott* and *Herald* of the Royal Navy are equipped with the Type 2090 system. A total of 88 systems have been delivered.

Contractors
Ultra Electronics Sonar & Communication Systems, Greenford, Middlesex.
Sippican Inc, Marion, Massachusetts.

UPDATED

Netherlands

PRS-02/pathfinder

Type
Processor recorder for expendable bathythermograph (XBT) and sound velocity (XSV) probes.

Development
Developed in close co-operation with the Royal Netherlands Navy.

Description
The PRS-02 system is used to process and record: seawater temperature in relation to depth (by an expendable bathythermograph probe), and sound velocity as a function of the depth (by a velocimeter probe).

The probes transmit their data via signal wire to the combined processor recorder which then translates the data into temperature/depth or sound velocity/depth profiles and makes it available in both hard-copy or via an RS-232 or -422 interface.

Operated by a single person, the unit can remotely control the launcher for the probes, carrying out the necessary automatic pre-launch test. Five depth scales are available.

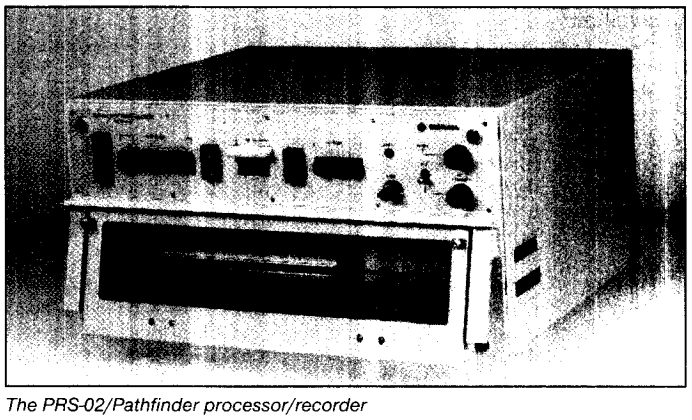
The unit provides a digital interface with the ships sonar or data handling system, enabling the PRS-02 profiles to be used in propagation systems.

Operational status
The system is in production and has been delivered to several navies and is operational on board submarines and surface ships. In the Royal Netherlands Navy it is aboard the M class frigates and Walrus class submarines; the system is on order for the German Type 124 frigates and the MEKO 200 frigates of the Turkish Navy.

Specifications
Velocity range: 1,404 to 1,506 m/s
Resolution: 0.05 m/s
Temperature range: –1.5 to +37.5°C
Resolution: 0.0125°C
Salinity (in 40 steps): 00 to 40%
Depth range/resolution:
100/0.1 m
200/0.1 m
400/0.2 m
1,000/0.5 m
2,000/1.0 m

Contractor
Thales Special Products, Zoetermeer.

VERIFIED



The PRS-02/Pathfinder processor/recorder

Sweden

SonTak

Type
Sonar tactical decision aid.

Description
SonTak is an onboard PC-based sonar tactical decision aid developed by SSPA Sweden AB, in conjunction with the Swedish Defence Materiel Administration (FMV). The system is designed to aid the command in deciding the best sonar to use, the best depth at which to deploy the sonar and how the various onboard sonars can best be combined to achieve the greatest probability of detection for possible targets in the vessel's operating environment. It is also valuable in submarines for calculating the possibility of detection by hostile ASW systems.

The sound velocity profile is measured in situ. Together with ray tracing and normal mode algorithms in the SonTak system, it is used to determine the sound propagation transmission loss as a function of range and depth. Other data relating to both active and passive modes of sonar operations are estimated from environmental parameters (for example sea state, bottom depth and bottom type), and a databank of possible targets and own sonar and platform data.

By combining information on anticipated targets, the environment in which the vessel is operating, and own sonar and own ship parameters, detection probability is calculated and displayed as a function of target range and depth.

SonTak consists of four main subsystems:
- sound velocity measurement and environmental database
- modem link to HAIS
- sonar and target database
- detection probability and transmission loss calculation.

SonTak both acquires and provides data for the shore-based HAIS (Hydro Acoustic Information System — purchased from BAE Systems (formerly BAe SEMA) in the UK (see also separate entry on NECTA). Also forming part of the new ASW capability is a ship-based system for tactical use which has been installed on all ASW units of the Swedish Navy. This latter system comprises small, rugged MIU 2000 PCs. These PCs are connected to one or two probes (XBTs on coastal corvettes), which measure various parameters such as conductivity, pressure and temperature, necessary for calculating sound velocity. The PCs are able to send and receive data from HAIS via modems.

To provide the necessary data for decision making, two programmes are run on board the ships - SonTak and HYDAB (Hydroacoustic Database). HYDAB allows the operator to run operational classification of passive sonar contacts (both radiated ship noise and pings from active sonars).

Two models are used for sound propagation calculations. Above 1 kHz a ray tracing algorithm including sound absorption is used. Surface bounces are taken into account but bottom bounces are ignored. Below 1 kHz a normal mode model with bottom sediment propagation is used. The programme can be set for various types of bottom to take into account reverberation.

SonTak is designed for use with hull, VDS and towed array sonars and detection probability is calculated and displayed as a function of target range and depth.

Operational status
Installed on all ASW units of the Swedish Navy.

Contractor
SSPA Sweden AB, Gothenburg.

VERIFIED

United Kingdom

Acoustic Support Function (ASF)

Type
Environmental tactical aid.

Description
The ASF provides environmental data processing and performance prediction for ASW sonar applications. Initially developed to be embedded in the Royal Netherlands Navy's M class frigate command system, the ASF is flexible and portable, designed and implemented to operational standards to provide:
- environmental data access and manipulation
- environmental and sonar sensor data interfaces
- signal data interfaces
- propagation loss models and ray tracing
- sonar performance and probability of detection
- sonar deployment assessment.

At the heart of ASF is a suite of complementary propagation loss models from a number of leading NATO naval and research organisations incorporated as 'black boxes'. This is supported by comprehensive environmental and contact databases, interfaces to online data sources and oceanographic and acoustic processing functions to ensure that the models are supplied with the best available input data.

The ASF contains its own local database of data for the current operational area and sonars/platforms. A software presentation layer interfaces to the host environment, providing the means to populate the local database from an external master database. The interface also supports operator inputs and responses to ASF, integrated sensor inputs, signal data and datalogger outputs from ASF, and the result from ASF processing functions.

Sensor inputs include observed profiles, directional ambient noise and reverberation.

Predictions can be made for any known combinations of platforms and sonars and are not limited to 'own ship' calculations.

Operational status
In service with the Royal Netherlands Navy.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

DINAMO

Type
Ambient Noise Prediction Model.

Description
DINAMO (DIstributed Noise Array MOdel) is a fast range-dependant ambient noise model that computes the 3D noise field at the centre of a user defined array. Outputs from the model include the 3D noise field, noise in the beam and tactical displays on how best to deploy the array.

At the core of DINAMO are fast integral formulae that compute the noise field at the centre of an acoustic array for distributed noise sources.

The operator locates and orientates the array on a world map. Shipping, wind, rain, oil rig and seismic profiler noise sources can be input manually as distributive (polygon) sources on the world map. Shipping density can be read from the HITS database as a default option. In addition the wind and rain can be read automatically from weather forecasts in GRIB format. Bathymetry, bottom type and sound speed profiles are input from data files.

The 3-D noise field is computed and mapped onto the beam pattern from which the optimum array heading and depth can be calculated for a given scenario.

Contractor
Corda Ltd, Farnborough, Hampshire.

NEW ENTRY

INSIGHT

Type
Propagation and sonar performance model.

Description
INSIGHT is a fast propagation and sonar performance model hosted on a PC. It provides a complete sonar performance modelling capability, which puts all the active and passive sonar equation terms at the disposal of the operator. INSIGHT is able to model monostatic or bistatic sonars.

At the heart of INSIGHT is a fast propagation, ambient noise and reverberation model which enables operators to understand acoustics in complex environments, displaying colour-coded acoustic components. INSIGHT identifies acoustic components (surface duct, bottom reflection, convergence zone and so on) or multipaths and summing the contributions from each. Noise levels are calculated by analytically scanning all multipaths (for example shipping noise, rain, wind and so on) separately.

Sensitivity analysis is simple to use and special features are available for reconciling trials data with predictions. A large number of plot options (against any parameter) are available allowing the operator to investigate interference and finite frequency band affects, boundary losses, sound speed profile (SSP) details and beam patterns. These include various standard and user-defined volume and boundary loss laws, including an under-ice capability.

Arbitrary sound speed profiles are easily handled and broken down into phase speed (or angle/wave number) bands which are shown explicitly and interactively on the SSP plot. The corresponding acoustic contributions are shown, using the same colour coding, on the transmission loss plot. Effects of convergence zones, surface ducts, bottom ducts and so on are thus seen instantaneously.

As well as propagation calculations, INSIGHT includes predictions of signal versus a background, which could be simply ambient noise for a passive sonar or reverberation plus noise for an active sonar. One of INSIGHT's major features is its self-consistent approach to the calculation of signal, ambient noise and reverberation.

A comprehensive beam pattern facility provides a number of options for calculating beam responses. These options allow for input by selected beam pattern type or array type.

Contractor
Corda Ltd, Farnborough, Hampshire.

UPDATED

Mermaid

Type
Software and database package for predicting in-water environmental conditions in shallow water areas.

Development
Mermaid (Marine Environmental Model and Integrated Database) concept has been developed by QinetiQ and the Unit for Coastal and Estuarine Studies at the University of Wales, Bangor.

Description
A forecast model enables Mermaid to make predictions over large or small shallow water regions for such parameters as temperature, sound speed, tides and currents. It also incorporates a search and rescue package for predicting the track of drifting objects or the movement of oil slicks, for example. The integral database contains an extensive set of temperature profiles, tidal components and bathymetry.

In naval applications, Mermaid can be used in support of shallow water ASW where it provides predictions of thermal structure and sound speed profiles for input to sonar performance models. It also predicts the position and strength of oceanographic features (for example fronts) from database and other considerations. Data on the depth of the surface mixed layer and estimates of diurnal heating effects can be provided together with estimates of environmental factors affecting ASW tactics.

In support of mine countermeasures Mermaid predicts the strength and direction of tidal currents in order to determine safe standoff distances from hostile objects. It also predicts tidal currents in support of diver and ROV operations. Waves and tides are predicted in order to determine the MCM platform's dynamics and response. It also provides estimates of near-seabed tidal and wave-induced currents for mine burial prediction and forecasts temperatures and sound speed profiles for input to MCM sonar performance prediction models. The search and rescue package can also be used to predict mine drift.

Operational status
The forecast model component of Mermaid has been incorporated in the HAIS (Hydro Acoustic Information System) developed for the Swedish Navy.

Contractor
QinetiQ, Farnborough, Hampshire.

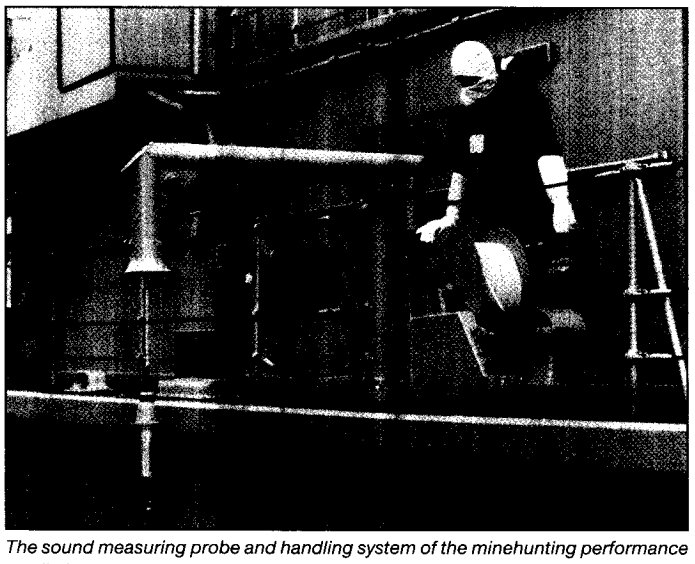
VERIFIED

Minehunting performance prediction system

Type
Computer-based prediction system.

Development
The Thales Underwater System minehunting performance and prediction system has been developed to supplement modern minehunting sonars. Gathering data on underwater environmental and operating conditions, the system enables sonar operators to select optimum operating parameters and derive a probability factor for detection and classification of perceived mines using those parameters.

Description
The self-contained, computer-based system consists of a variable depth sound velocity measuring probe which is lowered and raised by an outboard winch and jib assembly sited on the upper deck, which is controlled either remotely from the operations room or from a local control panel on the winch. The computer, plotter and electronic panel and rack are located below deck in the operations room.



The sound measuring probe and handling system of the minehunting performance prediction system

The probe measures the velocity of sound, pressure (indicating the depth) and temperature at intervals of time as the probe is raised from the operator-selected depth (usually considered to be 5 m above the seabed). An optional lightweight probe is available which can replace the winch and probe assembly.

Using this data together with keyed in data and data received from minehunting sonar, the computer applies preprogrammed algorithms to produce recommendations for the sonar parameters to be used, together with predictions of the classification and detection performance which can be obtained.

The operator interacts with the menu-driven program software in the computer using a keyboard and screen displays to insert parameters, select options, deploy the probe and request recommendations and graphical and tabulated information.

The four-colour X-Y plotter is used to obtain hard-copy printout of the computer screen displays.

In computing the recommended sonar parameters and performance predictions, the system takes account of the ship's sonar characteristics (frequency, pulse length and so on); underwater environment (reverberation, ambient noise, sound profile and so on); ship characteristics (flow/propulsion noise levels and so on); detection, classification and operator performance models; and specific mission inputs (that is, ship speed, sonar operating mode, target characteristics and deployment). The system computes and displays detection range and depth characteristics (detection contour); probability of detection against range; probability of classification against range for moored and ground mines; real-time monitoring of sonar conditions; performance summary; velocity of sound versus depth; ray trace display; optimum towed body height for the variable depth sonar; and data for mission planning, allowing selection of optimum operating modes.

Operational status
The system is operational aboard Hunt and Sandown class MCMVs of the Royal Navy. It also forms part of Sonar 2093 systems sold to Saudi Arabia, Japan, South Korea, Turkey and Australia.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

NECTA

Type
Sonar performance prediction system.

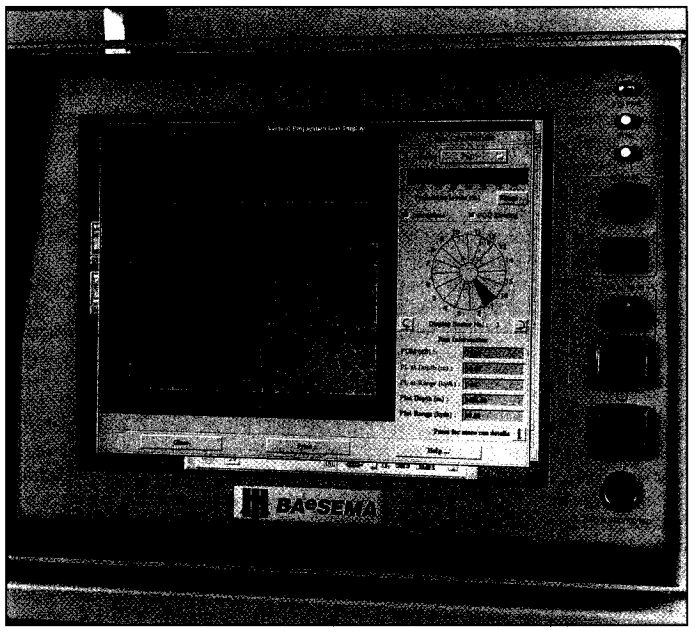
Description
The Naval Environmental Command Tactical Aid (NECTA) is a scenario-based sonar performance prediction system suitable for both shallow and deep water environments. It is available in variants addressing the requirements of research users, data gathering and analysis activities and operational use. NECTA provides a suite of graphical tools for visualising potentially complex underwater environments and, of crucial importance, tools which provide a rapid assessment and visual presentation of sonar performance.

NECTA meets the following requirements for a sonar performance prediction system:

- to provide a simple process for obtaining sonar range predictions quickly, while allowing detailed control of the process for more advanced users
- to perform across the complete range of operational conditions (shallow or deep, LF or HF, passive or active, noise-limited or reverberation-limited)
- to provide interactive and intuitive graphical visualisation of complex datasets, using both two-dimensional and three-dimensional displays
- to handle the integration of range-dependent environmental data from variable-resolution grids and scattered observations (an important feature for data compilation and research
- to allow the integration of different PL (propagation loss) models and databases, according to the requirements of individual customers
- to be open systems compliant enabling NECTA to run stand-alone or integrated within a full command support system.

NECTA provides the following key features:

- a chart display with worldwide coverage which provides the geographical context for scenarios. Chart overlays can be produced to show environmental and tactical data including bathymetry, sound speed, temperature, sonic layer, sound channel, convergence zone potential and the position of XBT/XSV/CTD drops
- a fully integrated suite of acoustic propagation loss models which can be configured to suit individual customer requirements. Supported models include Hodgson, Supersnap, MIMIC, Instant, Mocassin and IFD
- environmental data management and analysis facilities. These provide for the storage and display of both historical and observed oceanographic data with a global capability
- a tactical database for sonar and platform acoustic characteristics
- performance calculations based on evaluation of the sonar equation for the defined scenario.



NECTA 0009860

In addition to cross-sectional views of PL and POD) which the core facilities provide, there is an optional tactical overlay facility which enables plan views of the same results to be superimposed on the NECTA chart. These overlays provide: PL viewed at any depth; Probability of Detection (PoD) viewed at any depth; best evasion depth; best detection depth.

Additional overlays available can display navigational data including shipping lanes, height of features, which fishing, traffic and topography data can also be inserted.

NECTA can be interfaced to onboard sensors (through the command system, the sonar system or directly as appropriate) to provide automatic input of navigational, oceanographic, sonar and noise data.

In the variant on order for the Visby class corvettes the NECTA will provide facilities for calculating the most effective sensor configuration taking into account the prevailing environmental conditions. This feature is available for both ASW and MCM operations.

ASW sonar range prediction will use current NECTA technology, but extended to include an alert capability to warn the operator of changes in the environment which would affect sensor performance. The probability of detection factor will then be updated using this data. For MCM operations the current NECTA will be enhanced with a 3-D visual facility which will allow operators to manoeuvre an ROV taking into account seabed topography and monitor the coverage of its sonar. Being integrated into the Hydra will allow NECTA access to all the environmental and acoustic conditions available in the sonar system. Also incorporated into the NECTA software will be a Swedish government developed acoustic model and hydrographic data specific to the Baltic Sea.

The NECTA (MCM) is designed to enhance the deployment of MCM sonars and to assess the effectiveness of an operation and to assist in carrying out route survey operations. NECTA (MCM) enhances the basic ASW version with a suite of 3-D graphics facilities to provide MCM operators with assistance in the planning, real-time and post-mission analysis phases of MCM operations using UUVs.

The latest development of NECTA Version 9 which incorporates a number of significant improvements and which is now available on Windows PCs. The new developments include:

- enhanced data management with support for variable resolution gridded environmental data
- a new platform and sonar database linked to improved scenario based calculation tools
- an all new wizard which leads the user through the process of defining scenarios and generating detection predictions
- a large number of other operability improvements.

Operational status

NECTA systems have been delivered to the Swedish Navy and the Finnish Navy. A variant of NECTA will be embedded and integrated into the Hydra MSS of the new Visby class corvettes of the Swedish Navy where it forms the basis of the UEMS (Underwater Environmental Monitoring System), the Swedish Hydrographic Information Sound Propagation Programme (HISPP). The system will be installed on a Visby corvette at the end of 2004. A specially tailored variant is being installed on all Royal Navy submarines and a further variant is embedded in the UK Type 2087 sonar. The Finnish Naval Research Institute (FNRI) has recently carried out final acceptance tests of a NECTA environmental and sonar modelling system installed in late 2003. It will be used to assess the performance of many sonar-based programmes being developed by the Institute.

Contractor

AMS, Frimley, Surrey.

UPDATED

OCIDAS-1 (Ocean Intervention and Data Assimilation System, Phase 1)

Type

Software and database package for forecasting in-water environmental conditions using numerical models and observations.

Development

Developed by QinetiQ as a research prototype to enable a forecaster to compare historical data with numerical model forecasts and observations, and to generate predictions of in-water conditions in standard format signals.

Description

OCIDAS-1 is part of a continuing development of prototype software tools for oceanographic and acoustic forecasters. Incorporating a mixed layer model, the software enables a forecaster to make the best possible use of scarce in-water observations which can predict changes in the upper ocean in response to atmospheric effects, and historical databases of typical conditions for different ocean regions and different times of the year. Four acoustic propagation loss models are also incorporated to cover deep and shallow water regions, and high- and low-frequency regimes.

Driven by forecast fluxes from a numerical weather prediction model, the mixed layer model can generate forecasts on a grid of locations, or for irregularly defined regions. Contoured synoptic charts can be displayed, and maps can also be selected showing observation locations and the positions of ocean fronts and the ice edge. A 'quick-look' assessment of the acoustically important features of temperature profiles can be used to give an overall impression of the location of good, medium and poor acoustic propagation areas.

OCIDAS-1 is hosted on a SUN Sparc 2 system, incorporating high-resolution graphics and multiwindowing facilities. The software has been written in a modular form so that various combinations of components can be transported to other systems.

Operational status

OCIDAS-1 has been evaluated by QinetiQ in collaboration with the Royal Navy, and is being integrated into RN operational systems.

Contractor

QinetiQ, Farnborough, Hampshire.

VERIFIED

Type 2068 (SEPADS)

Type

Environmental tactical aid.

Description

The Type 2068 Sonar Environmental Prediction and Display System (SEPADS) has been designed to provide real-time advice to the command on the most effective deployment of units and sensors. This is a particular requirement for towed array sonars which need accurate information so that they can be used to the best effect.

SEPADS interfaces with onboard sensors for the direct input of bathythermograph, sonar and meteorological information which is stored on a computer disk. This information together with other tactical data provides the basis of input to environmental and acoustic models from which tactical decisions are evaluated and displayed. In conjunction with sound-propagation-loss models, it is used to forecast parameters such as the sonar ranges and the optimum depth at



Typical display from the SEPADS system

which to deploy the towed array. Processing is carried out in a PDP 11/44 computer.

The system also features advanced TMA packages which complement the tactical environmental decision facilities.

Operational status
In service with the Royal Navy.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

UwEM

Type
Underwater environment monitoring system.

Description
The UwEM is the sonar performance modelling and envrionmental analysis suite, which forms an integral part of the General Dynamics Canada Hydra multisonar system for the Visby class corvettes. UwEM is highly integrated into the sonar providing real time access to local environmental data allowing it to continuously monitor the environment and update sonar performance predictions. The software is based on the existing NECTA (see entry on NECTA) system.

UwEM provides a comprehensive support for both the ASW and MCM roles of the Visby and offers a unique 3D-visualisation capability to support the planning and conduct of remote minehunting operations.

Operational status
1 June 2002 - Successful Factory Acceptance Test (FAT).

UwEM was supplied to General Dynamics Canada who are responsible for the Hydra sonar system of the Visby in 2002.

Contractor
AMS, Frimley, Surrey.

UPDATED

United States

ATMS

Type
ASW database management system.

Description
The ASW Track Management System (ATMS) receives undersea ocean surveillance information from supporting sensors and sources, and correlates and tracks this information to maintain a database of user-selected surface, subsurface and air reports.

ATMS provides the user with colour graphics, maps, decision aids and dynamic displays of all platforms and ambiguous contacts within a specified region of the globe using NTDS symbology. Real-time tracking is supported by sophisticated correlation and tracker algorithms. These algorithms produce a database available to the operator. Through this database, the user can access track/contact, library, communications, decision tools, correlator information and automated message generation. The user can edit the information as required.

The baseline ATMS is hosted on a network of DTC II (or Sun 4) workstations over a standard Ethernet local area network. The maximum number of workstations is currently limited to 50. The preferred workstation configuration is a 19 in colour monitor, 32 Mbytes RAM and 250 Mbytes of available disk storage. User interaction is via both keyboard and trackerball or mouse. ATMS is hosted under SunOS version 4.0.3. ATMS is written in C and FORTRAN.

Contractor
Lockheed Martin Space Systems, Sunnyvale, California.

UPDATED

OCEANOGRAPHIC AND HYDROGRAPHIC SURVEY EQUIPMENT

Canada

MS 900/900D scanning sonar system

Type
Scanning sonar processor.

Description
The MS 900 has been designed as a portable, cost-efficient processor to meet today's mechanically scanned sonar imaging and profiling needs. Its compact size, powerful capacity, and rugged construction means it is suited for both commercial and military applications. Applications include ROV guidance, target search and identification, diver positioning, underwater construction support, inspection of underwater structures and other civil applications.

Modes of operation include: polar, sector, linear, and profiling. Real-time acoustic imagery is available in VGA/RGB/NTSC and PAL video formats. A printer port is provided to enable hard-copy output, or Bitmap screen image transfer to a PC. External control and data acquisition of the MS 900 is possible via the serial port; NMEA serial data input is via the same port.

The MS 900 is available with either HF or LF analogue telemetry and will operate over 80 different types of head configurations (including 120/330/675 kHz, and 2.25 MHz frequencies). Range is adjustable using a joystick with 13 settings between 5 and 500 m. Sector width is adjustable between 7.2 and 360° in 7.2° steps. The sector centre is adjustable between ±180° in 7.2° steps.

The MS 900D mechanical scanning sonar processor features digital telemetry with telemetry rates up to 230 kb/s and switching between RS-485 and RS-232 telemetry for uplink and downlink communications.

Operational status
In full-scale production and in service.

Contractor
Kongsberg Maritime Mesotech Ltd, Port Coquitlam, British Columbia.

UPDATED

MS 1000

Type
Scanning sonar processor.

Description
The MS 1000 is designed to convert any standard PC platform into a fully functional sonar processor without the use of proprietary boards or hardware. The MS 1000 is a Windows 95/98/NT12000/XP-based application, utilising the familiar Windows interface. The MS 1000 program also contains a 'trackplotter' module that allows the end-user to geo-code sonar targets, set up a search grid, pre-plot survey lines, and display sonar coverage. This multitasking module is embedded in the program. It provides the sonar operator with a view of the sonar coverage, geographic position and sonar data.



Laptop computer with MS 1000 display and sonar head
(Kongsberg Maritime Mesotech) 0134685

Among the features provided by the MS 1000:

- Data storage to hard drive or any memory device supported by the operating system
- Simultaneous operation of multiple sonar head and/or profiler operation
- Target measurement tools and detailed annotation
- Data logging capability for both sonar heads and external sensors.
- Ping synchronisation for multiple-head operation
- Fused data display for dual head profiling
- Time-tagged recording of all sonar and sensor inputs to the PCs hard drive or external recording device

The MS 1000 permits the simultaneous operation of multiple sonar heads (imaging and/or profiling). In addition, the user can input and record any external sensor(s) via RS-232 with an ASCII or BCD serial output format.

Operational status
In production and service.

Contractor
Kongsberg Maritime Mesotech Ltd, Port Coquitlam, British Columbia.

UPDATED

SHOALS

Type
Airborne lidar bathymeter.

Description
Airborne lidar bathymetry systems are currently used to measure coastal water depths for standard hydrographic charts and to detect mines and other underwater targets (MCM/ASW). Airborne lidar bathymeters are also proving useful for harbour, waterways and dredging projects.

The SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey Systems) is a laser-based scanning lidar bathymeter that offers hydrographers a cost-effective and rapid means of surveying shallow coastal or inland waters with depth and precision accurate to International Hydrographic Organisation (IHO) order 1.

SHOALS-1000, Optech's fifth generation airborne lidar bathymeter, offers a high area coverage rate (up to 77 km²/hr), ease of operation and flexibility, all of which combine for a cost-effective alternative to ship-mounted surveys.

Optech has also combined its expertise in terrestrial mapping with SHOALS to introduce a topographic mapping option (SHOALS-1000T) for continuous coverage from shallow waters onto the adjacent shore with a single flight pass. The ALTM terrain mapping solutions include the new 70 kHz ALTM 30/70 system, which offers area coverage rates as high as 70 kHz at 1,500 m for elevation data of exceptional density.

The SHOALS-1000 also features an integrated digital still camera and integrated flight management/post processing/data editing software suite. The system thus offers a comprehensive solution for surveying the entire littoral zone.

SHOALS is designed to function in a variety of fixed or rotary wing aircraft, and provides an improvement over acoustic systems both in area coverage and in uniformity of sounding density.

Effective over most coastal areas that are of critical concern to the hydrographer, the system's speed and flexibility in deployment, and convenience in sounding dangerously shallow or highly confined and irregular areas, offer unique advantages in survey planning and deployment strategy. The SHOALS system measures water depths at 1,000 Hz from an altitude of 200 to 400 m and is usable by day or night.

Airborne lidar bathymetry uses a technique called lidar (light detection and ranging) to measure depth. The system uses two short duration laser pulses, one green and one IR in wavelength, transmitted simultaneously and coaxially from the aircraft down onto the surface of the water. Reflection of the IR pulse from the water surface is detected by a receiver located at the laser source. The green pulse is partially transmitted through the water, and its reflection from the bottom is also detected by the receiver at a later time. The water depth is determined by measuring the elapsed time between receiving the IR and green return signals. This depth value is subsequently corrected for geometric and environmental effects.

To provide wide ground coverage, the consecutive laser pulses are directed by a scanner sequentially across the flight path into pre-selected orientations that optimise the sounding pattern, in 2 × 2, 3 × 3, 4 × 4 and 5 × 5 m grids.

The location of each sounding is derived from data provided by aircraft positioning, attitude reference and scan angle control systems. Depth penetration is strongly dependent on the water quality, varying from several metres in turbid water to greater than 50 m in very clear water. Typically the SHOALS system has a penetration capability of 20 to 35 m in most coastal areas.

The SHOALS system consists of the airborne element that acquires the sensor data and a ground-based unit used for mission planning and data analysis. In operation the pilot uses a guidance monitor to fly the aircraft along pre-determined

flight paths. Depths, or underwater objects, are detected in real time and displayed to the system operator, together with navigation information. The operator display also includes a real-time display of already surveyed areas, depicted as swaths of colour-coded depths, and streaming digital video of the actual surface scene below the aircraft.

Operational status
The first operational airborne laser bathymeter was produced for the Canadian Hydrographic Service in 1985. Known as the Larsen 500, it is still operational.

ALARMS (Airborne LAser Radar Mine Sensor), a mine detection system, was developed and built for the United States Defense Advanced Research Projects Agency (DARPA) in 1988. Flight-testing has shown this technique to be valuable in the area of MCM.

SHOALS was delivered to the US Army Corps of Engineers in 1994, and has since been upgraded and is operational world wide. Two Hawkeye systems, largely derivative of SHOALS, were delivered to the Swedish Navy and Swedish Hydrographic Department in 1994 and 1995. One system is operational in the Baltic while the other has been sold for surveying in Indonesia.

The first SHAOLS-1000 system was delivered to the Japan Coast Guard in February 2003 and the second, a SHOALS-100T system, is being delivered to the US Navy in July 2003.

Specifications

	Bathymetric (SHOALS-1000)	Topographic (SHOALS-1000T)
Measurement rate	1 kHz	10 kHz m
Measurement depth	0.2 – 50 m	n/k
Depth penetration	kD > 3 (day), kD > 3 (night)	n/k
Operating altitude	200 – 400 m	300 – 700 m
Aircraft speed	125 – 175 kt	125 – 175 kt
Swath width	up to 0.58 × altitude	up to 0.58 × altitude
Measurement accuracy	IHO Order 1	25 cm/1 m
Airborne system weight	200 kg	< 3 kg (incremental)
Spot spacing	2 × 2, 3 × 3, 4 × 4, 5 × 5	1 × 1, 1.5 × 1.5, 1.5 × 2
Area coverage rate (km²)	14 31 50 77	32 67 94

Contractor
Optech Inc, Toronto, Ontario.

VERIFIED

SM 2000

Type
Multibeam imaging/profiling sonar.

Description
The SM 2000's compact size, lightweight and versatile architecture makes it ideal for all acoustic-imaging applications. The surface processor is PC-based with operating software remaining under Windows to provide flexibility in sonar control, data output and interfaces. Data recording options include storage of raw or beam-formed data to hard drive and CD. The system's telemetry uses either electrical or fibre optic links. Electrical telemetry rates are variable and can accommodate a wide variety of cable lengths and bandwidths. Selectable 'on-the-fly' features include variable beam-forming configurations, ping-to-ping averaging and preset or user-defined TVG and gain curves and maximum resolution/maximum speed settings.

The SM 2000 operating software includes a track plotter display, pinger receiver and passive tracking system modes of operation.

The electronically scanned multibeam (160 separate beams) sonar operates at either 90 or 200 kHz with a depth rating of 3,000 or 6,000 m respectively. A 6,000 m depth rated version of the 200 kHz 120° coverage head is also available. The 90 kHz sonar head has a field of view coverage of 90° (receive beam angle of 1.8°) while the 200 kHz head has fields of view coverage of 60, 120, and 180° (with receive beam angle <1°). When used as an underwater surveillance system the SM 2000 is compatible with the USN AN/WQX-2 ASDCAP auto-detection and tracking software.

Subsurface electronics are mounted on a pan mechanism capable of 4°/s rotation at speeds over 4 kt. This allows the operator to change the azimuthal angle of coverage and follow a target. The sonar head and pan drives are controlled by the SM 2000 surface processor. The display is pitch-stabilised to minimise the effect of vessel movement. The sonar can be switched from imaging to profiling modes of operation by enabling a software selection when the optional profiling transducer is used.

Applications for the SM 2000 include:
- obstacle avoidance
- inspection
- mine hunting
- underwater surveillance
- diver detection/diver support
- ROV/AUV sonar

The SM 2000 will also operate as a passive 90 kHz or 200 kHz tracking sonar, and features advanced background removal features for underwater surveillance applications.

The SM 2000 multibeam imaging sonar can be easily converted to an echo sounder with the addition of an optional transmit transducer. The echo sounder is available in 200 kHz, with either 120 or 150° swath width transducers and can be supplied with a faired mount for over-the-side deployment. The 90 kHz system is available with 90° swath coverage.

Operational status
In full-scale production and in service.

Specifications
SM 2000 200 kHz Multibeam Imaging and Profiling Sonar

Swatch Width:	120°	180°
System Frequency:	200 kHz	200 kHz
Range Resolution:	Down to 5 cm	Down to 5 cm
Pulse Width:	40 to 1,300µs	40 to 1,300µs
Bandwidth:	20 kHz (max)	20 kHz (max)
Source Level:	Nominal 203 dB	Nominal 200 dB
Range Scales:	5 to 400 m	5 to 400 m
Horizontal Beamwidth:	Receive 1.5° Transmit 88°	Receive 2° Transmit 155°
Vertical Beamwidth:	Receive 17° Transmit 17°	Receive 16° Transmit 16°
Depth Rating:	3,000 m	3,000 m

Contractor
Kongsberg Maritime Mesotech Ltd, Port Coquitlam, British Columbia.

UPDATED

Denmark

SeaBat 8101 multibeam echo-sounder

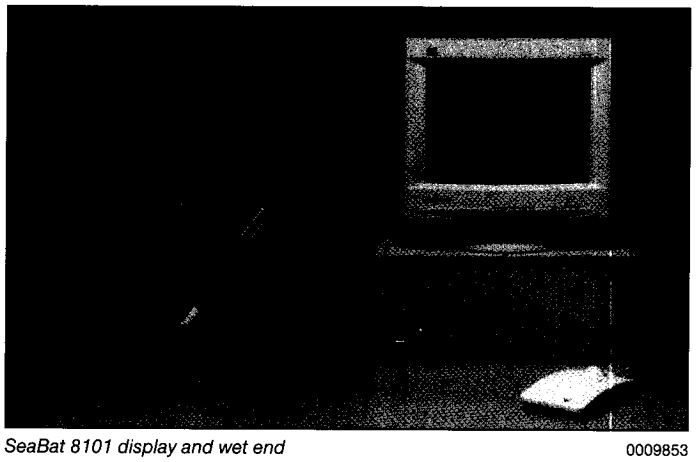
Type
Hydrographic sonar.

Description
The new generation SeaBat 8101 multibeam echo-sounder is designed for continental shelf survey operations, measuring a wider swath at higher survey speeds and complying with International Hydrographic Organization (IHO) and US Army Corps of Engineers (USACE) Class 1 standards.

Operating at 240 kHz, the SeaBat 8101 measures a 150° swath consisting of 1.5 × 1.5° beams. Each beam is both phase and amplitude analysed, with one or both methods used to digitise the seafloor. Dense coverage is achieved utilising up to 3,000 soundings per second for 100 per cent coverage of a swath that can be over 500 m wide, even as the survey vessel travels at speeds of 18 kt.

Being lightweight and portable, the SeaBat 8101 transducer head can be mounted temporarily on vessels of opportunity, mounted permanently through the hull of a survey vessel, or mounted on an underwater platform such as an ROV, AUV, or ROTVs. The head can be ordered pressure-rated for operating depths of 300, 1,500, 3,000 or 6,000 m.

The system utilises RESON's advanced 8100 Series processor. This unit can download new firmware through a communications port or Ethernet – enabling changes to the processor firmware to be made in just 30 seconds. Thus, the processor can accommodate a 455 kHz, 240, 120, 60, 30 or 12 kHz SeaBat swath bathymetry system. It will sense automatically whether the right transducer is mounted, set itself up and calibrate the total system by introducing a test signal into all transducer elements. This arrangement gives maximum operational flexibility, minimises requirements for operator training and spare parts inventory, and means that keeping pace with the latest bottom detection methods and beam geometries requires just a firmware upgrade of the processor unit.



SeaBat 8101 display and wet end 0009853

The processor is just one example of the modular design philosophy underlying the SeaBat 8101. A wide range of upgrades and options is available to tailor the SeaBat to the user's current and future needs.

Operational status
The SeaBat 8101 is in operation with hydrographic surveyors worldwide, including the Danish Coastal Authority, the Chinese Academy of Sciences, and the UK North Sea oil and gas industry.

Specifications
Operating frequency: 240 kHz
Resolution: 1.25 cm
Horizontal beamwidth: 200° (transmit); 1.5° (receive)
Vertical beamwidth: 1.5 (transmit); 20° (receive)
Swath width: 150° (210° optional)
Swath coverage: to 7.4 × water depth
No of beams: 101
Range: 1-400 m

Contractors
RESON Inc, Goleta, California.
RESON A/S, Slangerup, Denmark.
RESON Offshore Ltd, UK.

UPDATED

SeaBat 8111

Type
Multibeam echo sounder.

Description
Operating at 100 kHz, the portable wide-swath multibeam SeaBat 8111 features an extended depth range to support full continental shelf mapping projects, as well as general hydrographic surveying and dredging support.

The modular design offers permanent through-hull installations and also temporary over-the-side mountings. The transducer assembly is fully rubberised for corrosion protection.

Like all 8100 Series models, the SeaBat 8111 uses the RESON advanced 81-P processor, which allows the operator to fine-tune settings for local conditions, provides advanced self-diagnostics and can quickly download new firmware through a communications port. The sonar features a cylindrical receive array and a linear transmitter array mounted together on a support cradle which provides mounting points to the vessel.

The sonar complies to IHO accuracy which is maximised by the system's fast update rate, its use of narrow beams (1.5°) and ability to automatically select the most accurate bottom detection method for individual beam – that is phase, amplitude, or a combination of both. The system also features a pitch stabilisation capability operating within ±10° .

The sonar surveys a swath that is 7.4 times the water depth in width down to 150 m water depth covering a 150° swath. Narrower swaths can be measured to reach depths down to 600 m.

To minimise weight and bulk, much of the electronics package has been mounted in the shipboard transceiver box instead of being incorporated in the sonar head.

Operational status
The SeaBat 8111 is used by numerous hydrographic survey authorities and private survey contractors in Asia, Europe and the United States. An extended range system (8111ER) has recently been delivered to the Council for National Research of Italy. Initial sea trials were undertaken in September 2001 by the Thales Geosolutions vessel MV *Thetis*.

Specifications
Operating frequency: 100 kHz
Resolution: 5 cm
Number of beams: 101
Beam width: 1.5 × 1.5°
Swath width: 150°
Swath coverage: to 7.4 × water depth
Range: 3-600 m

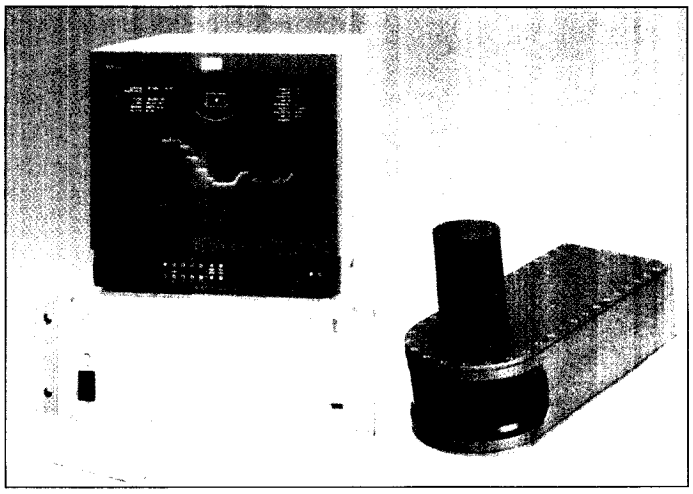
Contractors
RESON Inc, Goleta, California.
RESON A/S, Slangerup, Denmark.
RESON Offshore Ltd, UK.

UPDATED

SeaBat 9001

Type
Hydrographic sonar.

Description
The SeaBat 9001 is a lightweight, portable, multibeam echo-sounder designed to measure accurately a swath of the seabed from small vessels or ROVs.



SeaBat 9001 display and wet end 0007420

The system measures a 90° swath consisting of 60 soundings. The measured profile is output to an onboard computer system for display and storage. Additionally, a real-time video profile is provided for quality control. If desired, it can be recorded to a standard VHS recorder or data collection system for archiving and replay.

The SeaBat 9001's 60 1.5 × 1.5° narrow 455 kHz beams update up to 15 times per second. With this high-frequency, narrow footprint, and fast update rate, the SeaBat can operate at vessel speeds in excess of 12 kt while maintaining 100 per cent coverage of the seabed.

The SeaBat 9001 transducer head is very small and weighs less than 15 lb wet. Accordingly, the system can quickly be mobilised on virtually any vessel of opportunity to measure water depths to 100 m. Or, it can be mounted on ROVs or towed bodies and submerged to depths of 500 m.

Numerous factory options and upgrades are available for the SeaBat 9001. Two of the most popular are the 'S' option and Option 019. When equipped with the 'S' option, the flick of a switch on the processor changes the SeaBat's beam geometry and presentation display from bottom-mapping echo sounder function (SeaBat 9001 mode) to forward-looking sonar function (SeaBat 6012 mode). When equipped with Option 019, the SeaBat 9001 measures a side scan swath from 4 to 400 m. The operator may select two of three side scan beams, each at an angle of 40°. The analogue side scan data may be viewed and correlated with the bathymetry data in real time.

Operational status
Independent tests of the system's accuracy and performance have been carried out by the National Ocean Service, a division of the National Oceanic and Atmospheric Administration (NOAA). The SeaBat 9001 is in service with a number of customers including the US Army Corps of Engineers, the Port of Los Angeles, the Japan Maritime Safety Administration (on board a survey boat on the *Shoyo*) and the Brazilian Navy Hydrographic Department.

Specifications
Operating frequency: 455 kHz
Resolution: 5 cm
Number of beams: 60
Horizontal beamwidth: receive 1.5° (–3 dB points for each beam); transmit 100°
Vertical beamwidth: receive 15°; transmit 1.5°
Source level: 210 dB/1μPa/m (nominal)
Pulse width: 70 μs
Swath width: 90°
Range settings: 0.5, 2.5, 5, 10, 25, 50, 100, 200 m
Operating depth: 350 m (600 m available)

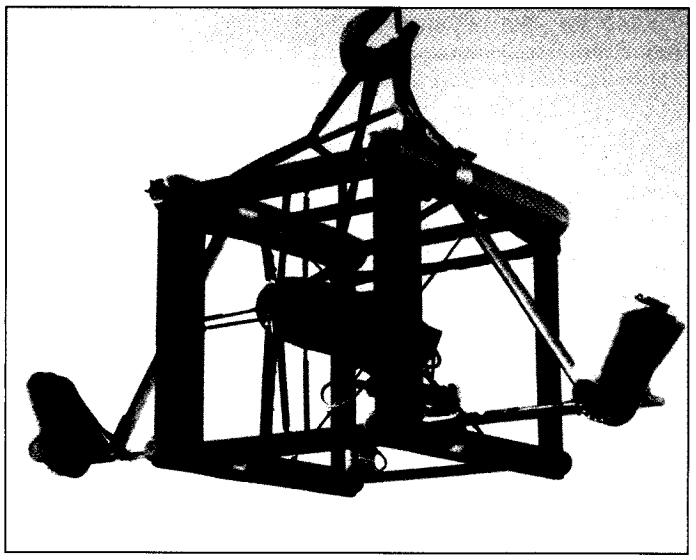
Contractors
RESON Inc, Goleta, California.
RESON A/S, Slangerup, Denmark.
RESON Offshore Ltd, UK.

UPDATED

SeaBat 9002

Type
Hydrographic sonar.

Description
The SeaBat 9002 multibeam echo-sounder is a dual-head system that provides synchronised returns from two separate sonar heads. The system, like the single-head SeaBat 9001, is designed to measure high accuracy swaths of the seabed. However, the SeaBat 9002 with its twin heads can be configured to extend the swathe coverage from 90 through to a maximum of 160° in order to extend the profile coverage and provide highly detailed running documentation of the survey.



A SeaBat 9002 system mounted on a MacArtney Focus 400 ROTV 0009854

The returns from the two sonar heads can be used either to increase the swathe width or increase the resolution. Even with its two sonar heads, it is still compact, lightweight and portable enough to be used on small surface vessels or ROVs.

The system comprises two complete SeaBat 9001 systems, each sonar head measuring a complete swath of 60 soundings at a rate of up to 15 times per second. The two sonar heads operate independently of each other: each one provides its own reception, transmission and bottom detection; however, they are interconnected and time synchronised to alternate measurements between one another. The measured profiles are fed to an onboard computer, where the images can be viewed and simultaneously transmitted via RS-232 to a data acquisition system. Real-time quality control is provided by the updating video profiles, compiled by the measured swaths and raw sonar data.

Operating at a frequency of 455 kHz, each sonar head measures a total of 60 soundings (120 combined) each 1.5 × 1.5° across the seabed. One hundred per cent coverage of the seabed, both along track and across track, can be obtained by the fast updating SeaBat, even at speeds greater than 12 kt.

When installed on a surface vessel or ROV, the sonar heads can be mounted in various positions, from separated locations angled towards each other and at varying angles for full coverage up to a 160° field of view. They are also capable of being mounted from a single mounting pole and from towed vessels/vehicles.

Operational status
Used daily by the National Ocean Service, a division of the NOAA, as its bathymetric system for least depth surveys.

Specifications
Operating frequency: 455 kHz
Number of beams: 60
Range settings: 2.5, 5, 10, 20, 25, 50, 100, 200 m
Range resolution: 5 cm
Horizontal beamwidth: receive 1.5° (–3 dB points for each beam); transmit up to 200°
Vertical beamwidth: receive 15°; transmit 1.5°

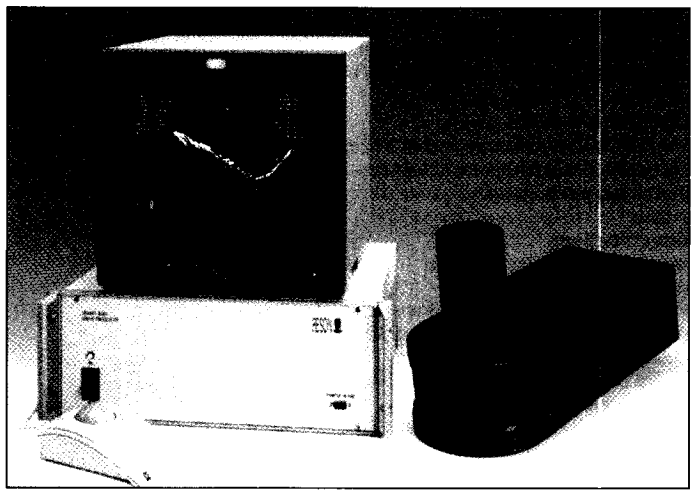
Contractors
RESON Inc, Goleta, California.
RESON A/S, Slangerup, Denmark.
RESON Offshore, UK.

VERIFIED

SeaBat 9003

Type
Hydrographic sonar.

Description
The SeaBat 9003 multibeam echo sounder is similar to the SeaBat 9001 in function and form, except that it features a 120° swath made up of 40 × 3° beams rather than a 90° swath made up of 60 × 1.5° beams. The 40 soundings carried out in a single swathe (combined to form a 120° wide by 1.5° long geometrically correct cross section) provide simultaneous sonar coverage that does not distort the measured profile due to any vessel movement. At speeds of over 10 kt, the unit is able to output up to 15 complete profiles per second, and still maintains 100 per cent coverage of the seabed. With the ability to orient the transducer, 100 per cent coverage of the seabed can be achieved from 3.5 to 4.7 times the measured water depth.



SeaBat 9003 system display 0009855

With swath width approaching that of the dual-head SeaBat 9002 at the price of the SeaBat 9001, the SeaBat 9003 offers hydrographic surveyors an intriguing new option.

The SeaBat 9003 is available with all the same options and upgrades as the SeaBat 9001.

Operational status
The SeaBat 9003 is in operation in Australia, Brazil and the USA.

Specifications
Operating frequency: 455 kHz
Number of beams: 40
Range settings: 2.5, 5, 10, 25, 50, 100, 200 m
Range resolution: 5 cm
Horizontal beamwidth: receive 3° (–3 dB points for each beam); transmit 140°
Vertical beamwidth: receive 15°; transmit 1.5°
Operating depth: 350 m (600 m available)

Contractors
RESON Inc, Goleta, California.
RESON A/S, Slangerup, Denmark.
RESON Offshore, UK.

VERIFIED

France

Seafalcon 5

Type
Medium water multibeam echo-sounder.

Description
The Seafalcon 5 medium water multibeam echo-sounder is the 25 kHz version of the Seafalcon 11 designed for offshore applications.

It delivers a swath of 7,000 m for a water depth of 3,000 m.

In its basic configuration it features a single multibeam transmission array, two reception arrays, a transmitter cabinet and receiver cabinet, processing workstation, control workstation, bathymetric workstation and plotter, imagery workstation and printer and data logging. Optional equipment includes a vertical reference unit, sound velocity meter, sub-bottom transmission array and sub-bottom profiler workstation and printer.

Specifications
Operating depth: 10-5,000 m
Typical speed: 12-16 kt
Sea state: 5 (dependant on draft of the vessel)
Roll:±15°
Pitch: ±10°

Bathymetry
Accuracy: IHO standard
Frequency: 25 kHz
Simultaneous independent pulses: 5
Coverage: up to 7,000 m @ 2,000/3,000 m
Soundings per swath: 2,000 (400 per pulse)
Transmission beamwidth: 1.5 × 150°
Receive beamwidth: 3 × 24° (1 or 2° optional)

Sub-bottom profiler (optional)
Frequency: 3.5 kHz
Penetration: 150-200 m (typical)
Reception beams: 5
Beamwidth: 5 × 10

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Seafalcon 11

Type
Deep water multibeam echo-sounder.

Description
The Seafalcon 11 deep water multibeam echo-sounder has been developed to equip the oceanographic vessel *Marion Dufresne* from the French Polar Institute (IFRTP).

This new multibeam echo-sounder provides the following functions: bathymetry, imagery, seabed classification and sub-bottom profiling.

Bathymetry and imagery are carried out with five simultaneous multibeam echo-sounders operating in five medium frequencies in the 12 kHz bandwidth to cover five adjacent areas of the seabed. This provides data redundancy and suppresses seabed gaps.

The sub-bottom profiler integrated in the system uses large 'Mill Cross' arrays and provides high resolution and deep penetration (up to 150 m at 5,000 m water depths).

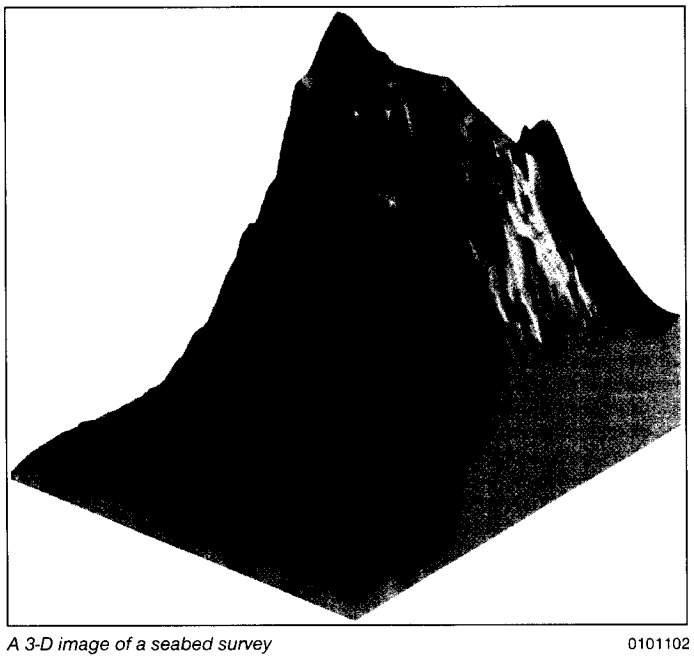
The unique capabilities of Seafalcon 11 make it ideal for many applications such as: oceanographic research and mapping, geological mapping, hydrography, oil exploration, deep water coring, pipe and cable laying as well as scientific investigation.

In its basic configuration it features a single multibeam transmission array, two reception arrays, a transmitter cabinet and a receiver cabinet, processing unit, control workstation, bathymetric workstation and plotter, imagery workstation and printer and data logging. Optional equipment includes a vertical reference unit, sound velocity meter, sub-bottom transmission array and sub-bottom profiler workstation and printer.

Operational status
In service on board the French Polar Institute's research vessel *Marion Dufresne II*.

Specifications
Operating depth: 80-11,000 m
Typical speed: 12-16 kt
Sea state: 7 (dependant on draft of the vessel)
Roll: ±15°
Pitch: ±10°

Bathymetry:
Accuracy: IHO standard
Frequency: 12 kHz
Simultaneous independent pulses: 5
Coverage: 120° @ 5,000 m
Soundings per swath: 2,000 (400 per pulse)



A 3-D image of a seabed survey 0101102

Transmission beamwidth: 1.4 ×140°
Receive beamwidth: 3.6 × 24°

Sub-bottom profiler (optional)
Frequency: 3.75 kHz
Penetration: 150-200 m (typical)
Reception beams: 5
Beamwidth: 5 × 5°

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Germany

DESO 14

Type
Survey echo-sounder.

Description
The DESO 14 is a portable, single-channel, dual-frequency, hydrographic echo-sounder. The compact, rugged but lightweight housing makes it convenient to use in portable applications. It can operate from 24 V DC batteries. The depth is recorded by means of a high-resolution thermo-electric printer with over 800 pixels in three grey levels across 10 cm recording width. The operation is menu-controlled; parameters and depths are displayed on dedicated LCD displays. Survey computers can be connected via a serial data interface. The operating range extends to 650 m.

Operational status
These echo-sounders are in widespread use with the navies of Australia, Brazil, CIS, France, Greece, India, South Korea, Netherlands, New Zealand, Portugal, Sweden, Thailand, Turkey, UK and US.

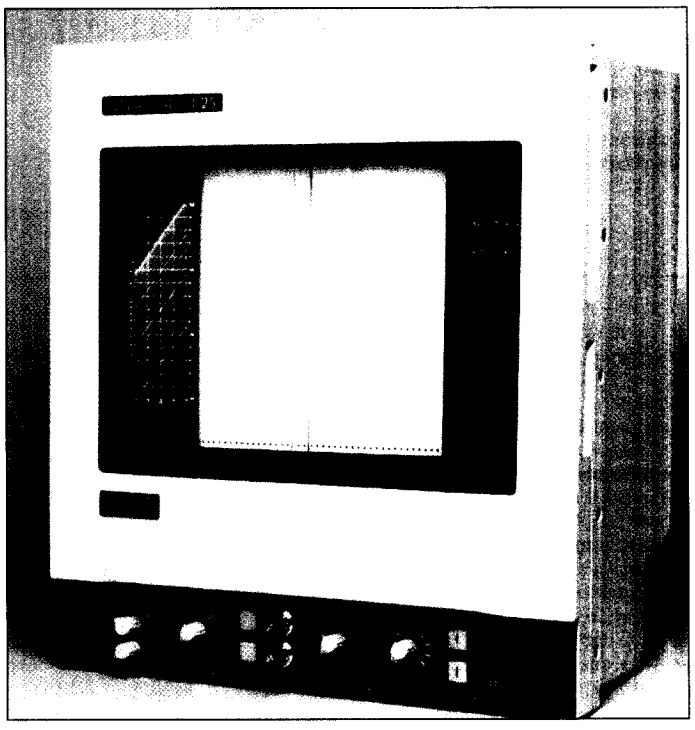
Contractor
SAM Marine Electronics GmbH, Hamburg.

VERIFIED

DESO 25 echo-sounder

Type
Survey echo-sounder.

Description
The DESO 25 is a dual-channel hydrographic echo-sounder covering the full application range from inshore to deep ocean surveying. The particularly refined



DESO 25 dual-channel precision sounder

sediment recording functions are supported by a high-resolution thermo-electric printer and a net recording width of 20 cm.

The strength of the echo can be recorded as an additional line providing information on ocean floor properties. The chart is fully annotated with all measurement parameters including date and time from an internal clock. The measurement range extends to 15,000 m. Optionally, one of the two channels can be fitted with a side scan electronics board and transducer. This provides an imaging function in addition to the depth recording.

Operational status
The DESO 25 is used by various navies, including the Royal Navy, Chilean Navy, French Navy, Netherlands Navy and the Portuguese Navy. The DESO 25 has also been selected to equip the Astute class submarines of the Royal Navy.

Contractor
SAM Marine Electronics GmbH, Hamburg.

VERIFIED

Fansweep 20

Type
Multibeam swath surveying system.

Description
A portable multibeam swath sounding system which combines bathymetric measurement and side scan imaging for shallow water applications at depths down to 600 m.

It is available in two versions for 100 kHz and 200 kHz operation with equivalent key technical parameters for both configurations.

Incorporating advanced hydroacoustic and electronic signal processing facilities, the system provides high accuracy. The system meets the latest accuracy requirements of the IHO, relating to IHO guideline SP44.

The bathymetric coverage is freely selectable up to ×12 of the vertical depth, which corresponds to an angle of 161°. At the same time and fully independent of the bathymetric measurement, the system is able to collect high-resolution side scan values within an angle of up to 180°. Realtime output and display of bathymetric and side scan data is simultaneous with up to 1,440 depth and 4,096 side scan measurements being available at a rate of up to 12 sweeps per second. Systems accuracy at up to six times coverage is typically ±0.05 m (100 kHz to 0.1 m) + 0.2 per cent water depth.

It can be interfaced to a wide range of processing facilities and sensors, including a proprietary high-precision motion sensor.

Operational status
The system is in use by several survey offices, port authorities, marine boards and navies such as the Royal Navy, Royal Malaysian Navy, Royal New Zealand Navy (onboard HMNZS *Resolution*), Royal Australian Navy, Peruvian Navy and the French naval hydrographic and oceanographic service. In the latter the system is installed on a 10 m survey launch where it is used in conjunction with Hydromap ECDIS software.

Specifications
Frequency: 100 and 200 kHz
Pulse: 120 to 40 µs
Power/transducer: 3,000/700 W

Contractor
SAM Marine Electronics GmbH, Hamburg.

VERIFIED

Hydromap

Type
Hydrographic data processing system.

Description
Hydromap is a comprehensive and modular hydrographic data processing system. It consists of the parts Hydromap Online and Offline, which are able to record, process, display and manage hydrographic and oceanographic survey data. The various functions of the ECDIS-based Hydromap Online cover all aspects of a hydrographic survey featuring sensor interfacing, time synchronisation, data validation, data storage, real-time visualisation, quality control and navigation. The optional Hydromap Offline provides automatic and interactive tools to clean and edit all kinds of survey data like position, vessel motion data, depth, tide, sound velocity, side scan and backscatter data. The post-processing functions of Hydromap Offline allow digital terrain modelling, contouring, profiling and final bathymetry plots.

The software is designed for workstations with a UNIX operating system. The graphical user interface is based on the international software standard X-Windows and OSF Motif. It provides application-oriented and user-friendly menu operation and guarantees widely uniform and self-explanatory handling. Integrated systems with extended workstations solutions are possible.

Operational status
In service with the Royal Navy and other navies.

Contractor
SAM Marine Electronics GmbH, Hamburg.

VERIFIED

Hydromap Susy

Type
Hydrographic software system.

Description
The Hydrographic Susy extends the spectrum of the Hydromap family by the addition of a PC or notebook version running under Windows. It is designed for small- to medium-sized hydrographic survey applications operating with vertical echo sounders. It allows the connection and processing of all usual vertical echo sounders, positioning systems and survey sensors. All measurement data is individually time stamped during acquisition. By means of the graphic and alphanumeric presentation of data, the user is comprehensively informed about the status of the system.

Hydromap Susy contains software modules for:
- survey planning;
- data logging and online graphic presentation;
- editing;
- processing and presentation of data;
- import and export of data.

Additional features include:
- graphical operating environment;
- programmable device interfaces;
- curves survey.

Operational status
The system is in use by several port authorities, marine boards and the German Navy.

Contractor
SAM Marine Electronics GmbH, Bremen.

UPDATED

Hydrosweep DS-2

Type
Multibeam surveying system.

Description
The full ocean depth DS-2 sonar system with incorporated bottom imaging and classification functions using a frequency of 15.5 kHz (± 0.6 kHz) has been developed for large-scale surveying over depths down to 10,000 m, the multibeam Hydrosweep DS-2 system uses advanced electronic beam-forming techniques (1 × 59 or 2 × 59 preformed beams) to provide a swath width equivalent to almost four times water depth. This is achieved by two transducer arrays mounted in a 'T' configuration flush with a duct keel or in a streamlined fairing below a flat bottom. The fully automatic system is self-calibrating, with mean sound velocity applied for depth and slant angle correction in real time.

For system control and operation as well as data acquisition and quality control, a powerful workstation serves as operator interface. Geometrically corrected side scan imaging and seafloor backscatter analysis for feature display and bottom properties are also available. A fully IMO/IHO compliant electronic chart database can be overlaid to view real-time swath data in their true geographic reference. Interfaces to various sensors and navigation systems as well as powerful data processing systems are provided for developing fully integrated hydrographic survey systems.

Operational status
Various systems are in use by oceanographic institutions. A system is installed in the US Navy's Naval Sea Systems Command *Thomas G Thompson*, 263 ft oceanographic research vessel.

Specifications
Frequency: 15.5 ± 0.6 kHz
Operating modes: 1×59 preformed beams (*circa* 2° beam spacing) or 2×59 preformed beams (alternating port/starboard with *circa* 1° beam spacing)
Insonification angle: 120 to 90°

Contractor
SAM Marine Electronics GmbH, Hamburg.

VERIFIED

Hydrosweep MD-2

Type
Hydrographic multibeam surveying sonar with incorporated side scan imaging function for medium water application.

Description
The Hydrosweep MD-2 system is available in two frequency versions (30 kHz and 50 kHz) and covers a maximum swath width of eight times water depth in a depth range from 5 to 4,000 m (at 30 kHz) and 5 to 1,400 m (at 50 kHz). A novel function is the slant range corrected side scan image which can be produced in real time with an overlay of isobathic depth contour lines and backscatter analysis of the seabed. A powerful workstation serves as operation interface and provides online data quality control. A fully functional electronic chart can be overlaid to view real-time depth data with their true geographic reference. Interfaces to navigation systems and hydrographic survey systems provide the possibility for total integrated system structure.

Besides the hydrographic application, the system is also suitable for object search, for example wrecks, pipelines and the like.

Operational status
The first system has been operational since the beginning of 1991 on the German hydrographic vessel *Wega*. Systems have also been supplied to other hydrographic services and the NATO SACLANT centre.

A system (MD-2/30) has been supplied to the New Zealand Navy and is installed on the survey vessel *Resolution*. Another system has been supplied to the Malaysian Navy.

Specifications
Frequency: 50 and 30 kHz
Beams: up to 150 preformed beams
Accuracy: ± 0.1 m at + 0.2% water depth and ± 0.15 m at + 0.2% water depth

Contractor
SAM Marine Electronics GmbH, Hamburg. ***VERIFIED***

Parasound

Type
High-resolution sub-bottom profiler.

Description
Parasound is a hull-mounted combined narrow beam deep sea sounder and sub-bottom profiler with an overall depth sounding capability extending from 3 to 10,000 m. Designed essentially for research and geological survey applications, it comprises a Narrow Beam Sounder (NBS) for precise surveying of the seabed and a low-frequency sediment sounder or Sub-Bottom Profiler (SBP) for high-resolution presentation of sediment layers with parametric frequencies between 2.5 and 5 kHz; both generate highly directional sound beams electronically stabilised against ship's motion. In NBS mode a beamwidth of 2.5° (33 kHz) or 4° (18 kHz) can be generated which can be reduced to 2° in the receiving section and extended by about five times in the transmitter section.

Incorporating an ice-tested, flush-mounted transducer assembly consisting of two, three or four arrays, the system ensures particularly high vertical and horizontal resolution, enabling detection of very fine layers of sediment while maintaining high ground penetration without necessitating traditional costly towed-fish methods of measurement. It has a deep sea sediment penetration capability in excess of 100 m and can be operated at vessel speeds of around 10 kt, even in gale force conditions.

The Parasound is available in two versions: DS-2 with high output power and normal transducer array: and MD-2 with reduced transmission power and half the transducer array.

Operational status
The system is operational in several offshore companies and on research vessels like the *Meteor* and *Polarstern*.

Contractor
SAM Marine Electronics GmbH, Hamburg. ***VERIFIED***

Norway

EM 120

Type
Deep-water multibeam sonar.

Description
The EM 120 is designed to undertake mapping to full ocean depth. The receive transducer is wideband and in conjunction with a separate low frequency transmit transducer, the EM 120 may optionally be able to deliver sub-bottom profiling capabilities with a very narrow beamwidth.

The nominal sonar frequency is 12 kHz with an angular coverage sector of up to 150° and 191 beams per ping as narrow as 1°. The angular coverage sector and beam pointing angles may be set to vary automatically with depth according to achievable coverage. This maximises the number of usable beams. The beam spacing is normally equidistant with equiangle available.

The transmit fan is split into several individual sectors with independent active steering according to vessel roll, pitch and yaw. This places all soundings on a 'best fit' to a line perpendicular to the survey line, thus ensuring a uniform sampling of the bottom and 100 per cent coverage. The sectors are frequency coded (11.25 to 12.75 kHz), and are all transmitted sequentially at each ping. Steering is taken into account when the position and depth of each sounding is calculated, as is the refraction due to the sound speed profile, vessel attitude and installation angles. Pulse length and range sampling rate are variable with depth for best resolution, and in shallow waters due care is taken of the near field effect. The ping rate is only limited by the round trip travel time in the water up to a ping rate of 5 Hz.

The transducers are linear arrays in a Mills cross configuration with separate units for transmit and receive. The arrays are divided into modules, which can be replaced by a diver. The number of modules used (and hence the beamwidth) can be adjusted according to particular installation requirements. For both arrays 1° and 2° beamwidths are standard options, and 4° beamwidth is available for the receive array. The resulting array lengths are between 2 and 8 m.

The EM 120 is a total system with all necessary sensor interfaces, data displays for quality control and sensor calibration, seabed visualisation, and data logging being a standard part of the system, as is integrated seabed acoustical imaging capability (side scan). A combination of phase and amplitude detection is used, resulting in a measurement accuracy in the order of 50 cm or 0.2 per cent of depth RMS (whichever is greater) practically independent of beam pointing angle.

The swath width in shallow waters is typically 6 times the water depth to about 2,000 m. A swath width of about 20 km or more is generally achievable for deep waters, depending upon bottom conditions and chosen system beamwidths.

In deep water, a pulse length of 15 ms is used. The transmit fan is then split into nine different sectors transmitted sequentially. This method increases the system source level, and thus depth and coverage capability significantly. Using electronic steering, the sectors individually take into account the vessel's current roll, pitch and yaw with respect to the survey line heading. The swath can then be stabilised to fall on a line perpendicular to the survey line. Pitch and especially yaw steering in individual sectors is required to guarantee 100 per cent bottom coverage in deep waters. Using this technique the EM 120 can reach full ocean depth.

At intermediate depths a pulse length of 5 ms is used and the transmit fan is split in three sectors which are stabilised according to vessel roll, pitch and yaw. Note that yaw steering may be required even at a few hundred metres depth despite the higher ping rate the lesser depth allows.

In shallow waters, a pulse length of 2 ms is used and the number of beams is reduced to 135. In very shallow waters, say down to approximately 250 m, special processing is used to overcome the near field effect.

Operational status
The EM 120 is in service aboard the USNS *Kilo Moana* (AGOR-26).

Specifications
Frequency: 12 kHz
Maximum ping rate: 5 Hz
Number of beams per ping: 191
Beamwidth: 1 × 1, 1 × 2, 2 × 2 or 2 × 4°
Beam spacing: equidistant and equiangle
Depth range from transducers: 20 m to 11,000 m
Depth resolution: 10, 20, 40 cm
Pulse length: 2, 5 and 15 ms
Range sampling rate: 2 kHz (37 cm)

Contractor
Kongsberg Maritime, Horten.

UPDATED

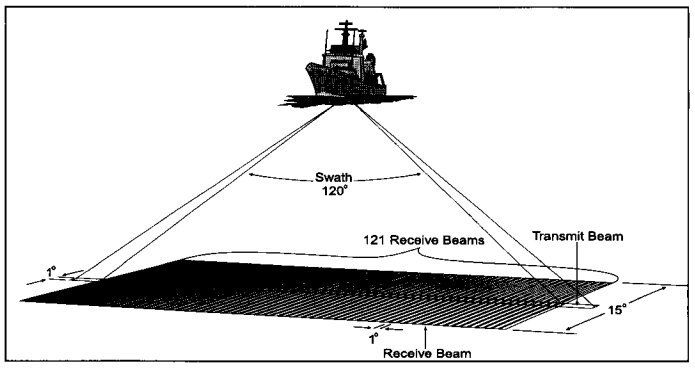
EM 121A

Type
Multibeam bathymetric mapping sonar system.

Description
The EM 121A multibeam echo-sounder is the first commercially available 1° bathymetric mapping sonar system. It operates at a frequency of 12 kHz with a variable transmit pulse length from 1 to 20 ms, providing precise mapping and calibrated backscatter measurement capability from 10 m to full ocean depth (11,000 m). When operated with maximum resolution, the sonar transmits a beam measuring 1° fore and aft by 140° athwartships and forms 121 × 1° receive beams covering a swath across the vessel track. The transmit beam is stabilised for pitch and the receive beams are stabilised for roll which is important in minimising the position, depth and signal amplitude offset corrections. This feature extends the sonar's full system performance to Sea State 4 and also contributes to the system's typical depth sounding accuracies of 0.1 per cent of water depth or 30 cm (whichever is greater) and the precise bottom reflectivity measurements. Bottom

Specifications—EM 121A

	Shallow	Intermediate	Deep	Very deep
Typical depths	10-300 m	200-1,500 m	1,200-5,000 m	4,500-11,000 m
Transmission sector coverage	120°	120°	120°	120° (90° at 11,000 m)
Transmission beamwidth	4°	2°	1 or 2°	1 or 2°
Source level (u30 dB sidelobe shading)	226 dB/µPa/m	232 dB/µPa/m	238 dB/µPa/m	238 dB/µPa/m
Default pulse length	1 ms	2 ms	7 ms	20 ms
Number of receive beams	61	121	121	121
Receive beamwidth (u30 dB sidelobe shading)	4°	2°	1 or 2°	1 or 2°
Range sampling interval	30 cm	60 cm	240 cm	480 cm



Swath coverage of the EM 121A multibeam echo-sounder

detection is based on combined amplitude envelope detection and phase detection (interferometric principle), a technique which has proved to be highly reliable and productive on previous Simrad designs. Also included is full and automatic compensation for ray bending caused by varying sound velocities in the water column.

The EM 121A functions without operator intervention under almost any condition. The system automatically produces, in real time, bathymetric contour maps and sonar images of the seabed (equivalent to those produced by towed side scan sonars). The system features extensive built-in automatic test and calibration equipment to ensure that it functions within specification continuously and which also facilitates maintenance. For example, the performance of each of the 58 power amplifiers is measured during each ping and each of the 128 preamplifiers is monitored for overloads at three different stages. This quality assurance information is displayed for the operator and also recorded with the other datagrams. The volume and consistency of the recorded data provides a far more accurate basis for construction of the desired digital terrain models than is possible with any earlier generation of equipment. From these models contour maps and three-dimensional views of any size and scale can be produced. These products can also be combined with the very high-resolution bottom reflectivity data. As an option, the raw data, complex samples from all 128 hydrophone channels, can be output from the receiver to an external system or logged on high-density tape (along with vessel attitude data) for other research and development applications. All output data formats include every vital system and ship parameter thus ensuring exact correlation and calibration of the data during post-processing.

Four of the T-AGS 60 class ships have been upgraded with the MF (95 kHz) EM 1002 multibeam echo-sounder to optimise performance in intermediate depths. Ten shallow water integrated mapping systems have been procured to equip hydrographic survey launches to be deployed on these ships. This equipment includes the EM 3000 (300 kHz) multibeam and EA 502 dual-frequency single-beam echo-sounders.

Operational status
The first EM 121 (a variant of the EM 121A which includes Simrad's complete post-processing package Neptune) was commissioned into the US Navy *Zeus* in January 1994. Simrad has been contracted to build and install six more EM 121A systems for NAVOCEANO's new class of multimission oceanographic research vessels: USNS *Pathfinder* (T-AGOS 60), USNS *Sumner* (T-AGS 61), USNS *Bowditch* (T-AGS 62), USNS *Henson* (T-AGS 63), USNS *Bruce C Heezen* (T-AGS 64) and *Mary Sears* (T-AGS 65). All these systems have been commissioned.

Contractor
Kongsberg Maritime, Horten. ***UPDATED***

United Kingdom

Aquashuttle Mk III

Type
Towed undulating data acquisition vehicle.

Description
The Aquashuttle Mk III is a stable, highly robust, versatile undulating towed vehicle for deploying a wide range of oceanographic monitoring equipment. Designed and developed by Chelsea Technologies Group and the Plymouth Marine Laboratory, UK it has a proven record of reliability over many thousands of miles of operation.

The vehicle features a strong Glass Reinforced Plastic (GRP) body with a robust integral stainless steel chassis which increases overall vehicle strength and offers better distribution of towing loads, enabling the carriage of a multisensor package with 16 channels of data logged. The vehicle's flight profile is maintained by a servo-controlled elevator, the servo being powered by the vehicle's own impeller-driven alternator which is housed in a polypropylene package. The flight profiles are controlled in real time via an interface unit and PC housed in the laboratory. The vehicle is shipped to the port of departure, deployed upon leaving port by the ship's crew and can automatically commence sampling on entering the water. The speed of tow and period/amplitude of operation can provide full two-dimensional (2-D) coverage of the mixed layer to >120 m over long-range ocean transects.

On previous data-gathering missions the Aquashuttle collected information on chlorophyll-α and thermoclines in the North Atlantic and in the South West approaches to Britain. Comparison of this data has shown the development of the seasonal thermocline from south to north, paralleled by the progression of the phytoplankton production northwards and the shallowing in depth of the euphotic zone. The relative importance and interaction of these influences on production are subjects of continuing study. Among studies currently being undertaken are nutrient supply and availability; light limitation and cloud cover (incident solar radiation); and mixing and stratification of the surface waters. Apart from chlorophyll-α, conductivity and temperature measurement, the Aquashuttle data package can measure *in situ* particle concentration; nitrate/nitrite determination; upwelling and downwelling; light; and bioluminescence, pH, redox, dissolved oxygen and plankton sampling.

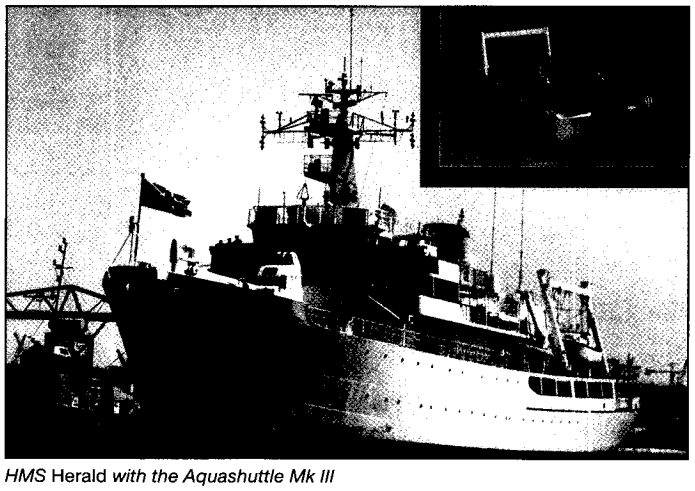
The data so gathered is of considerable benefit in attempting to predict ocean fronts and climatic conditions which affect sonar propagation. Payload combinations can typically include CTD, fluorimeters, transmissometer, nephelometer, bioluminescence, irradiance meter, optical plankton recorder, plankton sampler and SeaWifs bands sensors.

In addition to the commercial fleet, the Royal Navy deploys Aquashuttle from its survey ships. On these platforms, the system will integrate navigation data and includes a tow cable strain monitor. Real-time control and data display enables the operator to observe the 2-D oceanographic conditions and adjust the flight parameters accordingly. The vehicle is capable of being towed at speeds from 8 to 25 kt and can undulate from the surface to >120 m depending on cable configuration.

Operational status
In service with the Royal Navy aboard HMS *Scott*.

Specifications
Length: 1.39 m (impeller to bridle)
Width: 0.38 m
Height: 0.50 m
Weight: 66 kg (in air) (including servo control, but excluding Logger Pot and sensors)
Depth range: 0- >120 m
Towing speed: 8-25 kt
Dive/climb speed: 1.0 m/s (max)

Contractor
Chelsea Technologies Group, West Molesey. ***UPDATED***



HMS Herald *with the Aquashuttle Mk III*

Bathyscan

Type
Precision ultra-wide swath depth sounder.

Development
Bathyscan is a seafloor mapping system which operates at frequencies of 100 kHz and 300 kHz. In the 100 kHz mode, it can map in full continental shelf water depths with a swath width of up to 500 m, whilst at 300 kHz it is more suitable for rivers, harbours and estuaries. The system has been successfully used in a variety of environments worldwide for hydrographic surveys, pipeline route surveys, rig site inspection, harbour surveys and dredging operations. It provides an accuracy better than 30 cm at 300 kHz. The towing speed of the survey vessel is normally 6 kt.

Description
The Bathyscan swath sounding system provides high-density depth information on both sides of a ship's track. Side scan signals are transmitted and received on multiple interferometers providing about 1,500 soundings per second. These are combined with attitude data of the towed 'fish' to provide real-time display of seabed profiles. With the navigation data, a 'footprint' plot is produced in real time so that survey coverage can be monitored.

Other attitude data, tide corrections and swath merging are applied during post-survey processing.

Sophisticated fast post-processing software merges the depth swaths, taking account of the tidal correction, and provides detailed quality control data about the resulting depth matrix. The latter can be presented on a scale suitable for detailed site investigation or ready for chart compilation.

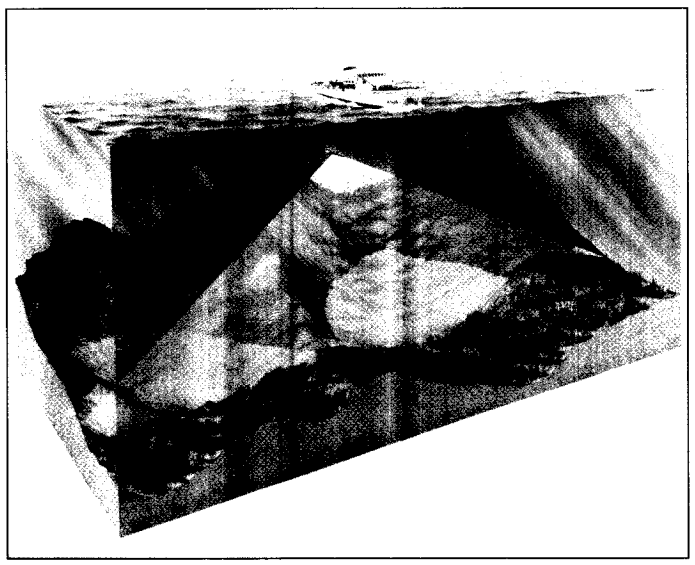
Side scan sonar signals are available and can be displayed on a suitable recorder.

Real-time seabed profiles, corrected for roll and heave, are shown on a colour graphics display. About 50 profiles on both sides are shown and scrolled downwards with each transmission. The control VDU displays towed fish attitude, roll, pitch, heave, depth, heading, system condition, mode of operation and system and error messages.

Operational status
The hydrographic service of the Royal Netherlands Navy has been operating Bathyscan on the survey vessel Hr Ms *Blommendal* and her sister ship, Hr Ms *Buyskes*. Another Bathyscan system is in service with the Royal Thai Navy hydrographic department. Bathyscan is also available for lease. A wide range of surveys has been undertaken in the North Sea for the major oil companies and operations have also extended to overseas surveys including the Caspian Sea.

Contractor
BAE Systems, Underwater Systems, Waterlooville, Hampshire.

UPDATED

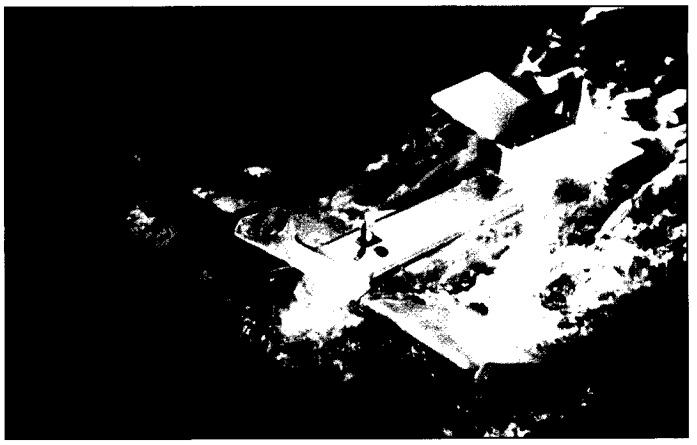


Bathyscan precision ultra-wide swath depth sounder

SEASOAR

Type
Open ocean towed undulating data acquisition vehicle.

Description
The SeaSoar vehicle is designed to provide a platform for a wide range of instrumentation for monitoring the ocean environment. It is capable of operating from the surface to 500 m at tow speeds of up to 12 kt following a controlled and adjustable undulating path. The maximum operating depth is dependent on the



The SeaSoar vehicle showing towing bridle and part of the faired tow cable 0092501

system's configuration. The PC-based SeaSoar deck control unit on the surface vessel enables the operator to have real-time computer control over the vehicle's flight profile, together with the storage and display of flight parameters.

Sampled data, obtained from sensors mounted in the vehicle and passed to the parent vessel via a multicore tow cable, is displayed in real time and stored in a suitable format for post processing.

The standard system comprises the stainless steel, deepsided frame, underwater tow vehicle; hydraulic unit; towing bridle; deck control unit; a PC-based flight control software (SeaFlight). The instrumentation payload is carried within the stainless steel body which is fitted with quick release steel panels top and bottom to facilitate easy removal of instruments without the need for tools and to give maximum possible accessibility to the payload.

A typical payload might include CTD, fluorimeter, transmissometer, nephelometer, bioluminescence and irradiance meter.

Operational status
SeaSoar systems are currently in service with many defence organisations around the world including, for example QinetiQ (formally the Defence Evaluation & Research Agency) - UK, SHOM - France and the Naval Research Laboratory - USA. Fully instrumented systems are in service on HMS *Echo* and *Enterprise*, the UK Hydrographer's new survey vessels.

Specifications
Length: 1.5 m (excluding bridle)
Beam: 1.60 m (over wing hooks)
Height: 0.98 m (rudder bar down)
Weight: 150 kg (in air but excluding sensor package)

Contractor
Chelsea Technologies Group, West Molesey.

UPDATED

SSMS

Type
Sea Surface Monitoring System (SSMS).

Description
Developed by Chelsea Technologies Group in conjunction with the MoD since 1979, this surface vessel version of TEDAS (see separate entry) measures physical and biological oceanographic parameters and bioluminescence. The sensor suite is housed in a rugged flow-through chamber that can easily be fitted to the seawater intake of a surface vessel. A deck unit provides power to, and accepts data from, the sensor suite. The interface unit converts the received data to engineering units and the correct format for input to a PC for storage and real-time display.

The sensor suite incorporates sophisticated built-in self-test and calibrator circuitry and is designed for ease of installation and for use over long periods of operation in harsh environments.

SSMS can identify water mass types, upwelling areas, eddies and ocean fronts. Acoustically significant features are easily mapped and predicted; which offers a significant tactical advantage.

Operational status
Currently used for research purposes.

Contractor
Chelsea Technologies Group, West Molesey.

UPDATED

TEDAS

Type
Tactical Environmental Data Acquisition System (TEDAS).

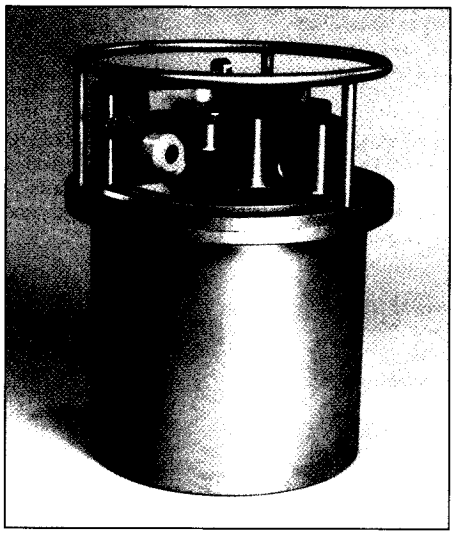
Description
TEDAS is an oceanographic system designed to full military specification. It is based upon the technically advanced Type 2115 sonar, the successor to the Type 2081 sonar which is fitted to all UK submarines. Type 2115 is being fitted to the Royal Navy's new Astute class submarines.

The outboard multi-parameter sensor suite measures those physical and biological parameters that collectively ensure that the maximum tactical advantage can be sustained. The sensor suite is housed in a compact, robust housing, designed to withstand the full rigours of the military environment. The inboard rack-mounted deck unit allows processing, display and storage of the collected and derived data. The 'Astute' system includes IBIS (Integrated Bathymetric Information System see separate entry) formerly known as Type 2090 sonar. The system is sufficiently versatile to accommodate up to two outboard sensor suites operating simultaneously to allow differentials to be monitored, with provision for additional sensors if required. Two displays, operating independently, are provided for the Astute class fit.

A surface ship version is also available.

Operational status
In service throughout the UK submarine flotilla and being adopted by several other navies.

Contractor
Chelsea Technologies Group, West Molesey. ***UPDATED***



TEDAS measures conductivity, temperature and depth. Together with novel fluorometric techniques it detects changes in water/mass types associated with ocean fronts, eddies and stratification
(Chelsea Technologies Group)
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Type 2034 sonar

Type
Dual side scan sonar for hydrographic work.

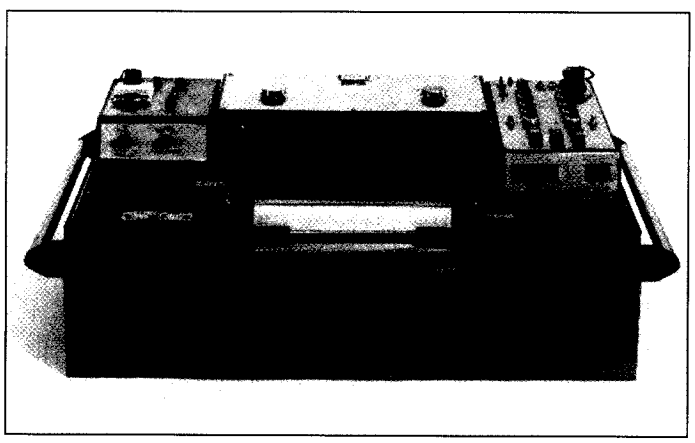
Description
The sonar Type 2034 is a short-range, high-definition, dual side scan sonar, suitable for: establishing the position of ships, aircraft or other objects lost at sea; charting obstructions in shipping channels or at sea floor engineering sites and evaluating underwater topography. Designed for the utmost reliability and to meet exacting military standards, Type 2034 sonars have been in use with the Royal Navy since 1976. The system is standard equipment on ocean-going and coastal vessels of the survey fleet.

The sideways-looking left and right transducers are housed in a towed body, called the towfish, the current version of which is the Mk 3. Some of the electronics are contained in the towfish but the majority of this part of the system is housed in the recorder unit which provides for operation and control of the equipment, and display by hard-copy, printout chart recordings.

The sonar operating frequency is 110 kHz with a nominal transmitted pulse length of 100 µs. A choice of three range scales, 75, 150 or 300 m, and one of three recording paper speeds, 30, 60 or 150 lines/cm, can be selected to suit the prevailing operating conditions. The transmission repetition rate depends on the selected range scale and is 10 pps for 75 m range, 5 pps for 150 m range or 2.5 pps for 300 m range. For all range settings, scale lines are recorded at 15 m range intervals to aid interpretation of the recordings. Facilities are provided for putting event markers on the recording.

Operational status
This system is now obsolescent, but units remain in service with the Royal Navy Hydrographic Service and other users worldwide.

Contractor
Ultra Electronics Ocean Systems, Weymouth, Dorset. ***UPDATED***



Type 2034 sonar

Type 2053/Sonar 3000

Type
Hydrographic survey sonar system.

Description
The Sonar 3000 family of side scan sonars has been developed from the Type 2034 high-definition sonar. The system uses modular construction which allows the assembly of variants to suit a range of applications. The system, originally aimed at the commercial market, is also in use for military applications. One variant known as the Type 2053 is in use with the Royal Navy for inshore hydrographic survey work.

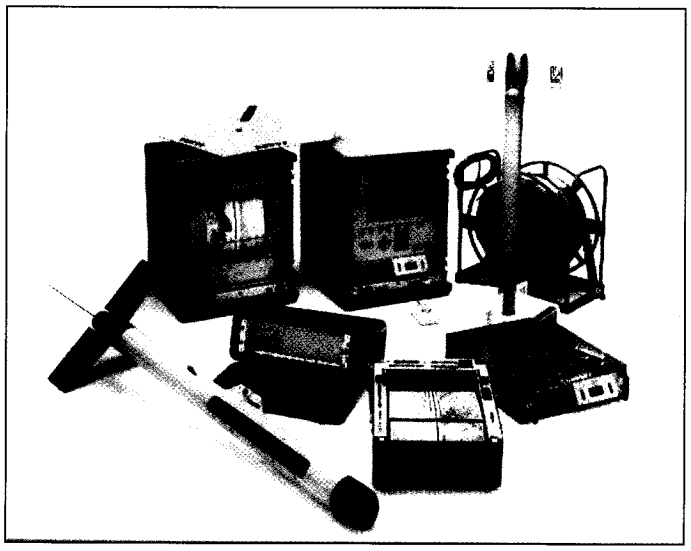
The Sonar 3000 family includes a variety of options and accessories including lightweight and heavyweight towfish and a range of recorders and winch systems.

Operational status
Sonar 2053 is in service with the Royal Navy Hydrographic Service (30 systems).

About 50 Sonar 3000 systems are in use with various other hydrographic survey organisations. The Sonar 3000 family has now been replaced by the Widescan family described in the following entry.

Manufacturer
Ultra Electronics Ocean Systems, Weymouth, Dorset.

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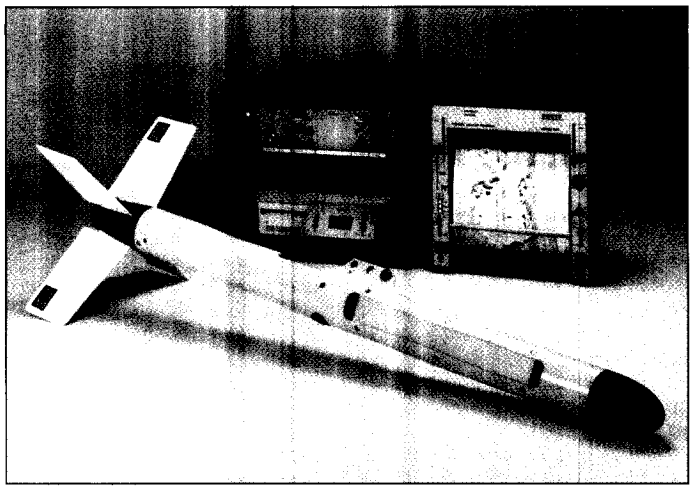


RN Type 2053 Sonar 3000 0518708

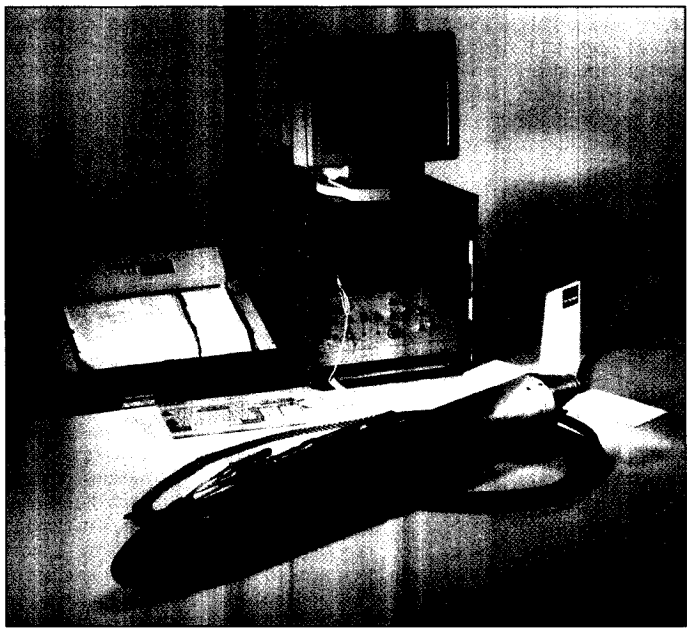
Type 3050 (Widescan)

Type
Digital side scan sonar.

Description
The Widescan sonar is designed for hydrographic survey, pipeline survey, and explosive ordnance disposal applications. The dual-frequency, image corrected,



Elements of the Widescan II Model 3050 sonar



Widescan III towfish and shipboard elements 0009852

side scan sonar operates at frequencies of 100 kHz and 325 kHz to provide a combination of long-range and high-resolution coverage. Ranges of up to 400 m per side are achievable at 100 kHz, and up to 200 m per side at 325 kHz. The 0.6° horizontal beamwidth at 325 kHz provides very high resolution seabed and bottom object imagery.

The Widescan III variant is a high-performance digital side scan sonar whose key features include: digital two-wire telemetry; dual simultaneous frequencies; composite transducer technology; built-in motion sensing; built-in altimeter; auxiliary channels for acoustic and serial data; and compatibility with all workstations.

The all new digital two-wire towcable telemetry system allows operation on commonly used armoured coaxial cables at lengths of 3,000 m or more. All acoustic data (16-bit resolution) together with bidirectional serial data and power is multiplexed on to the single coaxial cable. With one spare acoustic data channel and three serial data channels, additional instrumentation is easily integrated. Requiring only one coaxial, Widescan III is also easily integrated onto RQVs and so on.

Advanced composite transducer technology offers many advantages over standard transducers including improvements in beam patterns and power output, resulting in better image quality. Longer transducers can be fitted as an option, providing improved resolution and selectable beam patterns. With longer transducers fitted, the user can select either standard or long aperture online.

The dual frequency stainless steel towfish has a built-in acoustic altimeter and features a third channel towfish height display on the thermal printing recorder unit. Image correction for slant range and speed-over-ground can be selected from the front panel.

The system features an advanced self-adaptive gain system which guarantees optimum records without the need for operator intervention, making Widescan ideal for non-expert users as well as for experienced users such as hydrographic surveyors.

Control of the system is provided by the host sonar workstation via the sonar interface unit. All towfish parameters including frequency, pulse length, range, repetition rate and TVG are controlled from the surface and can be changed at any time during operation. Other facilities such as digital recording and playback, target identification and logging and real-time mosaicing are all available as part of the workstation software package. Auxiliary towfish information including altitude, heading, pitch, roll, temperature and status is telemetered to the surface on the serial uplink. A basic Windows control programme is provided allowing user control of the system independent of the workstation.

Options include a lightweight Kevlar towcable for small boat/shallow water operations and a wide range of sonar processing workstations for digital display recording and processing.

Operational status
The Widescan sonar is in use with the Royal Netherlands Navy, the Sultan of Oman's Navy, the UK Naval Hydrographer and more than 30 civil survey organisations.

Specifications
Towfish
Long array
Length: 1.61 m
Diameter: 11.2 cm
Weight: 35 kg

Short array
Length: 1.56 m
Diameter: 16.8 cm
Weight: 45 kg
Operating depth: 1,000 m
Towing speed: 6 kt
Frequencies: 100 and 325 kHz
Pulse length: 30-150 µs (100 kHz), 100-500 µs (325 kHz)
Beamwidth: horizontal long array: 0.76° (100 kHz) and 0.21° (325 kHz)
horizontal half length array: 1.3° (100 kHz) and 0.42° (325 kHz)
vertical: 35°

Contractor
Ultra Electronics Ocean Systems, Weymouth, Dorset. ***UPDATED***

Ultrascan 5000

Type
Side scan seabed survey sonar.

Description
Ultrascan 5000 is a seabed survey sonar developed to satisfy the requirements of commercial surveys and military applications alike where high-resolution long range images of seabed artifacts are of primary importance. The system combines a high-resolution, focused, 120 kHz side scan, and swath bathymetry system generating data out to 400 m per side at resolutions normally associated with 300 to 500 kHz sonars.

Ultrascan 5000 is derived from technology developed for Deepscan 60 and uses the latest digital signal processing techniques combined with fibre optic towcable telemetry and the general purpose Tessa sonar workstation. Sufficient spare processing and telemetry capacity has been included to facilitate system flexibility and future growth.

Each side scan transducer array is made up of separate electrical sections, each separately connected to facilitate electronic beam-forming and focusing in real time to achieve extremely high resolutions. A dual vernier interferometer operating in conjunction with the main side scan array is used to provide swath bathymetry.

All Ultrascan 5000 beam-forming, filtering, gain processing, bathymetry and image processing functions are performed on the surface, under software control, in the Tessa sonar workstation. This compact unit contains a powerful 32-bit computer and an array of high-speed digital signal processors which carry out all the real-time signal processing.

Operational status
Two systems based on Ultrascan 5000 have been supplied to Johns Hopkins University, Applied Physics Lab, USA, and are in service with the US Navy.

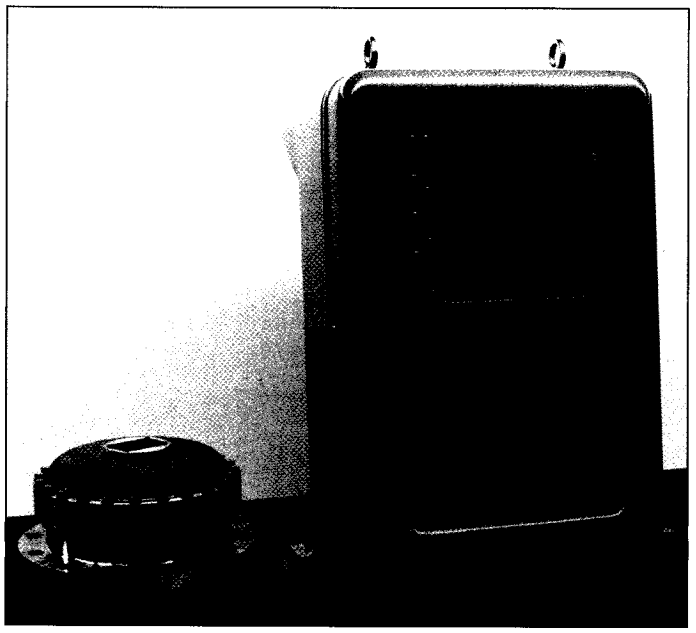
Contractor
Ultra Electronics Ocean Systems, Weymouth, Dorset. ***VERIFIED***

United States

AN/UQN-4/Model 9057

Type
Depth sounder.

Development
The AN/UQN-4/Model 9057 was developed as a replacement for the AN/UQN-1/Model 185 that was the standard equipment on virtually every vessel and submarine in the US Navy, US Coast Guard and Coastal Geodetic Service, as well as on domestic and foreign research and offshore vessels, for over 20 years.



Model 9057 sonar sounding set

Description
The model AN/UQN-4 digital depth sounder features improved accuracy together with field change upgrades to improve shallow water capability.

The depth sounder uses a 12 kHz ceramic piston-type transducer and visually presents digital and graphic displays of water depths (in feet or fathoms) in a choice of five ranges (0-600 ft, 0-600 fathoms short pulse, 0-600 fathoms long pulse, 0-6,000 fathoms, short pulse, and 0-6,000 fathoms long pulse). It presents this data on a digital numeric display and permanent strip chart recorder. The transducer comprises 15 ceramic (lead zirconate titanate) double mass loaded vibrator elements. Optionally a non-magnetic transducer for use in MCM applications and a special transducer designed to operate down to 1,828.8 m and tested to 3,000 psi for use in submarines is available.

Other improvements include: crystal oscillator timing which considerably improves accuracy; automatic bottom tracking range gate to reduce the possibility of false depth indications from fish, plankton and other anomalies; and selectable output power. It may also be used as a passive listening device.

Operational status
In service with Australia, France, Korea, Taiwan and the US Navy. The AN/UQN-4 has also been ordered for the 'Alvaro de Bazan' class frigate programme of the Spanish Navy.

Contractor
EDO Combat Systems, Chesapeake, Virginia. ***VERIFIED***

Bathy 500

Type
Single- or dual-frequency, thermal recording echo-sounder for hydrographic surveying.

Description
The lightweight, low-power Bathy 500 is a low-cost, high-functionality echo-sounder that is easy to operate and maintain. Its ease of integration with shipboard systems and compact construction offer portability, accuracy and reliability in generating precision chart recordings and digital data output. Designed for depth ranges to 160 m, the Bathy 500 offers a wide range of applications from hydrographic surveying to medium-depth bathymetry.

The echo-sounder provides advanced digital signal processing for reliable bottom detection and automatic chart annotation. Automatic and manual controls allow the user to control time and date, position, and alarms. Equipped with a built-in digitiser with RS-232 and RS-422 data output interface ports and an NMEA 0183 navigation input interface, the echo-sounder provides the user with a complete integrated hydrographic survey system.

The Bathy 500 uses modern microprocessor-based electronics and a thermal chart recorder mechanism. It features non-volatile internal clock and parameter set up memory, a sealed keypad and LCD for data entry and remote mark input. It is housed within a splashproof aluminium enclosure weighing 10 kg. The unit consumes less than 40 W and offers user selectable DC or AC input power.

Operational status
The Bathy 500 was introduced in 1996. Over 200 units have been delivered worldwide.

Contractor
Ocean Data Equipment Corporation, E Walpole, Massachusetts. ***VERIFIED***

Bathy 2000/2000P

Type
CHIRP dual-frequency echo-sounding for bathymetry and sub-bottom profiling.

Description
The Bathy 2000/2000P series are research survey systems offering maximum flexibility to meet a wide variety of mission requirements including CHIRP sub-bottom profiling, bathymetry, bottom type classification, and sub-bottom density calculations. They provide simultaneous dual-frequency operation and 8 cm resolution of sediment strata with bottom penetrations to 100 m.

The Bathy 2000 is configured with a controller, processor, 5 kW amplifier, video monitor and keyboard mounted in a standard rack for shipboard mounting. It is designed for full ocean depth operation to 12,000 m. The Bathy 2000P includes the same controller and processor, an LCD Display, sealed keypad, and 2 kW amplifiers contained in a single chassis for portable operation. It is designed for applications in rivers, harbours and coastal waters and performs to depths of 6,000 m.

Various options for transducers and mounting include towfish, sea chest and pole mount allowing installation on COOP in support of pipeline routeing surveys, engineering evaluations for construction sites, pre- and post-dredging volumetric/material classification survey and scientific studies.

Standard configurations include an array of six 7 kHz transducers mounted in a small, easy to handle towfish. This array provides 8 cm resolution sub-bottom profiles using an 8 kHz bandwidth FM CHIRP waveform, centred on 7 kHz for optimum penetration and resolution. Also available are arrays of 3.5 kHz CHIRP arrays for maximum penetration. CHIRP signal processing provides a processed SNR gain of greater than 23 dB for greater depth and enhanced performance in noisy environments. Other frequencies available include 12, 24, 33, 40, 100 and 200 kHz.

The 2,000 W power amplifier in the Bathy 2000P provides 25 ms CHIRP waveforms for operation to 6,000 m with typical sub-bottom penetration of 30 to 50 m. The 5,000 W amplifier in the Bathy 2000 extends operation to 12,000 m or gives deeper penetration in the sub-bottom.

Processed data is displayed on an integral colour LCD graphics display and recorded on an internal data logger. Optional recording on a colour plotter, thermal paper recorders or optical disk is available. Flexible data formats including SEG-Y are compatible with most post-survey data processing systems.

The Bathy 2000P uses a highly flexible, embedded PC/DSP open architecture which allows advanced real-time digital processing and expansion. Time domain digital correlation, coupled with variable length FM CHIRP waveforms, enables the system to perform extended depth operations while preserving sub-bottom layer resolution. A 30-point sound velocity profile permits accurate corrections for water column variability. Reliable data are obtained using Ocean Data Equipment Corporation's proven detection algorithms generating robust bottom tracking in sloping terrain and excellent performance in high-noise environments. Bottom detection uses selectable leading edge or peak detection for the best estimate of depth. Bottom tracking uses ship's speed and past depth history for a predictive estimate of the next expected depth. Pinger track and parametric modes are available.

Operator control is through a series of simple and logical dialogue boxes, data entry forms, pull down menus and buttons. Data entry and control is via an integral sealed keypad or standard keyboard. Automatic, built-in tests simplify troubleshooting.

The system is ideally suited to the needs of multimission research vessels. It has eight external interfaces for integrating with GPS navigation, heave sensors, sound velocimeters, IRIG-B or other devices along with remote VGA monitors, SCSI devices or ethernet systems.

Operational status
There have been 39 B2000/2000P systems sold worldwide and the system has become the standard deep water system in the US on Thomas G Thompson class AGOR (four vessels) and 'John McDonnell' (two vessels) and 'Pathfinder' (six vessels) T-AGS class vessels and is being adopted worldwide.

Contractor
Ocean Data Equipment Corporation, E Walpole, Massachusetts.

VERIFIED

Series 5000

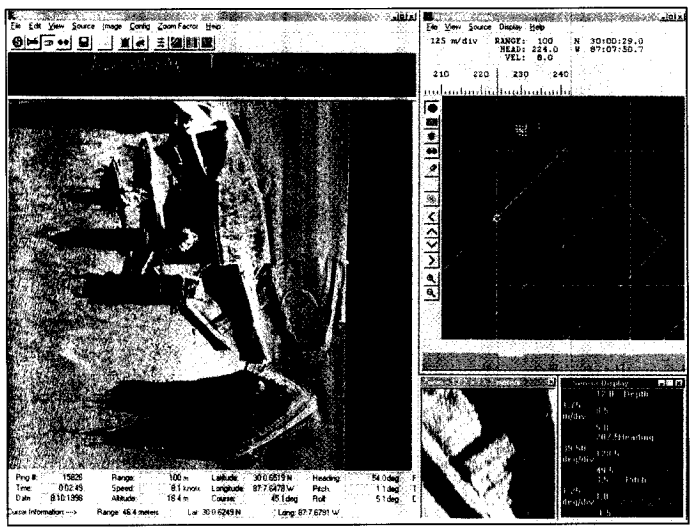
Type
Multibeam side scan sonar for ocean survey and oceanographic research.

Description
The Series 5000 multibeam side scan sonar uses digital technology to form multiple, dynamically focused and collimated sonar beams on each side of the sonar.

The design of the Series 5000 Sonar Systems permits contiguous placement of the collimated sonar beam allowing gap-free, 100 per cent bottom coverage at speeds up to the maximum speed of the specific sonar model, with the Model 5500 having a maximum speed of 10 kt. This capability is achieved while maintaining the specified along-track resolution. As a consequence of the use of



Series towfish (Klein Associates) 0011318



Series 5000 system viewer details (Klein associates) 0058808

multiple sonar beams, the Series 5000 sonars can produce up to five times the data of an unfocused, single-beam side scan sonar at significantly higher area coverage rates.

At slower speeds, the sonar beams are controlled to maintain equally spaced, contiguous beam placement, so that the sonar maintains 100 per cent bottom coverage. The use of multibeam side scan sonar increases the image quality and enhances the detection of small details and contacts, while increasing area coverage rates over that available through the use of single-beam side scan sonars.

The Series 5000 sonar systems have been designed to be operated from a tow cable, permitting the towfish (transducer) to be towed in the vicinity of the sea bottom for optimum resolution and for the avoidance of environmental interference. However, for shallow water operations, Series 5000 sonars can be hull-mounted and maintain operational capabilities in water depths as shallow as 2 m (6 ft).

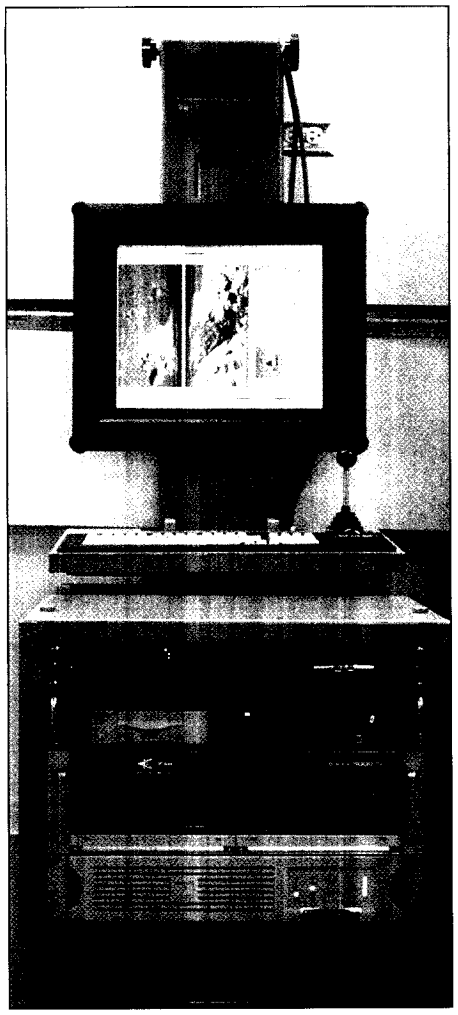
All Series 5000 systems consist of a towfish, tow cable, the transceiver/processor unit (TPU), and a display and control unit, typically an IBM type PC computer. The stainless steel towfish (nominally weighing 75 kg) incorporates two multi-channel acoustic arrays and a pressure canister which houses the electronics and sensors necessary for sonar data acquisition, height above seabed sensing, system control, and telemetry. The size of the towfish permits operations from small research and survey vessels without impact on vessel performance or seaworthiness.

Sonar and sensor data is transmitted up the tow cable via a high-speed digital telemetry link, requiring only a single coaxial or fibre-optic cable.

The surface-mounted TPU receives the data, performs all necessary digital processing functions on the acoustic data, and relays control commands to the towfish. Processed data is distributed to one or multiple PC display and control units (DCU) via a 100 Based T_x Ethernet LAN network, where data viewing on a 17 in video monitor, storage, and analysis are undertaken. The navigation input is NMEA 0183. The TPU operates on 115/240 V AC, 50/60 Hz, and it requires 120 W power. It weighs 12.7 kg; its rack-mount width is approximately 48.26 cm; it is 13.2 cm high and 54.6 cm deep.

The systems can be used in very shallow water and in deep water. Optional sensors are available to provide heading, depth, roll, pitch, responder and so on. A full range of accessories is available including tow cables, winches, depressors and so on.

The System 5400 is a 4-beam model designed for offshore surveying operating at towspeeds up to 8 kt. The System 5500 is a 5-beam model for hydrographic applications at speeds up to 10 kt, and the System 5800 is a 8-beam model designed for detection and classification applications at speeds up to 15 kt.



Display and control unit for Series 5000 sonar (Klein Associates) 0129628

Operational status

Series 5000 Systems are currently in production and in service with both commercial and governmental customers worldwide.

Specifications

System 5500
No of beams: 10 (5 per side)
Frequency: 455 kHz
Pulse length: 50-200 µs
Resolution (along track): 20-36 cm
Resolution (across track): 7.5-15 cm
Operating speed envelope: 2-10 kt
Sonar digitisation: 12 bits per channel
Operating range: 150 m (300 m swath)
Array length: 120 cm
Towfish length: 194 cm
Towfish diameter: 15.2 cm
Weight (in air): 70 kg

Contractor

L-3 Communications Klein Associates, Inc, Salem, New Hampshire.

UPDATED

System 3000

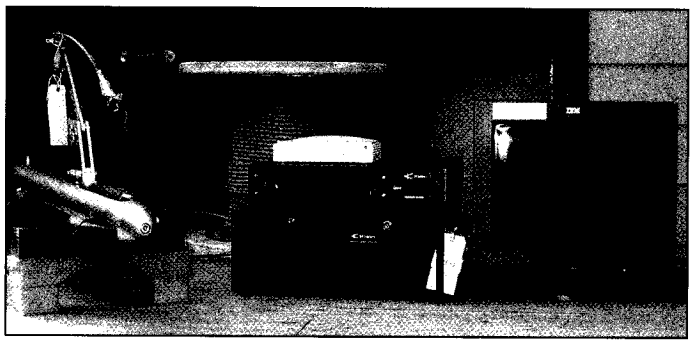
Type

Digital side scan sonar for explosive ordnance and lost submarine search operations.

Description

The System 3000 high-resolution, side scan sonars use digital technology and advanced transducers originally developed for the Series 5000 multibeam sonar systems. The Model 3000 sonar system produces longer ranges at high resolution from its simultaneous, dual frequency (100 and 500 kHz) beams.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com



Elements of the System 3000 sonar system (Klein Associates) 0129629

The towfish has a standard depth rating to 1,500 m, modularity for mounting to various platforms, and is portable. It is completely software driven on a PC platform employing Klein's SonarPro® software. SonarPro® is a custom designed acquisition program developed by experienced users for ease of use by both experienced and inexperienced operators. The program features survey planning tools, navigation charts, track plotting, target management and a LAN hub interface for multiple or third party users.

The small, lightweight and simple design is ideal for small vessel operations. Modularity of both the towfish and shipboard processor permits easy use on ROVs and AUVs. Standard towfish sensors include: pitch, roll and heading. Optional sensors include responders, magnetometers, and pressure (depth) sensors. The towfish is rated to 1,500 m depth with options available for 3,000 and 6,000 m. A new feature is the ability to adjust the tone burst transmission of each frequency independently from 25 to 400 µs. The stainless steel towfish is also adapted to have different frequency transducers such as single 100 or 500 kHz as well as 50 kHz. A100 BT LAN hub is standard permitting multiple PC workstations to process, view and store data independently. The TPU is also adapted to operate with several customer provided PCs and software via the LAN hub.

Other options and accessories include towfish depressors, winches with slip ring, armoured or lightweight cables, spares kits, dual monitors, and multiple data storage devices.

The Series 3000 sonar systems have been designed for operation from a tow cable, permitting the towfish to be towed in the vicinity of the sea bottom for optimum resolution and for the avoidance of environmental interference. However, for shallow water operations, Series 3000 sonars can be hull-mounted and maintain operational capabilities in water depths as shallow as 2 m. All surface units are available in a rack-mounted configuration.

Operational status

The Model 3000 sonar systems are currently in production and available off-the-shelf for immediate ocean operations. Systems are currently used for many search and survey operations.

Contractor

L-3 Communications Klein Associates, Inc, Salem, New Hampshire.

UPDATED

TRAINING AND SIMULATION SYSTEMS

Introduction

A great deal of time and effort has gone into the development and production of simulation and training systems associated with underwater warfare. This has resulted in a much better appreciation of the operational requirements that in turn has led to improved efficiency on the part of the operators, maintainers and designers.

Simulators and trainers for underwater warfare cover six major areas:

- command team trainers
- mine warfare trainers
- submarine equipment trainers which includes handling manoeuvring and machinery control simulators and trainers
- aircraft equipment trainers associated with underwater warfare systems
- sonar equipment trainers and
- targets.

The last area covers wide range of equipments which perform a number of roles not just associated with training sonar operators and weapon controllers, but also research into the underwater environment and trials associated with underwater weapons and sensors.

Much of the equipment covered in this section involves large land-based systems used for training underwater warfare teams and operators and makes considerable use of simulation. Other training systems that are of increasing importance are on-board trainers. These make use of operational on-board equipment but use simulation and stimulation techniques for training operators in a benign situation. Some of these systems can be found in the relevant sections on on-board equipments.

Full details on trainers and simulators can be found in *Jane's Simulation and Training Systems*.

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COMMAND TEAM TRAINERS

France

Type 209 simulator

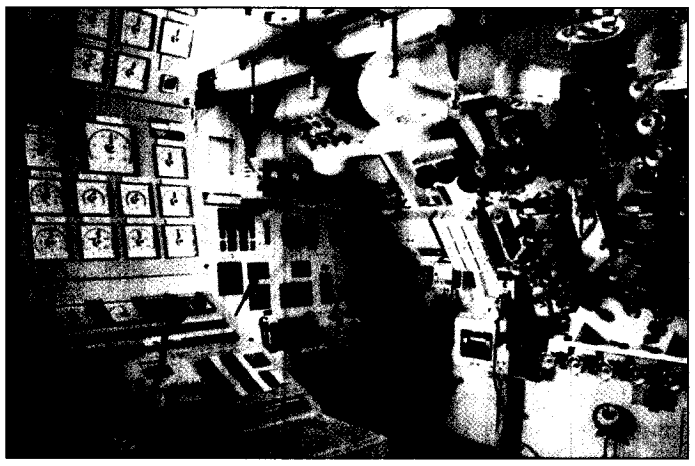
Type
Type 209 platform control simulator.

Description
The Type 209 simulator is designed to train the boat's diving officer, two steering operators and the air/water manifold operator in all aspects of normal and emergency procedures for submarine platform control. The simulator features an electric 2° freedom of motion system developed especially for submarine simulators.

Operational status
A simulator for Type 209/1500 boats is in service with the Indian Navy in Mumbai (Bombay) and another for Type 209/1400 boats is operational with the Brazilian Navy at the submarine base in Rio de Janeiro. Five other submarine platform control simulators of different types are operational.

Contractor
Thales Underwater Systems, Sophia Antipolis.

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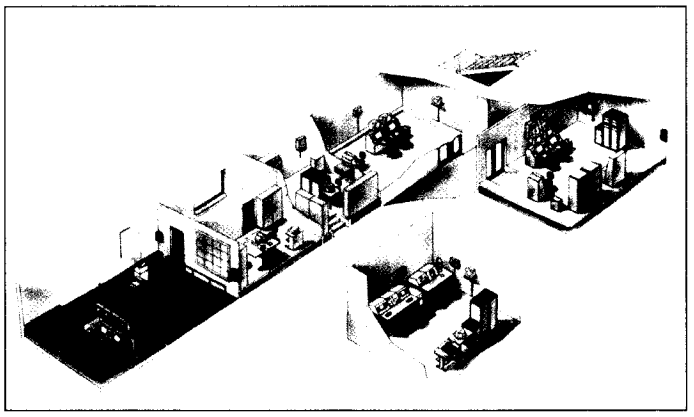
The Type 209/1500 simulator of the Indian Navy (Thales Underwater Systems)
0524687

Germany

AGUS ASW trainer

Type
Command team trainer for Anti-Submarine Warfare (ASW) operations.

Description
AGUS is designed to train and assess command information teams in ASW. It also trains and assesses operators of different grades in the use of sensors and weapon



Block schematic showing typical arrangement of an AGUS ASW trainer (STN Atlas Elektronik)
0093510

systems and provides training in tactics. It uses distributed computer architecture techniques employing STN Atlas MPR/EPR processors which allow modular construction to meet customers' requirements.

The system consists of a number of command information cubicles, an instructor's station, a debriefing auditorium with a large screen display and an electronics room. It can be equipped with either real operating equipment or with general purpose consoles which have intelligent graphic displays.

The simulator provides dynamic operating behaviour of own ship's course, speed and mission duration; realistic visual and acoustic presentation for active, passive and intercept sonar; presentation and operation on radar and ASW consoles; and weapon data together with combat situation displays. Also provided is realistic contact association, target motion analysis and data display, and weapon firing tactics, together with simulation of weapons and decoys.

For the German Navy three operations rooms are provided in the trainer: Bremen class, Brandenburg class, and Mk 88 Sea Lynx helicopter. Equipments simulated include: sonars - DSQS 21, DSQS 23, AN/AQS-18; fire-control systems - SATIR; navigation systems - TANS, radar; weapons - DM 3 torpedo, Mk 46 torpedo, DM 4 torpedo, DM 21 missile, DM 11 depth charge.

The system underwent a mid-life update in 1998.

Operational status
Operational with the German Navy.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

AWU 206A

Type
Submarine Command Team Trainer (SCTT).

Description
The AWU 206A is a shore-based computerised simulation system which replicates the control room of the Type 206A submarine for training all grades of submarine teams in order to achieve maximum combat power at sea.

The trainer features a computer-based sonar situation compilation and fire-control system; sonar trainer; navigation plotting table; periscope; and ESM system. The trainer simulates tactical situations which can be presented to the trainees who are working in the submarine's Combat Information Centre (CIC) installed at the naval base. The weapon officers and operators are trained in operations and response to specific tactical problems under the supervision of exercise controllers. The trainer also provides for development and analysis of naval procedures for torpedo firing and guidance methods, and optimum operation of onboard equipment.

Through co-operation between the simulator and the CIC, optimum training can be achieved for:

- attack of surface vessels and submarines;
- defence against attacking surface vessels, submarines, ASW aircraft and helicopters;
- operations in minefields.

The simulation can be programmed to include own ship and weapons (torpedoes and mines) and up to 20 dynamic targets, and about 250 different scenarios including coastlines, navigation marks, lighthouses, offshore features (oil rigs) and so on. The simulator also provides a wide range of environmental conditions to give students a realistic scenario in which to conduct operations.

The system consists of a 21 seat auditorium with large screen displays, instructor consoles with colour monitors and communications equipment, the CIC with real equipment (sonars, weapons control equipment, combat management system, periscope, radar, ESM, navigation system, own ship control) and a computer room. The latter generates the sonar, tactical data handling, weapon handling, periscope, navigation, ship's controls, radar and ESM inputs for the system.

All display or operating data can be rerun in real time or time compression over a period of up to 4 hours on the large screen display.

Operational status
In service with the German Navy.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

CIC simulator

Type
Combat Information Centre (CIC) simulator for surface ships.

Description
The CIC simulator is a shore-based training system using both emulation and stimulation techniques for individual operator training, subteam training, team training, maintainer training and research and development applications.

Multiple warfare scenarios covering AAW, ASW, AsuW with different complexities of targets can be simulated. The trainer can be fitted out using the original equipment of a surface ship's CIC with subsystems which include active and passive sonars, VDS, ECM/ECCM, communications and weapon systems (Harpoon missile and torpedo fire-control). An entire system comprises an auditorium with large screen display, CIC with real equipment, computer room and offices. The debriefing facility provides for the review and analysis of an entire exercise.

Operational status
In service with the Republic of Singapore Navy.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED



Combat Information Centre (CIC) simulator

HNSAS

Type
Submarine attack simulator.

Description
The HNSAS has been procured by the Hellenic Navy to train commanders and attack groups in target detection, surveillance, tracking and attack procedures involving torpedoes and missiles. The modular design of the simulator allows it to envisage several possible extensions, including training for all present and future types of submarine that will be in service with the Greek Navy.

The simulator is based around COTS PC hardware. The sonar and weapon control components are generically similar to the design of the ISUS 90 combat system which is being introduced into the Greek Navy.

The simulator replaces an existing system and includes a mock up of the CIC with simulated sonar and weapon control system, periscope simulation, radar simulation, ESM simulation, plotting table, intercom system and simulation of the submarine's control station. It also includes weapon simulation for torpedoes and missiles, instructor and debriefing station, and model data input station. The simulator is housed in a new building at the Submarine Training School in Salamis Naval Base.

Operational status
Under construction.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED

NATAT

Type
Naval tactical and command team trainer.

Description
A shore-based training system for command teams, post teams, midshipmen, system R & D teams and planning departments. It provides a full range of simulation facilities from communication, exchange of information, distribution of missions, co-operation between forces, to use of air support. The system can simulate any type of craft such as submarines, frigates and merchant ships over a typical exercise area of 2,048 × 2,048 n miles inclusive of shore lines, navigation marks, coastlines and bottom depths, wind, sea state, currents and bathymetrics.

Environmental type simulation includes wind, sea state, cloud, current, rain and bathymetric conditions.

Of modular design and expandable according to user requirements, a complete system comprises an instructor's console, trainee cubicles (typically 10 cubicles), computer facilities, auditorium, maintenance room, lobby and offices.

Operational status
In service.

Contractor
ATLAS Elektronik GmbH, Bremen.

VERIFIED

SCOTT

Type
Submarine COMbat Team Trainer (SCOTT).

Description
SCOTT belongs to the family of shore-based simulation systems for training all levels of submarine personnel.

The system provides simulation of a submarine's combat information centre with all working functions using multipurpose consoles which are independent of any specific type of console. SCOTT is thus virtually unlimited in its simulation capabilities. The system can also be linked with a diving trainer.

SCOTT offers the following functions: panoramic passive sonar, active sonar, intercept sonar, flank array sonar, passive ranging sonar, underwater telephony, attack periscope with visual system (CGI), fire-control systems, tactical data handling and radar with ESM and steering unit.

SCOTT can also be interfaced with a submarine diving trainer. Officers and operators are trained to operate and combine all available sensors using the right tactics and deployment of weapons, optimising, improving and developing tactical doctrines without having to use a real submarine and possibly putting it and its crew in a dangerous situation. SCOTT is supported by a comprehensive playback system and detailed briefing/debriefing can be carried out.

Using SCOTT enables command teams to be trained to carry out the full range of submarine operations against enemy forces including: surveillance and strikes against surface ships; convoys and/or submarines involving detection; classification; threat analysis; tactical navigation; weapon control and weapon deployment.

Detection and countermeasures against hostile attacks by surface vessels, submarines and ASW aircraft and helicopters can be practised and in addition submariners can be trained in minelaying operations, operations in mine areas, intercommunications during all combat situations and tactical manoeuvres.

The system uses MMI and standard software tools. Hardware and software is of modular design, allowing a wide range of different types of boat to be simulated. The flexible design approach allows subsequent additions of new equipments to be easily integrated and potential for growth is available for future extensions.

Operational status
In service with the German and South Korean navies. Two systems have been ordered for the German and Italian navies for the Type 212A programme and were completed in 2002.

Contractor
ATLAS Elektronik GmbH, Bremen. ***UPDATED***

SCTT

Type
Submarine Command Team Trainer (SCTT).

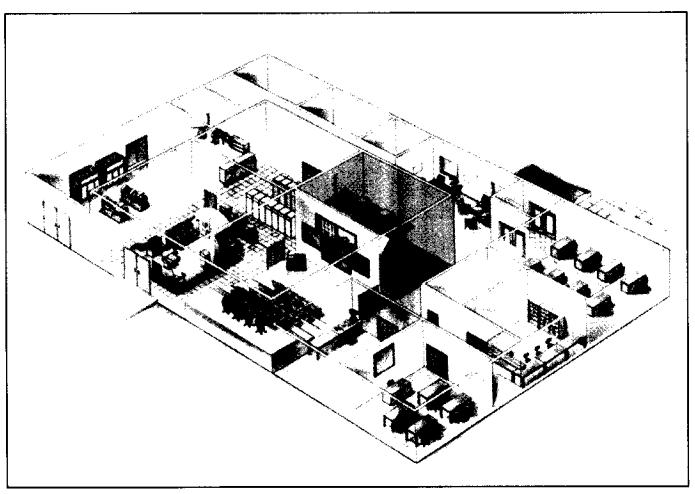
Description
The SCTT is a shore-based, computerised simulator system for training all grades of the submarine team in order to achieve maximum combat efficiency at sea.

The trainer comprises an auditorium with a large screen display, instructor's console and communication equipment, combat information centre with real equipment, periscope with visual system (CGI) and computer room.

SCTT simulates real tactical situations, which can be presented to trainees working in the submarine's combat information centre. The weapons officers and operators are trained in operation and response to specific tactical problems under the supervision of exercise controllers. SCTT also provides capabilities for the development and analysis of submarine tactics, torpedo firing and guidance methods and optimum operation of onboard equipment.



Auditorium showing large screen display and instructors' console (STN ATLAS Elektronik) 0093512



Block schematic showing general arrangement of the SCTT (STN ATLAS Elektronik) 0093511

Features which are available include: passive sonar, active sonar, flank array sonar, towed array sonar, intercept sonar, own noise analysis, passive ranging sonar, sonar information processor, weapon control (torpedoes, mines, missiles), tactical data handling, combat situation analysis, periscope, radar, ESM, mine avoidance sonar, navigation, own ship control and torpedo sonar.

Training functions include: the attack of surface vessels and submarines, defence against hostile surface vessels and submarines, aircraft and helicopters, and operating in minefields.

Relevant information is generated with detailed accuracy providing radar images as well as the display of coastlines and up to 40 external targets via the periscope (ships, boats, helicopters, torpedoes, buoys). The simulated exercise area covers an area up to 10,000 n miles^2 covering all conceivable scenarios of electronic warfare as possible, including the use of torpedoes and associated guidance methods.

Outside the combat management mock-up suite, trainees in the auditorium can keep track of the progress of the exercise.

The simulator provides exercise recording facilities covering periods up to four hours, which allows all critical situations and all decision-making processes where improvements can be made, to be dealt with easily in a detailed debriefing session.

Operational status
In service with the navies of Germany (206A class – see separate entry AWU 206A) and South Korea. The German Navy took delivery of an SCTT in 2003 and the system is also currently under delivery to the Italian Navy.

Contractor
ATLAS Elektronik GmbH , Bremen. ***UPDATED***

Italy

Submarine trainer

Type
Attack team trainer.

Description
The trainer is used to train attack teams of the Sauro class submarines.

The system comprises real onboard equipment (the command and control system MM/BSN-716(V)2 and the fire-control system for A184 wire-guided torpedoes) and the simulation and control facilities.

The simulation system comprises a computing subsystem for tactical scenario simulation based on a DEC mainframe with magnetic storage units and peripherals (terminals, printer, plotter digitiser). The ship simulation subsystem is based on the Motorola 68020 microprocessor and simulates sensors and equipment interfaces (NTDS, TTL digital I/O, synchro, analogue and so on). A torpedo simulator for A184 torpedoes is also included. Hardware comprises a number of consoles for controlling sensors and navigation equipment and includes a video terminal, multifunction keyboard and a control panel for internal and external communication networks. Exercise control is conducted from two instructor consoles based on a DEC VAX station. Each includes three video terminals (one high-resolution colour), three multifunction keyboards, trackerball and communications control panel. A debriefing system includes a graphics workstation and a large screen projector.

System functions include: scenario preparation with full support provided for storage and retrieval of data including full exercise description, sensors and target characteristics, geographic information and so on; tactical simulation, own ship and target's sensors simulation; data exchange and real onboard equipment; torpedo simulation (logical and electrical); and data recording and playback for debriefing.

A visual periscope simulator is integrated into the system, incorporating an SGI Onyx Reality Engine 2 workstation and a periscope mockup.

Operational status
The system was installed at the Italian Navy Training Centre at Taranto in June 1991. The periscope simulator entered service in early 1996.

Contractor
Datamat Ingegneria dei Sistemi SpA, Rome. ***UPDATED***

Netherlands

Sea Dragon Submarine Simulator

Type
Trainer for machinery and operations room operators.

Description
TNO has developed the Sea Dragon simulator to train the submariners of the Taiwanese Navy in the handling of their two Dutch-built submarines of the Hai Lung class.

The simulator creates a working environment for the operations room personnel. The cabin containing the control room mock-up has copies of the central operating and control panels. A second cabin contains the engine room control and operations panels.

A hydraulic system is used to recreate all the motions experienced by the submarine.

All normal routines can be practised together with emergency situations.

A computer controls all the commands given by the personnel and calculates the consequences of their actions. The computer relates to the instruments in a manner which produces real-life scenarios.

The simulator platform features 3-axis motion which can reproduce all boat motions including crash dive angles and is equipped with full replicas of the 'Hai Lung' operations room and machinery control room together with an instructor's facility.

Operational status
In service with the Taiwanese Navy since 1986.

Contractor
TNO, Delft.

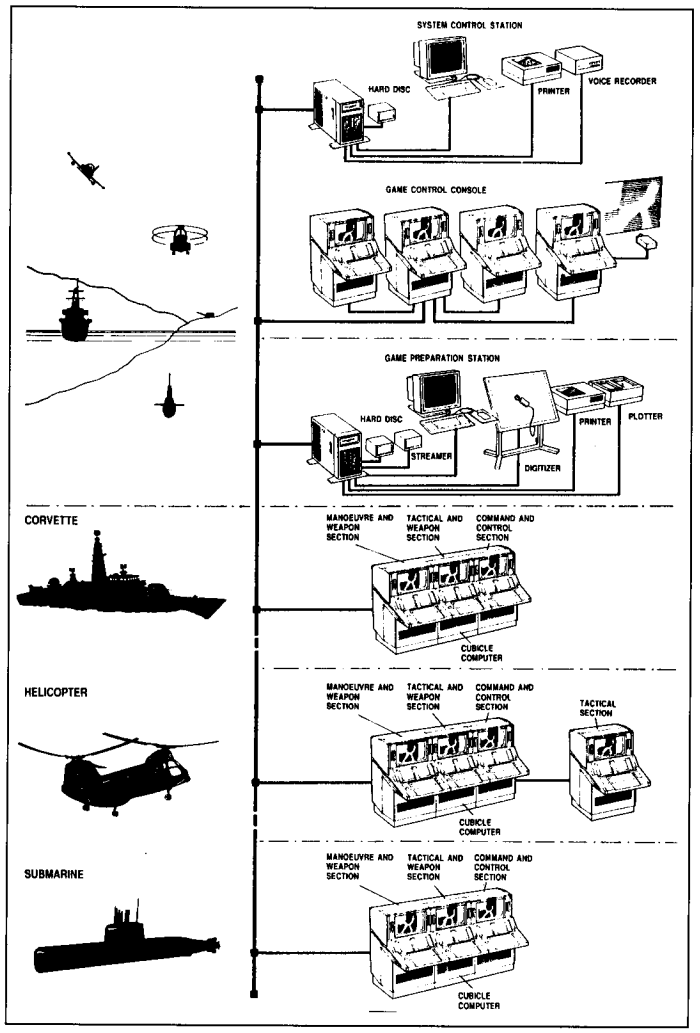
VERIFIED

Norway

MASTT

Type
Action speed tactical trainer.

Description
The MASTT is a flexible system for building naval tactical trainers and simulators extendable to almost any level of complexity, sophistication and standard. It is designed to fulfil the training requirements of seamen (reporting procedures, sensors and weapon operating procedures, classification training and operator training on real equipment), officers under training (decision making, team work, reporting procedures and weapon employment), and high-ranking officers (tactical disposition training, tactical analysis and exercise planning, analysis and debriefing). The system is stated to be very easy to use with students able to operate the cubicles by themselves after one or two 1-hour introductory sessions.



Schematic layout of an MASTT

MASTT was developed in close co-operation with the Royal Norwegian Navy and installed at the Royal Norwegian Training Establishment in Bergen.

The installation in Bergen consists of 10 cubicle consoles, an extended control section, a standard control section, a system console, two recorder/playback computers, two weapon computers, a communication control, three sonar simulators and two anti-submarine warfare consoles. Each trainer console is software configurable and the user has full control of model and scenario generation. The distributed concept, using an Ethernet network, makes it easy to expand the trainer by adding more cubicles or enhance it by interfacing with the real equipment simulators (such as radar, sonar and weapon control).

The model preparation and storage for the complete game is performed using a commercial computer. The user interacts with the system console via a menu-driven operator dialogue. All game settings and scenarios can be prepared and tested offline prior to the actual game, so it is possible to build up a library of preplanned games settings on disk.

The instructor workstation is provided with customised tools for game preparation, game control, game debrief and the monitoring/evaluation of student performance.

Scenarios are based on digitised map contours overlaid with the various optional synthetic information. The actual exercise area is generated from a map library. Two files are made: one for the three-dimensional terrain model and the other for a two-dimensional model for presentation. These files can be stored for later use.

Each cubicle console can be configured as a surface ship, a submarine, an aircraft, a land-based coastal defence installation, or a coastal radar station. A unit configuration consists of a set of parameters describing the unit type and its dynamic behaviour. In addition, the user specifies the sensors and weapons which the unit will use.

Wind, sea current, precipitation and sea temperature layers are among the data provided.

All types of voice communication are provided/simulated including intercom and radio with jamming, terrain cut-off, fading, noise, reverberation and echo. Communications are controlled using generic, mockup or real radio panels. Recording and playback are synchronised with exercise data.

The exercises are initiated from the same console used for set up and preparation. The system software is loaded into the different computers in each cubicle via the Local Area Network (LAN) data highway and the complete trainer is started. The user then selects the game set up to be used, downloads it and the exercise commences.

Following an exercise, a playback programme provides synchronised audio and video playback with freeze and fast wind/rewind functions. During replay the screen in the cubicles and control will contain the same information as during the exercise. Recorded information can be used during a game. The playback programme can also use recordings from real exercises.

Operational status
The MASTT system with 10 cubicles and two control suits has been operational at the Royal Norwegian Training Establishment in Bergen since 1986.

A MASTT system with 12 cubicles was delivered to the Swedish Navy in 1991.

A similar system has also been supplied to the United Arab Emirates Navy.

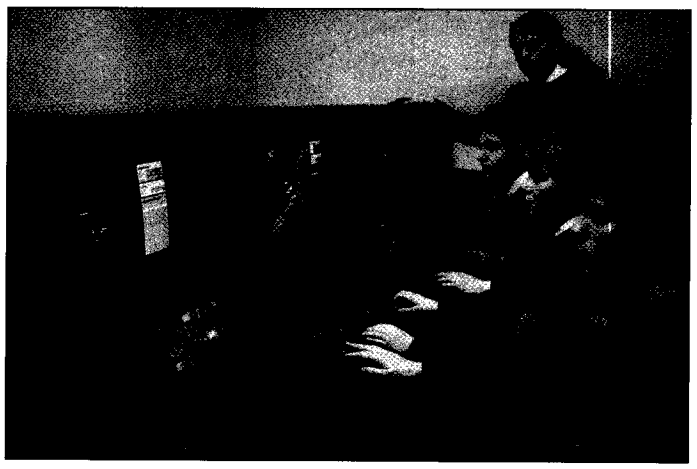
Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

UPDATED

MASWT

Type
Anti-submarine warfare trainer for commanding officers and sonar operators.

Description
The MASWT provides realistic and efficient training of commanding officers and sensor and weapon operators on board ASW destroyers, frigates, corvettes, fast



MASWT students under instruction



A student's console with platforms, weapons and sensors operated via dedicated easy to use panels

patrol boats and helicopters for the use of active sonars and other sensors. The MASWT also provides training in compilation of information, analysis and decision making in a realistic operational environment.

The MASWT concept gives an advanced simulation of the platforms, weapons, active sonars and other sensors. Consoles and weapon control panels are designed to look like the real consoles. The scenario definition is done via menu-driven programs. The concept has an easy to use Man/Machine Interface (MMI) and includes full recording and playback/debriefing facilities and a voice communication system.

The sonar equipment consists of the MPS Multibeam Sonar Simulator (MMSS).

Operational status
In service with the Norwegian and Swedish navies.

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

UPDATED

Submarine Tactical Trainer

Type
Command team trainer.

Description
The tactical trainer is designed to allow the instructor to exercise skills, team and tactical training of the entire submarine attack team comprising sonar operators, command team and commanding officer. The trainer provides for the training of team co-operation between the commanding officer, sonar operators, TMA (Target Motion Analysis) operators, weapon control operators and own ship manoeuvre/navigation operators. It trains the team in the most effective management of the various sensors on board the boat, the handling of contacts, TMA, classification and identification of targets, threat evaluation, engagement analysis, navigation and attack decision.

The facilities include:
- MSI-90U command and weapon control system (identical to the equipment on the 'Ula' class boats)
- Periscope simulator with a realistic 3-D modelling of targets, sea and coast
- Torpedo simulator for the DM2A3 torpedo
- Sonar analysis and surveillance consoles
- Submarine control station
- Intercom simulation for voice and sonar audio.

The advanced instructor station provides tools for the creation of situation plots with maps and terrain models for game preparation, game control, game debrief and monitoring/evaluation of student (crew) performance with different levels of difficulty and complexity and includes modelling tools for targets, torpedoes, sonar and radar. The instructor console and debriefing stations all run in Windows NT. Facilities are provided for data recording/replay of all crew operator monitors, instructor situation plot, voice and sonar audio including torpedo sonar. Intercom simulation is provided for voice and sonar audio using generic, mock-up intercom panels. The recording and replay of all audio is synchronised with exercise data.

The trainer can easily be adapted to different types of submarines.

Operational status
In service with the Norwegian Navy and dedicated to the 'Ula' class submarines.

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

VERIFIED

Spain

STTS (Submarine Tactical Training Simulator)

Type
Submarine trainer for commanding officers and combat teams.

Description
STTS is a shore-based computerised simulation system for training all grades of submarine combat team in tactics and operational procedures.

The primary training functions that the STTS achieves are:
- the training of submarine combat teams in various situations such as surveillance or attack through the gathering and analysis of data on hostile forces, the correct operational use of own fire-control system and weapons and defence against attacking surface vessels, submarines, helicopters and ASW patrol aircraft;
- the development and assessment of new naval tactics and procedures, primarily for torpedo firing and guidance;
- training to respond to specific tactical problems.

The system consists of an auditorium with large screen displays for briefing and post-analysis, instructor's console, CIC with simulated equipment that is an exact replica of those on board, attack/surveillance periscope, torpedo fire-control system, plotting table, active sonar, passive sonar, ranging sonar, ESM, time-bearing recorder and so on.

On board environmental noise is also simulated to create a realistic atmosphere.

The system is of modular design that allows for further incorporation of additional equipments.

Operational status
In service with the Spanish Navy.

Contractor
SAES, Cartagena.

VERIFIED



STTS system 0043235

United Kingdom

SCTT

Type
Submarine command team trainer.

Description
This trainer provides the control element of the 'Swiftsure' and 'Trafalgar' class submarine command team trainer modernisation programme.

The trainer accurately represents the control room that is easily supported and containerised. It will be used to deliver command and weapon system training for the 'Swiftsure' and 'Trafalgar' classes. The control room will link to the periscope simulator (also supplied by AMS) and the generic sound room simulator – which models the new Type 2076 sonar suite. The trainers have undergone a major upgrade programme which provides additional capability in three key areas:
- Improved bathymetry modelling including high fidelity bottom contouring, depth and land modelling
- New visual models to enhance the accuracy and range of ships 'models' which are displayed in the periscope eyepiece
- Enhancements to the weapons simulation

The upgrade also incorporated the latest COTS technology into the trainers.

Operational status
The system is in service with the UK Royal Navy at the Faslane submarine base. Similar systems in service in Australia, Brazil and Norway.

Contractor
AMS, Frimley.

UPDATED

SMCS trainer

Type
Operator trainer.

Description
The operator trainer is designed to train operators of the Royal Navy's combat management system, SMCS. The trainer exploits extensive reuse of the sea-going software of the operational SMCS system to ensure complete fidelity with the system fitted in the submarines.

The trainer simulates all the SMCS, CRT and IPP screens, as well as a level of scenario generation to enable the trainee to understand the functions of SMCS and become familiar with the screen representations. The system does not physically duplicate the layout of SMCS, but does incorporate sufficient fidelity to offer effective training.

The trainer comprises eight training stations, each comprising two displays (CRT and IP) and a puck pointing device. The system is organised in an office type environment and is arranged to resemble a typical layout found on a submarine. The system is completely self-contained, except for the standard mains power supply. The system does not interface with other equipment.

Software from all variants of SMCS is hosted to run on the trainer under the Unix operating system in a totally COTS environment.

Compatibility with the operational SMCS software ensures that upgrades to the sea-going systems can be reflected in the operator trainer quickly and easily, preserving the fidelity of the trainer through the life of the SMCS system.

Operational status
In service at the Royal Naval Submarine School at HMS *Raleigh*.

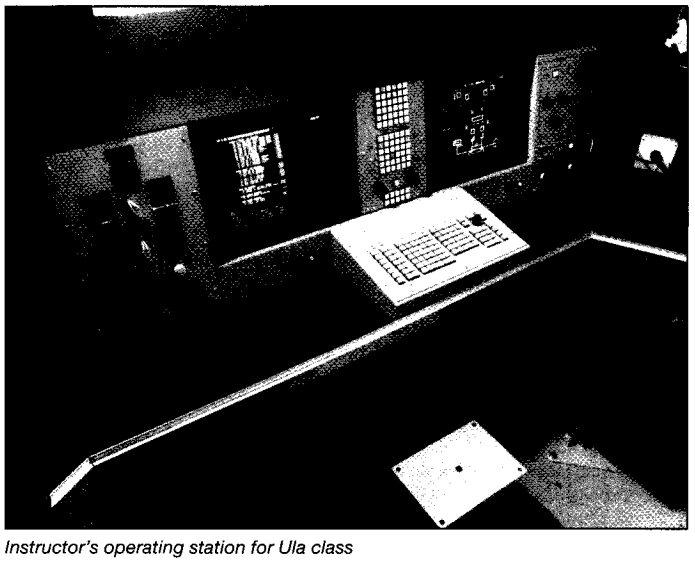
Contractor
AMS, Frimley, Surrey.

UPDATED

Submarine Command Team Trainer (SCTT)

Type
Command team trainer.

Description
This submarine command team trainer is designed to provide effective training in command, target detection and surveillance, weapons control, and the use of combat data systems. The heart of the SCTT is a replica of a submarine control room with microprocessor-driven facsimiles of the command, weapon control and sensors consoles, together with a simulated periscope. Visual simulation for the periscope uses computer-generated imagery. All tactical equipment is replicated including sonar, radar, ESM, communications, tactical data handling and fire control according to the class of submarine for which the trainer is required. In a total training package for the Royal Norwegian Navy's Ula class, Thales Training & Simulation has supplied SCTT, SCS, MCT (Machinery Control Trainer, a comprehensive Technical and Operational Trainer) plus computer-based training to make up 90 per cent of the total requirements.



Instructor's operating station for Ula class

Operational status
In service with the Royal Norwegian Navy at the Haakonsvern naval base near Bergen for use with the Ula class submarines.

Contractor
Thales Training & Simulation, Crawley.

VERIFIED

Submarine command team trainers

Type
Command team trainers.

Description
These trainers comprise one or two submarine control rooms with simulated sonar, radar, ESM, fire-control systems, attack periscope, plotting facilities and ship's instruments such as log and compass. Within the periscope a variety of aircraft and ship models can be displayed in daylight, LLTV or thermal imaging modes.

The trainer for the Royal Navy Vanguard class installed at the Clyde submarine base features two training rooms, an instructor's station, viewing area and debriefing facilities. One room houses a 10-position command team trainer with simulated fire control, weapons and tactical data handling system consoles. Computer-generated images are displayed on a screen at a two-position command desk.

The seven-position acoustic sensor area is housed in a separate room and incorporates a simulated Type 2054 sonar suite including ambient, biological and 'own ship' noise as affected by sea state, weather and bathythermal conditions. An additional CBT sonar trainer is incorporated.

The four-position instructor station provides monitoring, control and record/playback facilities.

Operational status
Command team trainers are in service with the navies of Australia, Brazil, Norway and the UK. Royal Navy trainers include those for Swiftsure and Trafalgar classes of nuclear submarine at Faslane, near Glasgow. These were updated in 2003 with improved bathymetry and sea bottom modelling, new visuals models and weapon system enhancements.

Contractor
AMS, Frimley.

UPDATED

United States

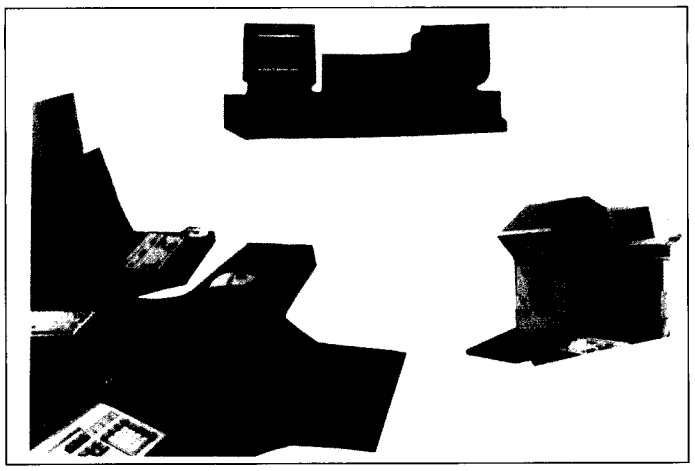
ASTT

Type
Action Speed Tactical Trainer (ASTT).

Description
The ASTT is a strategic and tactical combat command trainer used to enhance the decision making and teamwork skills of junior and senior officers. The system provides simulated war games between two opposing forces. It has a game control suite and a number of student and command control stations representing platforms such as ships, submarines, fixed- and rotary-wing aircraft. Actual and simulated radio voice channels allow for interplatform communications under instructor control. The exercise is played in a 2,048 × 2,048 n miles (3,795 × 3,795 km) gaming area that can include landmasses and minefields.

Sensor data is displayed graphically and in alphanumeric form on student stations whose Man/Machine Interface (MMI) for platform, sensor and weapon control is based on keyboards and a rollerball. In addition to receiving processed electronic and visual data, each platform also has available unprocessed radar and sonar data using the Ship Analytics radar simulator. The simulated weapons systems include air, surface and subsurface launched missiles, depth charges, torpedoes and guns in quantities appropriate to the platform.

Platform movement through the exercise area is controlled by the students and the platform continues to participate in the game until it is destroyed or the exercise is terminated. The instructor station creates and monitors all aspects of the exercises and the instructor monitors the data from individual platform sensors and weapon systems. The ASTT allows the instructor to simulate a variety of malfunctions, including craft performance, weapons, sensors and communications failures. The instructor can also introduce and control simulated platforms that may be assigned to either force or be neutral.



Typical ASTT cubicle and instructor equipment

Operational status
A system has been produced for a major Middle Eastern navy.

Contractor
Ship Analytics, North Stonnington, Connecticut. ***VERIFIED***

Device 14A12

Type
Tactical team trainer.

Description
The ASW team tactical trainer (Device 14A12) provides procedural, team tactical training and evaluation for conventional ASW warships and those equipped with tactical data systems. Simulated sonars, command information centres, bridges and platforms (aircraft and ships) are used to provide trainees with the capability of exercising essential anti-submarine warfare engagement procedures in a simulated multithreat environment.

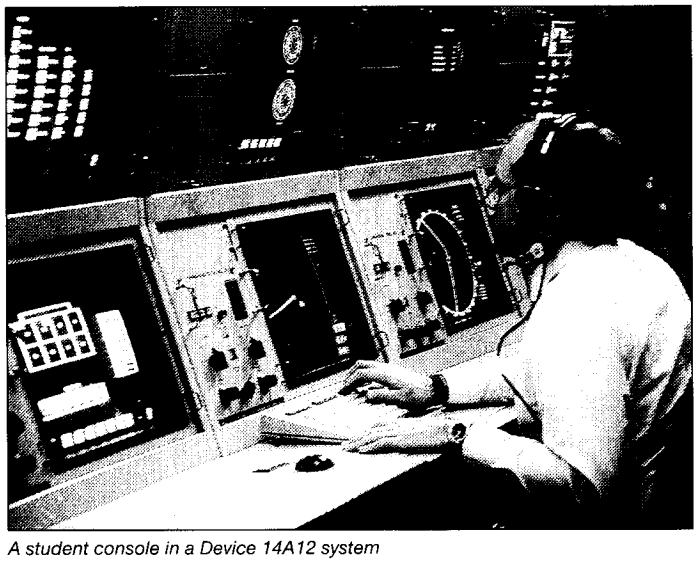
These simulated systems contain general purpose programmable consoles which can be reconfigured under software control to represent the anti-submarine capabilities inherent in any of the US Navy's 16 major classes of anti-submarine warfare ships. The simulated Underwater Battery Plot feature reprogrammable sonar general purpose consoles. The system's design covers six major categories of simulation: platform simulation (friendly and hostile), sensor detection, weapons employment, tactical environment, probability of interception calculations and damage assessment. A modular, database-driven design allows for ease of future modifications and additions as new platforms, weapons and sensors are added to the fleet.

Operational status
Five 14A12 Devices are in service at the US Navy Fleet Training Centres located at Norfolk Virginia, San Diego California, Mayport Florida, Pearl Harbor Hawaii and Charleston South Carolina.

Device 14A12J for the Japanese Maritime Self-Defence Force was delivered to Yokosuka Naval Base, headquarters of the Escort Fleet, in the Spring of 1994.

Manufacturer
L-3 Communications, Link Simulation and Training Division, Arlington, Texas.

VERIFIED



A student console in a Device 14A12 system

Device 21A42

Type
Trident Command and Control Team Trainer (CCTT).

Description
There are three types of Trident training device and four different simulators for various classes of nuclear attack submarines. They are designed to maintain proficiency and to increase crew effectiveness in a variety of tactical situations through highly advanced simulation.

The Trident CCTT (Device 21A42/A) simulates the Trident submarine tactical environment which consists of ocean models, contacts, weapons, sonar, the periscope visual targets and countermeasures. A second device, the defensive weapons subsystem operator trainer (Device 21B67/A), is used to train personnel in countermeasures procedures and tactics. The third device known as the Trident Unique Software Support Facility (TUSSF) supports future hardware and software development for the two operator-team trainers. Currently all trainers have undergone retrofits to reflect submarine modernisation programmes. In 1995 the instructor positions of the above three devices were upgraded to use the TrueGuide™ software on a Silicon Graphics workstation.

Submarine combat system trainers provide fire-control team training. All four devices simulate the tactical environment which includes oceans, targets, 'own ship' dynamics, sonar sensors, weapons and countermeasures. Device 21A37/A uses multiple attack centres to train crews, while Device 21A41, has a single attack centre to train one fire-control team. Personnel can be trained on the Mark 113 and the Mark 117 fire-control systems using realistic simulations for the Mark 48 and ADCAP torpedoes, the Sub-Harpoon anti-ship missile. Target data simulations for up to 57 targets with surface, submarine and air contacts are possible. The system stimulates the AN/WLR-9 and AN/BQQ-5E(V)4 sonar system.

Operational status
Systems have been sonar system supplied to act as the Trident CCTT and the Defensive Weapons Subsystem Operator Trainer (DWSOT) to the US Navy's Trident Training Facility at Bangor, Washington and King's Bay, Georgia (one each per site). The TUSSF is located at the Naval Undersea Warfare Center, Newport, Rhode Island. Attack and ballistic missile submarine combat system trainers have been supplied to the Fleet Ballistic Missile Training Center at Charleston, South Carolina, the Pacific Submarine Training Center at Pearl Harbor, Hawaii, the Fleet Anti-Submarine Warfare Training Centers at Pearl Harbor, Hawaii and Norfolk, Virginia and the Naval Submarine base at New London, Connecticut.

In 1995 Hughes Training Inc completed upgrading the Trident trainers, which involved converting the Mark 118 fire-control system to a CCS Mark II system, conversion from AN/BQQ-6 to AN/BQQ-5E sonar, conversion from the WLR-17 to the WLR-9, ESM upgrades on the 214A2/A and DWSOT upgrades (including adding periscopes and ESM upgrades). The simulators involved are the CCTT, the DWSOT and the TUSSF.

Manufacturer
L-3 Communications, Link Simulation and Training Division, Arlington, Texas.

VERIFIED



The simulated control room in a Hughes Training Inc Trident submarine command team trainer (Device 21A42)

Tactics trainer

Type
ASW tactical trainer.

Description
The tactics trainers are team trainers which can simulate up to 10 combat information centres and a shore based centre. Each trainer comprises a central auditorium and debriefing room with large screen displays and up to seven



The instructor's station in the Link ASTT

instructor consoles together with one or two communications controller consoles, a computer room and a number of individual instruction areas.

The trainers can produce up to 24 surface, submarine and air vehicles and can engage up to 280 targets of which 80 can 'fight back'. A full range of sensors and weapon systems can be simulated with voice, teletype and datalink communications in a game area of 2,000 × 2,000 n miles (3,700 × 3,700 km), 30,480 m in height and 1,000 m in depth. The speed of the action can be accelerated 20 times.

One trainer provides simulation of 10 combat information centres together with a land-based headquarters.

Operational status

Tactics trainers have been supplied to the Italian Navy at Taranto and to both the Portuguese and Turkish navies, while the Royal Danish Navy has a tactics trainer at Frederikshavn. In addition, several trainers have been delivered to Asian nations. The US Navy operates a number of the company's surface, subsurface and airborne tactics trainers.

Manufacturer

L-3 Communications, Link Simulation and Training Division, Texas.

VERIFIED

MINE WARFARE TRAINERS

Australia

Visem

Type
Mine exercise training aid.

Description
Visem has been developed to provide enhanced realism and situational awareness for ships' crews during MCM exercises. The system is based on an underwater flare launcher that provides visual and audio indication to the crews of surface vessels that they have triggered an exercise mine.

Currently, as ships navigate a path through an exercise minefield, the only indication that a mine has been triggered is a signal detected by the ship's own exercise monitors.

Visem releases a streamlined payload from the seabed as a ship triggers a mine. As the payload broaches the surface a flare is released giving off three loud reports alerting the crew to the fact that the ship has detonated an exercise mine.

Operational Status
On order for the Australian Navy to equip the 'Adelaide' and 'Anzac' class frigates. Development is continuing.

Contractor
ADI Limited, North Ryde, New South Wales.

VERIFIED

France

Mine Disposal Vehicles training simulator

Type
Simulator for the PAP or OLISTER mine disposal systems.

Description
The system simulates on shore the conditions under which the PAP mine destruction vehicle operates at sea. The system provides:

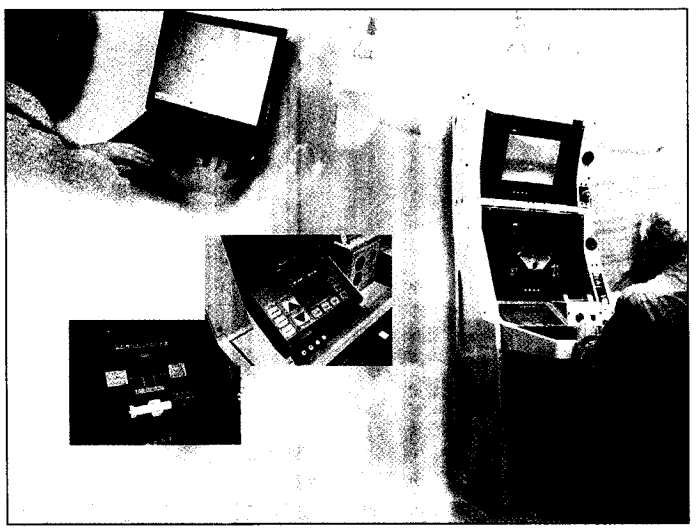
- Initial basic training of personnel
- Operators selection and periodic testing of their qualification
- Training

The simulator allows the optimisation of the PAP at sea at a reasonable cost.

Two versions are available: an onboard version using the console already used for the PAP, and a shore-based trainer for which a console is required.

The simulator includes basic equipment comprising:

- A main control console identical to the one mounted on board a MCMV
- An electronics unit comprising two subassemblies which generate the different scenarios, simulates the movement of the mine disposal vehicle during a mission and prompts the synthetically generated video and sonar pictures on the trainee's control console
- A PC type terminal into which the run parameters are entered and which allows for real time checks of the training exercise.



The mine disposal vehicle simulator (ECA) ***NEW***/1066440

The system simulates different phases of a mission, namely: preparation including payload selection, transit towards the target, target localisation, target classification, target identification, manipulation, placement of the ammunition and upward transit of the vehicle.

The exercise commences when the instructor has entered the run conditions into the system. This includes mine position, depth and type, type of seabed, tidal current and visibility. The instructor can at any time simulate vehicle failures (battery, cable and so on). When the trainee has completed his exercise the instructor carries out a comprehensive debriefing.

Operational status
Available and in service with several navies.

Contractor
ECA, Boulogne-Billancourt, Paris.

UPDATED

Germany

MCOT

Type
Minehunting Command and Operator Trainer (MCOT).

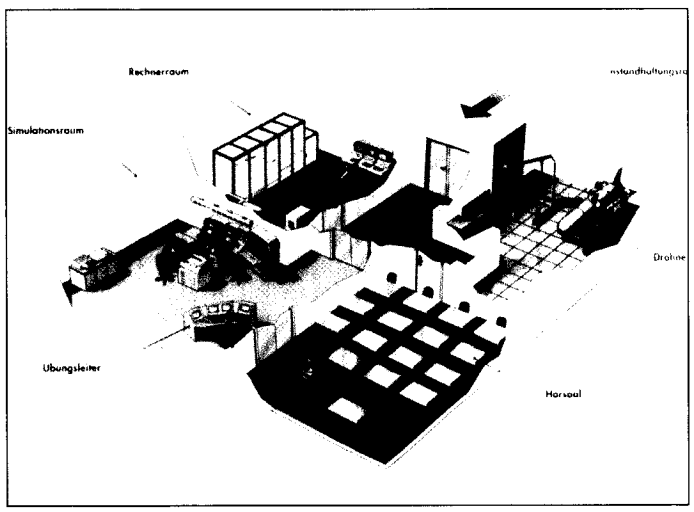
Description
The MCOT carries out operator training, command team training, procedural and tactical training for minehunting and maintainer training.

It comprises a minehunter's combat information centre, a mine disposal vehicle room, computer room and auditorium.

The Combat Information Centre (CIC) is an exact replica with identical equipment found on board the minehunter and consists of: a commanding officer's position; tactical display; command and documentation equipment;



Instructor's desk in simulation room (STN ATLAS Elektronik) 0093515



Block schematic of the MCOT (STN ATLAS Elektronik) 0093513

minehunting sonar equipment (DSQS-11M) operator's console; operator's console for the remotely controlled underwater vehicle; a ship control console; plotter and printer and instructor's console.

The maintenance room contains a real underwater vehicle and associated electronics cabinets.

The computer room houses the computer system consisting of the host computer (which carries out central management of targets and exercise areas), a digital sonar simulator and the sonar image generator for the active identification sonar. This is supplemented by a TV simulator for the underwater vehicle and a database generation station.

The auditorium features the usual equipment associated with a lecture theatre.

The simulator incorporates ship handling from the CIC, detection and classification of underwater objects, the identification, combat and documentation of mines and control of the underwater vehicle.

Operational status
In service with the German navy simulating the Frankenthal class MCMV with DSQS-11M sonar and Pinguin B3 ROV.

Contractor
Rheinmetall Defence Electronics GmbH (RDE), Simulation Division, Bremen.

UPDATED

ROV simulator

Type
Minehunting ROV simulator.

Description
Designed for training operators of minehunting ROVs, the system consists of an instructor station, a replica of the main control console, computerised sonar data calculation, sonar data display, TV image generation, ROV dynamic calculation and offline database generation facilities for three-dimensional modelling. Sonar data display and TV generation functions use Silicon Graphics' Indigo and Crimson workstations respectively.

Operational status
In service with an Asian navy.

Contractor
Rheinmetall Defence Electronics GmbH (RDE), Simulation Division, Bremen.

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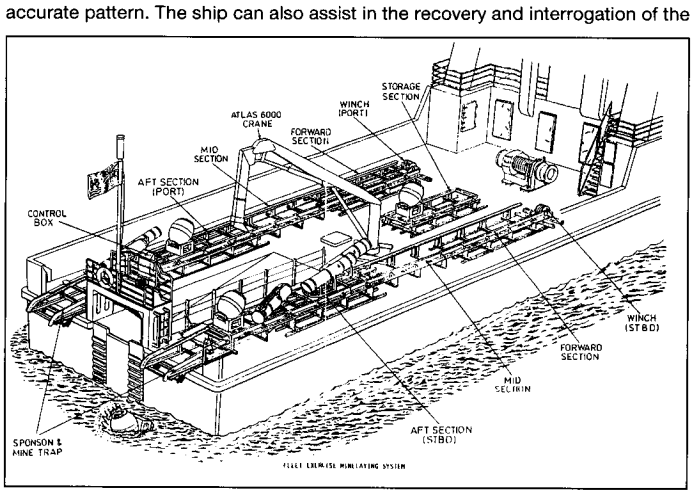
United Kingdom

FEMS

Type
Fleet Exercise Minelaying System (FEMS).

Description
FEMS is designed to be rapidly installed and removed from a host ship converting it to an exercise minelayer within 24 hours and removing the equipment within eight hours. The system is self-contained and requires only simple deck fixing and a standard ship's electrical supply.The mine stowage rails are bolted to deck pads welded to the ship's deck. A variety of exercise mines can be laid in a realistic and accurate pattern. The ship can also assist in the recovery and interrogation of the mines, providing real-time exercise analysis. On completion of exercises, mines are stowed onboard the host ship for return to the mine depot. FEMS can be removed from the ship in approximately eight hours.

The system carries the exercise mines on rails (one to port and one to starboard) with a midships stowage rail for either defective or extra mines. The mines are hauled aft to the minetraps by electrohydraulic winches (one to each rail) operated from a central remote-control unit. The minetrap enables the mines to be released on command (manual or automatic) and a sponson carries the mine clear of the ship. The system can be used in up to sea state 4. Up to 20 exercise or live mines (depending on type) or 16 VEMS can be deployed from the system. The system weighs 5.5 tonnes empty and 35 tonnes with a full complement of mines.



Fleet exercise minelaying system 0009862

Operational status
Operated and maintained by the Royal Navy.

Contractor
MSI-Defence Systems Ltd, Norwich, Norfolk.

UPDATED

Hunt class trainer

Type
Operations room simulator.

Description
This is a modular system for training individual operators and command teams. The system is contained in two semi-mobile trailers, one of which houses the computer and simulation hardware with two generators and the other the Computer Aided Action Information System (CAAIS) computer, instructor and student cubicle.

The student station features two CAAIS displays with an overhead visual control system, remote-control mine destruction system (RCMDS – PAP ROV), a Type 193M minesweeping sonar console, simulated acoustic and magnetic sweep equipment, chart table and echo-sounder.

The sonar display features sea bottom pictures, with digital models of mines and mine-like objects that are inserted by the instructor. The instructors console is a 2-position station with an adjacent helmsman's console separated from the instructor by a curtain. Synthesised Type 1006 navigation radar video signals provide displays with coastlines, sea clutter navigation buoys and other vessels with the instructor selecting range scale, PRF and pulse length.

The trainer also incorporates a combat data system identical to the operational system, communications facilities and ship control. Orders from the student commander are injected into the simulation computer at the helmsman's console.

Data for up to four hours of exercise time can be recorded and played back for debriefing and includes facilities for freeze and fast run. Front panels of the acoustic and magnetic sweep consoles are provided with indicators driven by simulated signals. Control of the ROV includes a synthesised TV view and the ROV light.

The trainer has been updated to incorporate the Nautis 3 command system and Type 2193 minehunting sonar.

The trainer is to be given a further major upgrade to allow it to replicate the new command and control system being fitted to the Hunt class as part of their mid-life update. The simulation system will include fully functional sonars, a full scenario and modelling database, minehunting visuals and fully interactive operator controls. Instructors will control the trainer's operation through a graphical user interface. Much of the upgrade is being accomplished using the latest COTS technology. The trainer is due to be delivered in the Spring of 2004.

Operational status
In service with the Royal Navy at HMS *Collingwood*.

Contractor
AMS, Frimley.

UPDATED

Sandown class trainer

Type
Operations room simulator.

Description
This trainer features an operations room outfitted with the Nautis command system, a Type 2093 sonar and the Remote Control Mine Disposal system (RCMDS – PAP ROV). The trainer also incorporates part of the bridge area of the Sandown with a replicated Nautis position and ship's position control station. This allows bridge and operations room crew to be trained as a team.

Operational status
In service with the Royal Navy and a variant with Nautis and Type 2093 sonar supplied to the Australian Navy. The company is under contract to supply a COTS-based variant with Nautis 3 and a replica operations room to the Turkish Navy.

Contractor
AMS, Frimley.

VERIFIED

United States

MWSIM

Type
Mine warfare training simulator.

Development
In November 1976, the Supervisory Council of Eguermin, the Mine Warfare School at Ostend, Belgium, set up a working group to investigate the training needs with regard to the operational aspects of minehunting. In May 1978, the joint working group comprising members of the Belgian and Dutch navies, formulated an operational request for a minehunting simulator. An official request to include the project in SACLANT's budgetary planning was sent to CINCHAN in June 1986, and the NATO Infrastructure Committee approved the budget in September 1987. The US$12 million contract was awarded to Hughes Training Inc in December 1990, and the purpose-designed mine warfare training simulator was inaugurated on 3 February 1994 at Eguermin.

The simulator will be used for basic and intermediate training, to be followed shortly by advanced training at command team and staff level. It can simulate all current types of MCMV, minehunting combat systems, sonars and sweep gear, the use of precise navigation equipment, powerful data processing, high-resolution sonars and ROVs used by NATO navies.

Description
To allow for objective-oriented training, three coherently interacting models are available; a natural environment model, a ship model and mine model. The interaction of these three models offers the possibility of simultaneously simulating four different mine warfare worlds: one for each of the three minehunting cubicles and one for the six minesweeping cubicles. The natural environment model comprises a sea area including a coastline, varying water depth, currents and sea bottom (the latter represented with a composition of the bottom relief, rocks, and manmade objects). The current seabed model can create 300 subzones in a 20 × 20 m operational area generated from the database. The ship model creates the type of ships with all their characteristics, while the mine model creates interactions between the mine and the ship.

The simulator comprises an instructor's cubicle, nine training cubicles (three for minehunting, six for minesweeping) and a debriefing room. The nine cubicles comprise equipment identical to that found on board most types of MCMV and fitted with generic Commercial-Off-The-Shelf (COTS) workstations showing indicators and displays according to their appearance in the type of equipment simulated.

Input devices such as control buttons have been replaced by programmable touchscreen panels.

The core of the system is the Ethernet TCP-ICP network with 47 Silicon Graphics computers using COTS hardware linked with the custom-designed software via Ethernet.

The main control computer (a modular 32 Mbyte IRIS SS-V35M16 with graphic cards, a 780 Mbyte and two 1.2 Gbyte hard disks, a 150 Mbyte tape drive and CD-ROM) provides global management of the system and shares the general data.

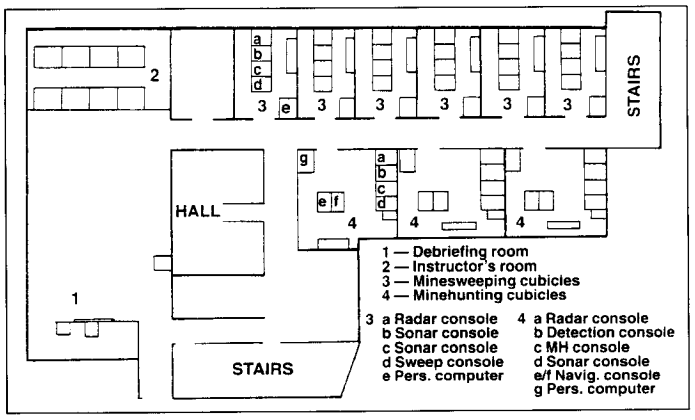
Exercises are controlled, commanded and created from eight instructor consoles, from which either standard or specially designed exercises, aimed at rehearsing standard procedures and drills for an MCM warfare team, can be composed. The instructor controls the initial moves of the exercise such as the positioning of ships, availability of assets, presence of targets and the simulation of system failures. He is also able to record the presentation on any cubicle screen during the exercise. Ambient sounds can be recorded at the same time. With each recording of a particular screen, data from the ship's computer is also recorded.

Each of the three minehunting cubicles features six computers: a server for general computation duties; one to simulate data presentation and processing and to control the automatic pilot console; one for radar simulation; a computer to simulate sonar detection; one to simulate sonar classification; and a computer to simulate ROVs (including camera images and near field sonars).

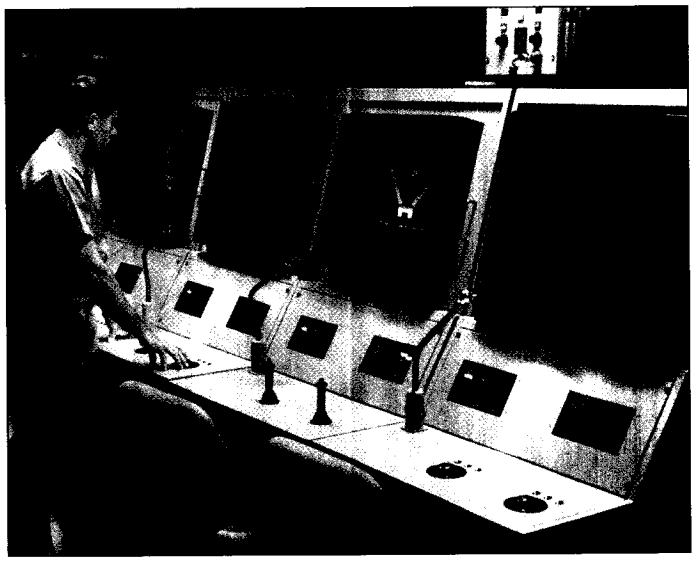
The six minesweeping cubicles each feature three computers: one to handle data processing and general computation tasks; one to simulate data presentation and processing; and one for radar simulation.

Additional items comprise: communication equipment (to simulate both internal and external communications); closed-circuit telephone; printers and plotters (one of which is a colour plotter for the hard copying of the sea bottom); three PCs for simulation of real-time performance monitors; a BARCO video projector for debriefing; trackballs; and joysticks for the consoles.

The main driver is the IRIX System V release 4 (a version of the Silicon Graphics UNIX system). The simulator uses COTS software programmes such as the MultiGen Visual Database and Visionworks. The simulation software is mainly written in Ada, with the exception of some applications using COTS software. The simulated MCMVs can be designed using menu-driven programmes, selecting the onboard systems (typically detection and classification sonar, ROV, automatic data processing, autopilot and manoeuvring) and by inputting the corresponding ship



General layout of the MWSIM


Minehunter simulation consoles at Eguermin, Ostend

characteristics (radiated noise, propulsion system radar reflectivity, hull parameters for shock resistance model and so on). Data such as wind, current, rain, sound velocity, underwater visibility and so on, can be modified by the instructor. In principle the simulation runs as a fully interactive programme, reacting to operations made by the trainees. Specific equipment or events are simulated by inputting the corresponding parameters.

For minesweeping, the sonar and ROV consoles are replaced by a minesweeping console offering simulation of a variety of magnetic, acoustic and mechanical sweep gears.

The simulator is equipped with an audio-visual recording facility which allows exercises to be recorded for replay in the auditorium when it is finished. All exercises are recorded and at the end of each one the instructor can generate post-game reports on navigation, detection identification, threat evaluation, sweep evaluation and classification.

Currently MWSIM is capable of simulating the following MCMVs: 'Tripartite' type (Belgium, France, Indonesia, Netherlands, Pakistan); Sandown class (UK and Saudi Arabia); Hunt class (UK); Avenger class (USA); Lerici class (Italy, Malaysia and now Australia); Frankenthal, Hameln and Lindau classes (Germany); Oksoy/Alta class (Norway); ex-US Agressive class (Belgium); and the Ton class (UK).

Sonars represented include: DUBM 21B, TSM 2022, 193M, 2093, AN/SQQ-14, AN/SQQ-14IT, AN/SQQ-32, DSQS-11H, DSQS-11M, AIS 11. ROVs covered include: PAP104, PAP104 Mk 5, Pinguin B3, Pluto Plus, MIN and AN/SLQ-48.

An upgrade to MWSIM is already being planned and will include a mine avoidance/moored mine detection sonar for the minesweeper cubicles. By the end of the decade it will also be possible to use the MWSIM as a minefield performance analysis tool, allowing the planning and preplay MC contingency operation in any area in the world.

Operational status
Inaugurated on 3 February 1994 at Eguermin, Ostend, Belgium at the Belgium /Netherlands mine warfare school and used by NATO navies.

Contractor
Raytheon Systems Co (Training Division), Arlington, Texas.

VERIFIED

SUBMARINE EQUIPMENT TRAINERS

Germany

SCS

Type
Trainer for submarine diving and control room operations.

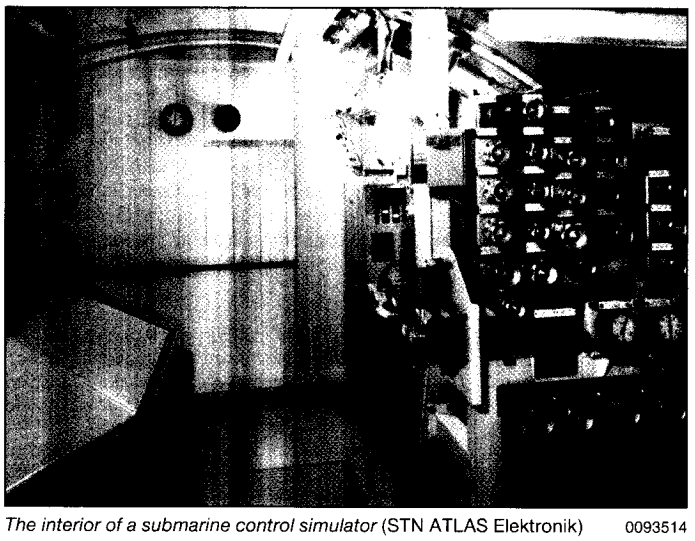
Description
The Submarine Control Simulator (SCS) trainer consists of a replica of the control room of a submarine, an instructor station inside the cabin on the motion platform, and a two-axis motion (typically ±30° roll and ±45° pitch) platform. The control room consists of all the submarine control and monitoring equipment necessary to train personnel in diving procedures, control equipment handling and emergency procedures. A mathematical model performs the simulation of the submarine dynamics in two Degrees of Freedom (DoF) in real time, within the entire mission envelope including sea states, salinity and water temperature. All the effects of the crew's activities at the control consoles and the submarine's environment are realistically simulated and verified with original sea trial data.

The modular concept allows for a customer-tailored design of the submarine control room equipment and training requirements and the fast integration of new or additional units. The instructor's station, which is integrated into the cabin, provides the tools necessary for the briefing, exercise control and debriefing activities. Additional components of ship operation equipment such as air and water systems and propulsion control units can be integrated. The instructor can set parameters for environmental conditions and operating modes and can programme faults and system failures. All training processes are recorded electronically in detail for a thorough post-exercise discussion and debriefing. The system can be installed in a building with minimised infrastructural requirements. Specific submarine equipments can be integrated using real units of equipment, mock-ups or graphic animations on computer screens.

Operational status
Fully developed and in operation in various navies including those of Germany, Greece, Italy, South Korea and Turkey. The German Navy took delivery of SCS in 2003 and the system is also currently under delivery to the Italian Navy.

Contractor
ATLAS Elektronik GmbH, Bremen.

UPDATED



The interior of a submarine control simulator (STN ATLAS Elektronik) 0093514

United Kingdom

ACTS

Type
Astute class submarines Training Service.

Description
The ACTS will be developed under a private finance initiative to provide comprehensive training services to the Royal Navy for the 40-year life expectancy of the new Astute class submarines. A purpose built complex will be assembled at Faslane in Scotland to house the various elements of what, in effect, will be an integrated training complex specific to the Astute class.

The trainer will comprise a command team trainer, weapon handling and launch trainer, optronics trainer and other training devices (to be built by AMS of the UK), platform simulators including the manoeuvring room trainer, submarine control trainer, platform management system trainer and other training aids (to be built by CAE of Canada) and courseware to be developed by Flagship Training Ltd (UK), who will also be responsible for the building of the training centre and providing the instructors.

The facility being built at Faslane, Scotland to house the trainer will also include classroom and office space.

AMS and CAE of Canada have formed a 50:50 grouping known as the FAST Consortium with a preferred shareholding by Flagship Training Ltd of the UK to manage the project. These have now been selected as the Preferred Bidder by the Defence Procurement Agency of the UK MoD.

Contractors
AMS, Frimley, Surrey, UK
CAE Electronics, Montreal, Canada
Flagship Training Ltd, UK.

VERIFIED

Machinery simulators

Type
Nuclear submarine propulsion simulators.

Description
Various simulators have been developed to provide engineering watch-keepers with training in start up, shut down and emergency procedures covering nuclear power plants and diesel generators in nuclear submarines of the Royal Navy. The simulators include sound effects that provide background noise for diesel generator run-up, rod drive transmitters, circuit breaker actions and instructor-induced steam leaks.

The instructor's console allows the input of initial conditions for the reactor including core age, power level of pervious operations, time since shutdown and desired pressuriser and heat exchange levels. The console overlooks the simulator control room through a one-way glass and incorporates facilities for record and post exercise playback.

Operational status
Seven units in service with the Royal Navy covering 'Swiftsure', 'Trafalgar' and 'Vanguard' class submarines.

Contractor
AMS, Frimley.

VERIFIED

MCT

Type
Machinery control trainer.

Description
The trainer replicates the operating consoles in the boat's machinery control room. Instrumentation and controls are supported and stimulated by realistic simulation models of the propulsion, power generation and auxiliary machinery and systems allowing real time normal and emergency operation of machinery control and monitoring systems. Multiple concurrent faults can be applied to simulate battle damage. The student station is overlooked by the instructor's station through a one-way glass. The instructor station provides facilities for measuring and monitoring trainee performance, lesson planning and control, control of systems and malfunctions, communications and recording and debriefing. The trainer can be integrated with a submarine control simulator.

Operational status
The system is in service in Australia (Collins class), Canada (Victoria class), Norway, the UK Royal Navy and a number of other European and Asian Navies.

Contractor
Thales Training & Simulation, Crawley, Sussex.

VERIFIED

Periscope simulator

Type
Periscope training system.

Description
Training operators in the use of periscopes at sea ties up operational resources and is limited in scope as it can place the submarine in potentially hazardous situations. The periscope trainer enables either initial or continuation training in both recognition and operational procedures related to any type or design of periscope to be simulated in a safe shore environment.

The simulator provides realistic training in search routines and attack procedures, with inshore or open water navigation in a multiship scenario, under normal or emergency conditions. To the operator the periscope feels and operates just as it would in a submarine, even rotational inertia being simulated for added realism.

Simulation features range from a generic periscope station with visuals presented on a colour monitor to a specific periscope incorporating full optics.

The fidelity of ship-modelling provides sufficient detail of superstructure and major features to enable vessel identification and accurate assessment of range, bearing and angle on the bow. The trainer uses advanced visual systems based on commercially available graphics engines of high performance to provide the best means of day, dusk, night scene representation in a variety of weather and sea state conditions. All aspects of the periscope picture are produced, such as graticule and data displays, providing total control from a single system.

As well as being offered as a stand-alone trainer, the periscope trainer can be integrated with existing command team trainers. In team training, information on 'own boat', targets and the environment is passed from the command team trainer to the periscope simulator to co-ordinate the periscope visuals with the data received from other sensors.

Among the features provided for the simulator for the Royal Navy are: underwater views of surface ships; simulation of drain-down effects occurring after periscope surfacing; infra-red and LLTV simulation. These effects enhance the realism offered by the visual system which includes a full three-dimensional textured wave motion to simulate various sea states and washover.

Operational status
Periscope simulators have been supplied to the Royal Navy's submarine command team trainers at HMS *Drake* (where it integrates with the AS1118 submarine command team trainer) and HMS *Neptune* and a generic simulator to the attack teacher at the submarine school at HMS *Dolphin.*

Further systems have also been supplied to the Royal Netherlands Navy and visual software to the Canadian Defence Forces.

Contractor
AMS, Frimley.

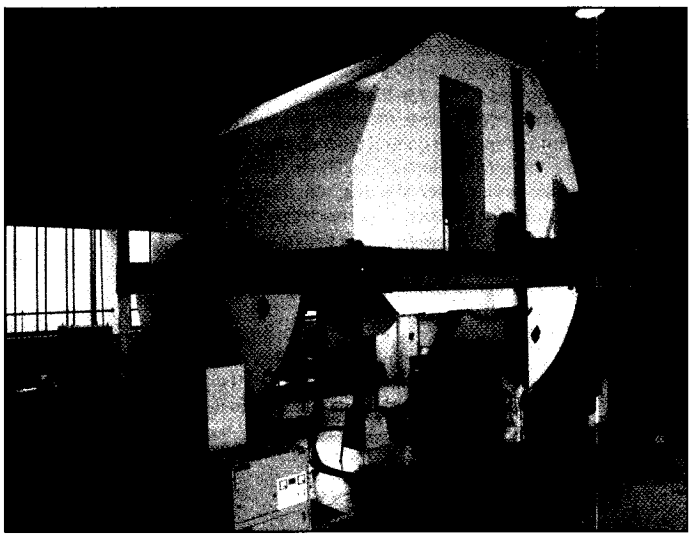
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Periscope simulated image



TT&S Helmsman's station in the Ula class team trainer ***2002***



Submarine Control Simulator for Royal Navy's Upholder class showing two-axis electrical motion system

Submarine Control Simulator (SCS)

Type
Control room simulator.

Description
The Thales Training & Simulation Submarine Control Simulator (SCS) incorporates a full-size replica of the forward and port side sections of a control room which is mounted, with the instructor's facilities and computer, on an electrically driven, two-axis (±45° pitch and roll) motion platform to give motion feedback to the planesman and ship control officer, and includes an onboard training management system. The SCS is designed to produce as authentic an environment as possible including sea motion, a simulated intercom system and authentic submarine lighting. A distributed architecture with microprocessors is used in the system.

The instructor's console and management station is separated from the students' compartments, but students can be observed by the instructor through a one-way mirror. Each instructor's position includes consoles for the instructor and the unit operator. The consoles can display detailed schematics which permit the instructor to adapt a wide variety of lesson plans. These facilities permit student-paced training as well as precise monitoring of performance.

They realistically replicate the steering and hydroplane console, the systems console and the valves, manifolds and pump controls of the waterman's station (if fitted) to provide a realistic training environment for the ship control officer of the watch and ship control team. Simulation software includes full hydrodynamic and hydrostatic models as well as systems and machinery simulation.

Operational status
In service with the Royal Navy (Vanguard class installed at HMS *Neptune*, the submarine base at Faslane, Scotland), Royal Netherlands Navy (Walrus class), Royal Norwegian Navy (Ula class), Royal Australian Navy (Collins class), Canadian Forces Maritime Command (Victoria class), Indian Navy (Shishumar class) and Brazilian Navy (Tupi class).

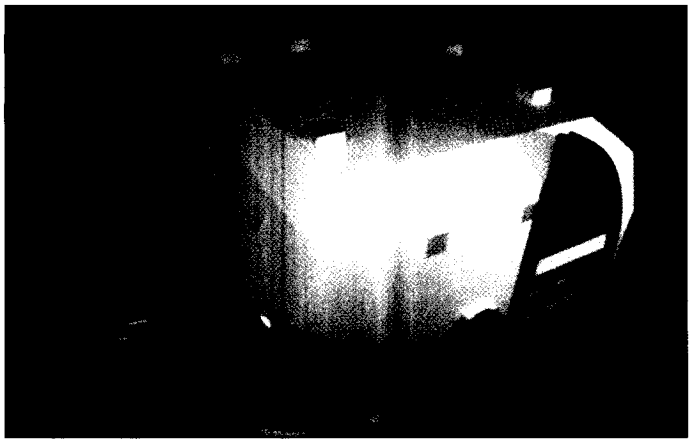
Contractor
Thales Training & Simulation, Crawley, Sussex.

VERIFIED

Submarine Control Trainer (SCT)

Type
Nuclear submarine handling trainer.

Description
The simulators fully replicate the centralised control area (the manoeuvring room) from where the nuclear propulsion system is controlled. The system provides continuation training for watch-keepers, in both normal operations and emergency procedures. Conditions such as plant failures and faults in the nuclear and auxiliary power systems can be simulated.



TT&S Vanguard class submarine control simulator showing the 2-DoF motion system which has a movement of ±40° in pitch and roll 0092401

Accurate real-time simulation of the instrumentation and controls related to the submarine's propulsion system is critical. This is achieved using a distributed processing system backed up with ultra fast reflective memory, a concept used throughout the flight simulator industry.

The instructor's console uses touch screen technology which allows the instructor to change the training scenario instantaneously, simply by selecting a function on the touch screen.

The SCT features two compartments, each configured to represent a different submarine, but both sharing the same motion platform giving ±40° pitch and roll motion. Only one student at a time undergoes training on the simulator.

Operational status
Two systems in service with the UK Royal Navy with one cabin replicating a 'Vanguard' class submarine and the other a 'Swiftsure/Trafalgar' submarine. The simulators are based at the Clyde Submarine base HMS *Neptune* ('Vanguard' simulator) and at Devonport HMS *Drake* ('Swiftsure'/'Trafalgar' simulator).

Contractor
Thales Training & Simulation, Crawley, Sussex.

UPDATED

TTF

Type
Trident training facility.

Description
Housed in a building at the UK submarine base at Faslane, the TTF (Trident Training Facility) includes equipment for tactical weapon certification, shore work-up, weapons fire-control officer training and other tasks. The primary element of the facility is a full size inert Trident D5 missile in its tube and associated control system. This allows crews to carry out drills on the full firing sequence.

Operational status
In service since early 1990.

VERIFIED

Vanguard Simulator

Type
Vanguard class machinery control room system trainer.

Description
The Vanguard machinery control room system trainer replicates the propulsion control room in the Royal Navy Vanguard class SSBNs. The simulator uses Thales touch-activated simulator control for set up, control, faults and record/replay.

Operational status
Two systems are operational at the UK Royal Navy's Vanguard submarine training complex at HMS *Neptune* at Faslane.

Contractor
Thales Training & Simulation, Crawley, Sussex.

VERIFIED

United States

Simulation and training system

Type
Navigation subsystem operational and maintenance training.

Description
This laboratory complex supports the Strategic Weapons System (SWS) of the Trident II submarine tactical navigation centre. It consists of an inertial laboratory, navigation aids laboratory, computer/electrostatic gyro navigator laboratory, computer-based training laboratory and navigation operational trainer laboratory.

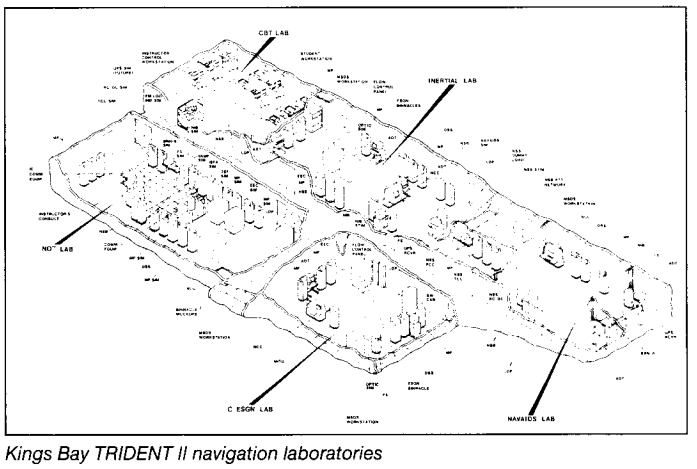
The Inertial Laboratory is a functional replica of the navigation centre in which tactical Electrostatically Supported Gyro Navigators (ESGNs), computers and support equipment and training-unique equipment simulators and stimulators are driven by tactical and training-unique simulation software. In this static laboratory, use of tactical technical documentation is emphasised during familiarisation and basic subsystem operational training conducted in real time. Specific subsystem and ancillary equipment maintenance training is also provided.

The Navaids Laboratory is a tear-down maintenance laboratory and contains tactical equipment and stimulators. Maintenance training on the Navigation Sonar System (NSS) and Global Position System (GPS) equipment emphasises tactical documentation and software diagnostic procedures. The Computer/ESGN (C/ESGN) Laboratory is also a maintenance laboratory containing tactical Memory Processor (MP) computers, an ESGN system and ancillary support equipment. Maintenance training on this equipment uses tactical documentation and software diagnostic procedures.

The Computer-Based Trainer (CBT) Laboratory augments and supports certain training requirements that could not be conducted in the Inertial, Navaids, or C/ESGN laboratories because of their static nature, the physical constraints imposed by the hardware configuration and design, or operational and training time limitations. The CBT Laboratory is a training-unique Personal Computer (PC)-based complex of 10 student workstations and an instructor workstation, each composed of commercial hardware, with trainer-unique software and courseware. The system integrates two-dimensional dual-screen simulation, Interactive Video Disk (IVD) images and a tactical Auxiliary Display Terminal (ADT) keyboard for man/machine interface. Forty one hours of courseware training modules exist for the CBT Laboratory. One student or an entire class can exercise any module. Courseware modules provide theory, operational and maintenance instruction on various topics, such as basic inertial principles and ESGN calibration procedures. Although the latter requires 9 to 10 days in a tactical environment to perform, it can be accomplished in the CBT Laboratory in only 5 hours. IVD simulation of tactical equipment parallels the tactical operational and maintenance documentation procedures utilised in each module.

The Navigational Operational Trainer (NOT) Laboratory was developed to support dynamic subsystem operational team training requirements. The NOT Laboratory is an array of training-unique simulators emulating and physically arranged to duplicate the Trident II submarine's navigation centre. Driven by simulation software, the trainer can functionally replicate all navigation subsystem normal operation as well as many system casualty operations. Submarine navigation crew members operate and man this trainer during each training period in the same team manner as they do on the ship. The laboratory interactively responds to the team's performance of tasks just as the real ship would, whether at sea or in port. Unlike the Inertial Laboratory, which supports only limited, real-time static operation training, the NOT Laboratory can provide a dynamic training capability at any location in which the submarine may operate. Using the available time compression capability, up to 24 hours of real-time performance can be achieved in 1 hour of laboratory time, thus shortening lengthy, real-time procedures. Training scenarios can also be saved for replay and evaluation at a later date. Instructors can interject malfunctions for the simulated tactical equipment support subsystem casualty operation. Adherence to documented operational and casualty procedures is emphasised.

Operational status
Five laboratories, consisting of tactical and training-unique hardware and software necessary to support the Trident II navigation community training requirements



Kings Bay TRIDENT II navigation laboratories

were installed at the Naval Submarine Center in Kings Bay, Georgia in 1991. Formal curricula were developed and, from 1987 to 1991, instruction was provided to the initial group of naval personnel assigned to the newly commissioned Trident II submarines and to the Trident Training Facility (TRITRAFAC) in Kings Bay, Georgia, using these laboratories.

These laboratories have been updated to support the Trident Navigation Commonality Program (TNCP) in the early part of 1995 and continue to maintain SWS navigation training.

Four laboratories, consisting of tactical and training-unique hardware and software necessary to support the TNCP training requirements were installed at the Naval Submarine Center in Bangor, Washington in the 1994-97 time frame. These laboratories were required when three Trident I submarines were converted to TNCP submarines. The Bangor Facility consolidated the tactical NSS and GPS equipment into the inertial laboratory to elminate the need for a separate Navaids laboratory. This reduction in laboratories was achievable based on the fewer number of TNCP SSBNs on the West Coast.

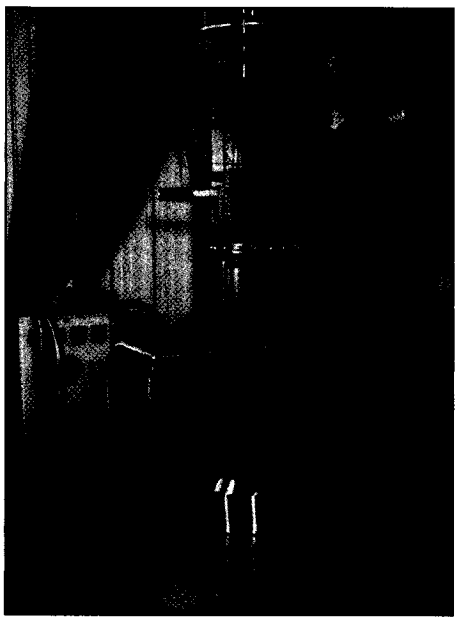
Contractor
No longer supported by private contractor. Maintained by US Navy.

VERIFIED

STVTS periscope training system

Type
Training device for periscope operation.

Description
Kollmorgen has been designing periscopes and periscope training systems for some years. The most recent example is a Submarine Tactical Visual Training System (STVTS) for the US Naval Training Systems Center at Orlando, Florida. Using a Type 18 periscope, STVTS provides a training device for individual operator, submarine attack centre subteam or submarine combat system team training in an at-sea environment.



Submarine Tactical Visual Training System

Operational status
STVTS is in production and service for the US Navy.

Contractor
Kollmorgen Corporation, Electro-Optical Division, Northampton, Massachusetts.

VERIFIED

AIRCRAFT ASW EQUIPMENT TRAINERS

Italy

ACTs 101A

Type
Hardware in the loop simulator.

Description
ACTs 101A is a software simulation package, which simulates the behaviour of the MU 90/Impact torpedo when launched from a helicopter.

The following main phases are simulated:

- Preset phase (fully representative)
- Flying phase (fully representative)
- Underwater phase (full dynamic behavioural representation of the weapon; the real behaviour of the MU90/Impact is very complex and so a simplified module, sufficient for training purposes, is delivered)

The ACTs 101A represents an evolution of the already existing software packages (real software, simulation software and so on) developed by WASS during the design phase of the MU 90/Impact weapon. These embrace features such as the torpedo control module on-board software (real software). During these phases, under instructor supervision, many predefined failure phases can be activated.

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

United Kingdom

Merlin Acoustic Trainer

Type
Stand-alone shipboard acoustic trainer.

Description
The Merlin Acoustic Trainer has been developed by AMS to provide Merlin helicopter sonar AQS-903 operators with continuation training to prevent deterioration of operational skills.

The system closely matches the real aircraft sonics system and has the potential to make a complete, deployable rear seat trainer. The trainer is designed to meet training objectives associated with analysis, classification and localisation undertaken via scenario-driven tactical exercises. The training is able to take place in individual, collective or adversarial exercises for six (or more) students. The exercises are designed to enhance individual operational and analysis skills combined with tactical decision making and to improve communication and teamwork.

The trainer's instructor station is used in a dynamic role to create and control scenarios and assess trainees. The instructor is supported by comprehensive lesson preparation, briefing and debriefing facilities. Student training takes place in individual, collective or adversarial exercises for up to six (or more) students.

The trainer is based on COTS networked PCs running Microsoft Windows operating systems.

Operational status
The system was delivered to the Royal Navy Operational Training Schools at RNAS Culdrose, UK in February 2002, and has subsequently undergone sea trials on HMS *Ark Royal*.

Contractor
AMS, Integrated Systems Division, Donibristle, Fife.

UPDATED

MPAST

Type
Computer-based sonar training systems

Description
Twelve PC-based MPAST (Maritime Patrol Acoustic System Trainer) systems are installed at RAFC Cranwell for training Nimrod crews in the use of the AQS-901 sonar. MPAST incorporates high fidelity exercise generation tools. It includes comprehensive dynamic simulation of sonar acoustic processing equipment in a networked classroom environment.

Operational status
Supplied to the UK Royal Navy (for ASW Sea King crews) and RAF (for Nimrod crews). Sonar trainers have also been supplied to the US Navy and the Royal Netherlands Navy.

Contractor
AMS, Donibristle.

NEW ENTRY

Sea King ASW sonar trainers

Type
Sonar training system.

Description
These PC-based trainers have emulations of the Mk 6 Sea King AQS902 sonics processing system and are designed to train operators in the use of the AQS-902 sonar. This includes passive and active signal generation with the modelling of sonobuoys, oceanographics and acoustic sources.

Operational status
Nineteen systems in service at Culdrose, Gibraltar, and on board HM ships.

Contractor
AMS, Donibiristle.

NEW ENTRY

United States

Airborne ASW trainers

Hughes Training Inc (now L-3 Communications, Link Simulation and Training Division) has provided most of the airborne anti-submarine warfare training systems used by the US Navy and also for use by the Canadian Forces. The systems include acoustic and non-acoustic sensor operator trainers for individual training together with team trainers. These programmes include the following.

P-3C Tactical Operational Readiness Trainers (TORT). These systems, designated Device 2F140(T) by the US Navy, are designed to provide integrated team training for the tactical crews of the Lockheed P-3C Orion. Link has provided four of these systems to the US Navy. The simulator provides training in a high-density acoustic/RF environment and has true operational simulation capabilities.

The trainer is a facsimile of the anti-submarine warfare compartment which uses actual hardware. There is also an instructor's station divided into non-acoustic, acoustic, tactical/navigation and pseudo-pilot areas. The simulated operational area is 1,326 km² and up to 22,860 m deep. Up to 35 targets, including eight acoustic, are available at any time, while up to 31 possible radar contacts are available together with up to 12 radar jammers.

S-3 position trainer
Designated Device 14B49A, this is a three-station, nine-position trainer currently being upgraded from Lockheed S-3A Viking to S-3B (Device 14B49B) status. The stations simulated are those of the co-pilot, the tactical co-ordinator and the sensor operator each of which is triplicated for multiple training. The system is designed to provide each crew member with individual skill levels. The enhancements include increased acoustic and Electronic Support Measures (ESM) capabilities, and the addition of a Harpoon anti-ship missile system capability.

P-3C ASW tactics trainer
This system, designated Device 2F87(T) by the US Navy, is designed to provide crew members of the Lockheed P-3C Orion with complete tactical training in the Anti-Submarine Warfare (ASW) mission. The system features high-fidelity simulation of the search radar, acoustics, ESM, magnetic anomaly detection, navigation and communications systems.

CP-140 operational mission simulator
This system is similar to the tactical trainers used to train US Navy P-3 and S-3 aircrew but has been adapted to incorporate specific Canadian systems as used in the CP-140.

P-3 acoustic target generator
Hughes Training Inc (now L-3 Communications, Link Simulation and Training Division) provided an acoustic target generator to the Mitsubishi Precision



A sensor station in a Device 2F140(T) TORT

Company Limited which was integrated into the third P-3 Operational Flight Tactical Trainer built by Mitsubishi for the Japanese Maritime Self-Defence Agency. The generator provides training in a high-density acoustic/RF environment for the P-3 tactical crew members. It simulates the real-world acoustic signals from sonobuoys used to detect, identify and track submarines. The Japanese trainer is based upon the P-3C Update III TORT.

Operational status

Device 2F140(T) is operational at NAS (Naval Air Station) Barbers Point, Hawaii; Brunswick, Maine; Jacksonville, Florida; and Moffet Field, California and another system is operational in Japan.

Device 14B49 is operational at NAS North Island, California and Cecil Field, Florida, with two Device 14B49B systems also deployed in Florida.

Contractor

L-3 Communications, Link Simulation and Training Division, Arlington, Texas.

VERIFIED

Air training systems

Type

Combat trainer, crew trainer and so on.

Description

Training systems have been developed by Lockheed Martin for the LAMPS Mk III SH-60B Seahawk helicopter for the US Navy. The LAMPS training suite includes: avionics maintenance trainer, mobile team training unit, operational flight trainer, weapons systems trainer and weapons tactics trainer.

The company is developing full-mission simulators for training the Royal Navy Merlin helicopter operators. The training elements include: cockpit dynamics simulator, cockpit procedures trainer, computer-based trainer, common control unit/tactical situation display trainer, engine change unit trainer, mechanical systems trainer, rear crew trainer and weapon system trainer.

For the Spanish Navy Lockheed Martin, in co-operation with Indra, has provided hardware and technical information to assist in the development of a tactical simulator for the Spanish LAMPS helicopter system. The simulator suite will train pilots and aircraft tactical officers to operate the LAMPS helicopters.

Lockheed Martin has provided the acoustic signal generator, electronic flight control system, system databus adaptor, converter multiplexer amplifier and motion system and seat shakers. The suite includes a version of the LAMPS trainer software which comprises the operational flight trainer and the weapon tactics trainer.

Operational status

Systems in operation for the Spanish Navy for LAMPS helicopters. All LAMPS systems for the US Navy are in operation.

A Merlin trainer is installed at the RNAS Culdrose, Cornwall, UK and incorporates: aircrew trainer with cockpit dynamic simulator, cockpit procedures trainer, and rear-crew trainer; a weapon system trainer with weapon loading, landing gear and flotation system maintenance training; a mechanical system trainer for first-line corrective and preventive maintenance, fault diagnosis and aircrew familiarisation; a common control unit/tactical situation display/part task trainer providing individual systems training for all the Merlin subsystems; and CBT consisting of disk-based sequenced CBT lessons.

Contractor

Lockheed Martin Naval Electronics & Surveillance Systems, Undersea Systems, Manassas, Virginia.

VERIFIED

SONAR EQUIPMENT TRAINERS

Canada

AN/FQR-503

Type
Towed array mission simulator.

Description
The primary objective of the AN/FQR-503 is to provide an advanced training platform for the training of CANTASS operators. It provides the operator with a comprehensive advanced training tool using high-fidelity simulation techniques.

The simulator consists of two instructor workstations, four student stations and a towed array stimulator. The instructor station stimulates the student stations by generating and transmitting up to four independent streams of raw acoustic data which reflects a realistic tactical problem. Students then analyse the simulated acoustic data.

The instructor's workstation allows the instructor to create, execute and control a simulated mission and simultaneously monitor the students' performance. Using the station the instructor can debrief the students on their performance by rapidly replaying the mission simulation on a debrief monitor at the student station.

The instructor's workstation displays tactical and environmental data as well as displaying the student's decisions on the debrief monitor. Any of the students' acoustic screen monitors can be viewed from a local monitor at the instructor's workstation. The instructor can also communicate verbally with the student while a mission simulation is in progress.

Each student station is similar in function and performance to a passive tactical towed array sonar system console. It comprises a COTS-based signal processor and data management/display units and a debrief recorder. The sonar signal processor and data management/display unit is functionally equivalent to an actual shipboard system. The system simulates a complex ocean environment. The model includes multi-path effects caused by space and time-varying sound velocity profiles.

The towed array stimulator incorporates a sensor performance simulator, an acoustic signal generator and an acoustic propagation model. The towed array modelling simulates:

- target aspect as 'viewed' from the towed array
- array gain, directivity, self-noise and degradation
- tow cable scope, array depths and array heading
- array non-linearity and motion through turns.

Each mission may include a wide range of components providing:

- up to three propagation loss curves and ambient noise profiles
- up to 16 complex targets with up to 150 narrowband and 15 broadband tonals per target
- up to 1,500 narrowband and 150 broadband components and so on.

The acoustic signal generator generates ambient target and upper platform radiated spectra over a standard frequency range associated with passive acoustics. The following sound sources can be generated by the signal generator:



Consoles for the AN/FQR-503 (Array Systems Computing) 0009872

- ambient noise (including surface-ship traffic, sea state, wind, precipitation and marine mammals)
- radiated user platform and target noise (including torpedoes, submarines, surface ships, decoys, machinery noise, propellers, hydrodynamic effects, aircraft overflying and multi-path effects).

The acoustic propagation model - RAYMODE - determines the acoustic energy loss over the frequency range in question. Sound propagation is modelled over 360° in azimuth about the student platform, and to a water depth of 10,000 m. The propagation loss for discrete frequency, target depth, receiver depth and range intervals is calculated off-line and stored in a propagation loss look-up table.

The debrief recorder captures and stores on the disk array, digital images of the video being displayed on each of the student station's four acoustic screen monitors. These images can later be replayed, under control of the instructor, and compared with a simultaneous recreation of the mission simulation. The audio commands from the student are also recorded.

The data stream output of the simulator can be configured to simulate the output from various towed arrays including CANTASS and the AN/SQR-19.

Operational status
In service with the Canadian Navy.

Contractor
Array Systems Computing Inc, Toronto, Ontario. ***VERIFIED***

AQQ-T501

Type
Acoustic simulation and training system.

Description
The AQQ-T501 tactical acoustic trainer is an advanced modular acoustic stimulator that provides realistic, dynamic and effective ASW acoustic training in a manner that is indistinguishable from actual live target in-contact time. Realistic signatures and operating scenarios are achieved through a multiple target environment that includes oceanographic and shipping interference and fully responsive and manoeuvring targets. Targets can be defined with each target following independent manoeuvring patterns for position, course, speed and depth. Also, each target is reactive to programmable oceanographic conditions and sonobuoy type and location. The result is type specific submarine signatures that are identical to, and indistinguishable from, actual live target signatures. Operators can easily build and store a library of realistic target signatures.

Both speed-dependent narrowband and non-speed related narrowband are accurately portrayed using over 1,500 simultaneously produced lines, with harmonic and gear ratio relationships. Broadband and transients are produced in an equally realistic manner. Detection opportunities are aspect dependent as individual lobing patterns are produced for each line family. Realism is further enhanced by variations in the passive acoustic environment such as sea state, interfering shipping, convergence zones, multipath and layering which can all be controlled by preset and/or online manipulation and in the active environment by ambient noise, reverberation, propagation loss, vertical attenuation, Doppler shift and by the use of multiple target reflective points.

These features make the AQQ-T501 a thoroughly flexible training system that can be used airborne or land-based in a classroom/laboratory environment. A hands-on instructor control can produce instantaneous target manoeuvres within the actual submarine operating envelopes, or preprogrammed scenarios can initiate random manoeuvres with predetermined submarine responses to external stimuli. Meaningful training can now be achieved without the significant costs associated with major submarine deployments, and these training opportunities can be available on a daily (rather than yearly) basis. Further cost savings exist in the area of consumable stores as the AQQ-T501 simulates all existing buoy types. Due to the unique architecture, any number of buoys can be simulated.

The AQQ-T501 provides dynamic and accurate responses throughout all phases of the ASW mission and all features are available using existing acoustic processors.

Operational status
No longer in production. In service with the Australian Air Force (supporting AP-3C operator training) and Navy, Canadian Forces (supporting CP-140 Aurora, CH-124 Sea King and ADAC operator training), and UK Royal Air Force (aboard Nimrod MR 2).

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com

Specifications
8 Difar configuration
Size: 13.2 × 26.2 × 54.6 cm (W × H × D)
Weight: 13.6 kg

Contractor
General Dynamics Canada, Maritime Systems,Ottawa, Ontario, Canada.

UPDATED

AQQ-T502

Type
Acoustic simulation and training system.

Description
The AQQ-T502 tactical acoustic trainer is an advanced modular acoustic stimulator that provides realistic, dynamic and effective ASW acoustic training in a manner that is indistinguishable from actual live target in-contact time. This trainer evolved from the original version, the AQQ-T501. Realistic signatures and operating scenarios are achieved through a multiple target environment that includes oceanographic and shipping interference and fully responsive and manoeuvring targets. Targets can each follow independent manoeuvring patterns for position, course, speed and depth. Also, each target's acoustic signature is fully reflective of the programmable oceanographic condition and sonobuoy type. The result is type specific submarine signatures that are identical to actual live target signatures. Operators can easily build and store a library of realistic target signatures that can be invoked as required. The ability to replay the simulated mission for operator debriefing completes the training cycle.

Both speed-dependent narrowband and non-speed related narrowband signatures are accurately portrayed with configurable harmonic and gear ratio relationships. Broadband and transients are produced in an equally realistic manner. Detection opportunities are aspect dependent as individual lobing patterns are produced for each line family. Realism is further enhanced by variations in the passive acoustic environment such as sea state, shipping interference, convergence zones, multipath and layering which can all be controlled by scenario presets and/or online instructor manipulation. Realism is added to the active environment by simulated ambient noise, reverberation, propagation loss, vertical attenuation, Doppler shift and by the use of multiple target reflective points.

These features make the AQQ-T502 a thoroughly flexible training system that can be used on an airborne platform or at a land-based classroom/laboratory environment. A hands-on instructor control can produce instantaneous target manoeuvres within the actual submarine operating envelopes. Alternatively, pre-programmed scenarios can initiate random manoeuvres with predetermined submarine responses to external stimuli. Meaningful training can now be achieved without the significant costs associated with major submarine or aircraft deployments on an as needed rather than an as available basis. Further cost savings exist in the area of consumable stores as the AQQ-T502 simulates all existing buoy types. Due to the unique architecture, any number of buoy types can be simulated.

The AQQ-T502 provides dynamic and accurate responses throughout all phases of the ASW mission and all features are available using existing acoustic processors.

Operational Status

AQQ-T502	Currently in production for the Canadian CP-140 Aurora fleet (will be embedded in MVASP acoustic processor).
	Installed at the NAWCAD lab at the USN's NAVAIR
	Operational at the AUTEC range for USN's NUWC
	Operational as part of the RAF Nimrod's Weapons System Trainer
	Delivered to Japan for use on P3 aircraft.
AQQ-T501	Operational on the UK Nimrod MR2 fleet.
	Operational with the Canadian Forces supporting CP-140 Aurora, CH-124 Sea King and ADAC operator training.
	Operation with the RAAF supporting AP-3C operator training.

Contractor
General Dynamics Canada, Maritime Systems, Ottawa, Ontario.

NEW ENTRY

HI-TASS

Type
Acoustic simulation and training system.

Description
The HI-TASS ASW training system is a portable, high-fidelity, COTS stimulator specifically designed to generate the full ASW array mission, by including acoustic signatures, sensor performance, environmental conditions and tactical scenarios for towed array sonars.

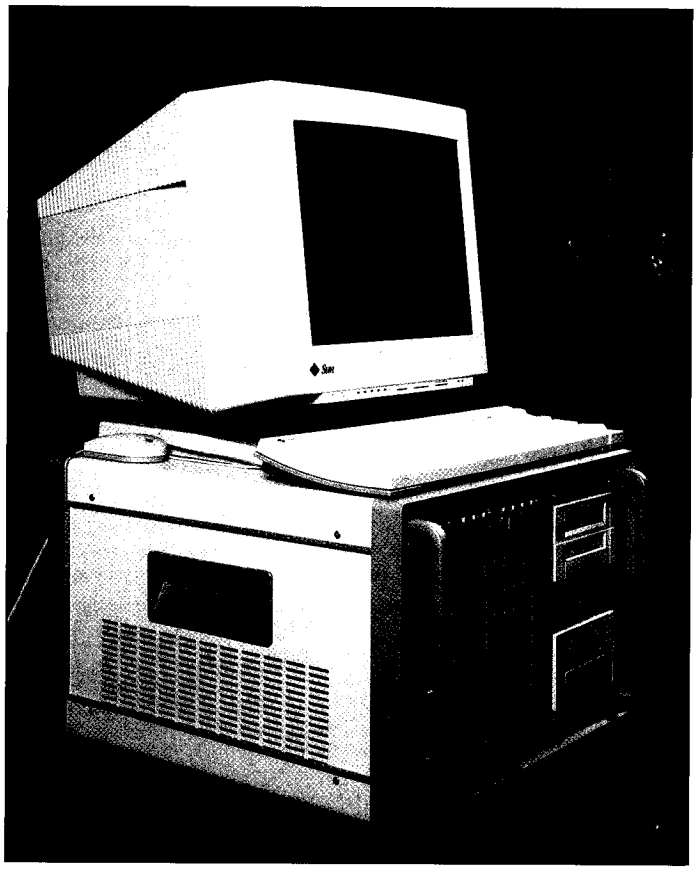
In use, the real sonar array (the 'wet-end' of the system) is disconnected from the towed array processor and the HI-TASS connected in its place. The HI-TASS is then used to generate signals as if they were coming from the sonar array. Data is entered for mission, acoustic simulation, environmental conditions, and so on, and this is used in training exercises.

The system provides operators and command teams alike with the opportunity to attain the highest proficiency levels. Complementing the training capability, HI-TASS provides a wide variety of user-selectable configurations, which can be utilised in a support role for system maintenance and own platform noise assessment.

Operational status
HI-TASS systems have been delivered to the Canadian Navy and Republic of South Korea Navy.

Contractor
General Dynamics Canada, Maritime Systems,Ottawa, Ontario.

VERIFIED



Elements of the COTS simulator HI-TASS

OH-5001/SQS-505 (V) 6

Type
Onboard sonar simulator stimulator.

Description
The simulator stimulator injects noise and signal into the front end of a sonar receiver, thereby acting as a substitute for the sonar's transducer outputs. The noise and target signals feed the processing circuits in the sonar receiver to provide video and audio outputs such as operators would experience during a live action.

The system can generate four targets as either ships/submarines/wrecks or torpedoes together with a full range of associated operational noises. If the target simulated is a submarine, an air bubble may also be deployed to simulate an attempt to mask the submarine's echoes. The operator can change or cancel any of the simulated parameters or targets, unless the selected target is a torpedo which is homed in on the ship by the simulation scenario.

The system has four operational modes:
- at sea, transmitter on – active and passive targets are simulated and signals superimposed on the ship's noise, flow noise and reverberation received through the transducer from normal operation
- at sea, transmitter off – no power is transmitted through the transducer and signals and reverberation are superimposed on own ship's noise and flow noise from the staves
- harbour operation – the simulator stimulator provides all signals, noise, reverberation and target data as well as supplying the receiver with artificial data to represent ship's course and speed
- test set – performs tests in the sonar receiver on:
- preformed beam patterns
- fine video calibration
- Doppler filter
- passive and active signal processing gain.

Operational status
In production. A total of 13 sets has been delivered for the Canadian Patrol Frigate programme.

Contractor
Northrop Grumman-Canada Inc, Burlington, Ontario.

UPDATED

France

Sygame/TMS 9001

Type
Audio training system.

Description
The Sygame (TMS 9001) acoustic training system comprises a sound generator and a workstation with a set of software tools. Menu-driven software enables progressive training from elementary sound recognition to target classification in a complex noise environment.

The system can be used either as a stand-alone system on land or on board ship at sea, or as a network consisting of two to eight workstations.

Sygame synthesises sounds from active or passive sonars that are then fed to the students to train them in recognising different sonar pulses and noises generated by propellers, engines, auxiliary machinery, hulls and transients. Up to 12 items of machinery can be mixed together in the system to provide realistic acoustic signatures for submarines (both diesel and nuclear) and surface ships (both military and civilian). Users can create acoustic signatures to define platform characteristics (dimensions, number of shafts and blades per shaft, asynchrony between shafts) and to mix various sound effects such as normal cavitation (strong, medium, hard), compressed cavitation (bubble, whip), shaft rub and singing propellers.

Using Sygame, students are taught to develop effective search, localisation and classification skills. To further improve training, the instructor can insert environmental conditions including noise created by traffic, weather conditions and the sea itself, as well as biological and reverberation noise.

The Sygame VI N is an improved version that can be integrated with a network and has an Internet protocol.

Operational status
In service with the navies of Australia, France and Italy.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Symen

Type
Sonar operator training system.

Description
The Thales Underwater Systems Symen sonar operator system is a modular system with an Ethernet-standard network configuration.

The trainer works with operators of the same kind of sonar, or with different sonars in the same ship, or with different sonars in different ships.

Students may be trained individually, as members of a single ship's ASW team or as part of an ASW task group team.

Operational status
Available and in service in the Pakistan Navy.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Italy

Multi-Application Sonar Trainer (MAST)

Type
Training system for sonar operators.

Development
MAST is a multi-application sonar trainer developed in co-operation with Raytheon, USA and has been delivered to the Italian Navy training centre.

Description
MAST consists of the following units:
- trainee equipment consisting of a set of units identical to those used operationally on board
- an instructor control station from which the instructor provides for the insertion of data related to own ship, and the target's course, speed, position and so on
- a medium-size mini-computer
- simulation hardware producing signal and noise to be injected into the front-end transducer array interface. These signals simulate those that would have been generated by the acoustic environment when converted from pressure to voltage by the receiving transducer array.

These include all possible variations due to motion, mutual interference, propagation characteristics and the environmental conditions simulated.

The MAST system is used for the training of operators and maintenance personnel on the DE 1160 and DE 1164 sonar systems (see DE 1160 and DE 1164 entries). Further improvements will allow training facilities for other passive sonar systems produced and also for the DE 1167 being manufactured under licence from Raytheon.

Operational status
In service with the Italian Navy.

Specifications
Number of targets: up to 8
Target types: own ship, surface ship, submarine, torpedo decoys, biologics, wakes
Ocean effects: propagation loss, sea state, reverberation
Passive simulation: broadband and narrowband noise
Active simulation: highlights, target strength

VERIFIED

Norway

MMSS (MPS Multibeam Sonar Simulator)

Type
Training system for commanding officers and sonar operators in the use of active sonar variable depth or dipping.

Description
The MPS Multibeam Sonar Simulator (MMSS) is a training system for the operators of hull-mounted and variable depth multibeam sonars. The system generates both sonar-image and audio signals in real time so that the student can use the controls of the sonar console, learn to understand the working principles of the equipment and assess the results when the control settings are altered. The system is based on the 32-bit Multibus II real-time computer using the Intel 80386 as the main processor.



MPS multibeam sonar simulator at the Swedish Navy Training School

Echoes from underwater objects are produced by a digitised representation of reflected sound at different aspect angles. This produces a very accurate generation of the acoustic characteristics of the sound return, which takes into account the size, geometry, location, aspect angle and Doppler effects. The operational characteristics of the sonar, including the source level, transmission modes, scanning sectors and pulse lengths, together with the actual operator settings such as range scale and tilt, are used as the simulator model.

The system comprises an instructor's position, a student steering console position, a student sonar console (using a specific system), a game preparation console/system control station, laser printer, digitiser for map and terrain-model preparation.

The operator can use either an actual sonar console or an MPS tactical console simulating the man/machine interface, presentation modes and signal processing capabilities of a specific, or a set of real sonar equipments. In order to steer and control the simulated sonar-carrying vessel, a manoeuvre console is connected for setting speed, course and manoeuvre models. The sensor platform and all the targets are controlled by the instructor.

Optional extras include a network interface with an action speed tactical trainer such as MASTT (see MASTT entry), a plotter for analysis purposes, additional tactical displays and an interface with a video-audio recorder.

Operational status
In service with the Royal Norwegian Navy (integrated with the MASWT) since 1989 and with the Swedish Navy since 1990. Upgrades with additional emulated sonar operator consoles for both the Royal Norwegian Navy and Swedish Navy were supplied in 1993.

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg. ***UPDATED***

United Kingdom

AS 2105 sonar stimulators

Type
Sonar test and training for ships and submarines.

Description
The AS 2105 sonar stimulators have been designed to generate the accurate signals required to test comprehensively modern, complex, passive sonar systems. They also provide basic training for sonar operators, target motion analysis teams, command teams and maintenance personnel. More comprehensive training facilities are available with the AS 2107 sonar trainer (see AS 2107 entry).

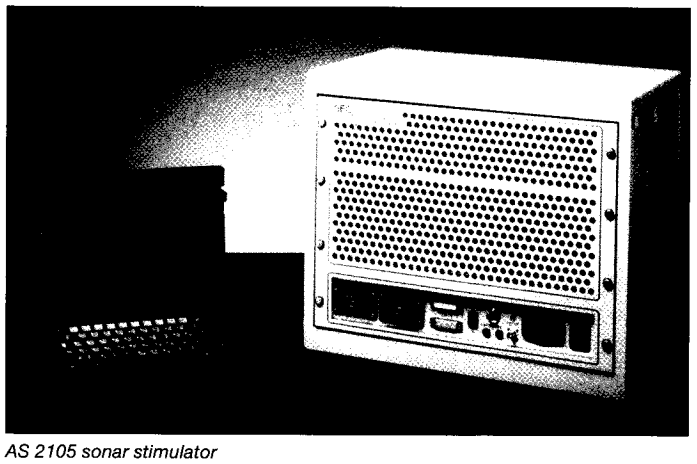
The AS 2105 equipments are compact, robust and lightweight, which makes them suitable for use ashore or on board surface ships and submarines, either at sea or in harbour. The AS 2105 can emulate a wide range of hull-mounted and towed hydrophone array geometrics (including towed, flank and conformal arrays), and by generating appropriate electrical signals, stimulate the inboard processing and display equipments.

The AS 2105 consists of two parts; a small lap computer which provides the man/machine interface allowing the user to construct scenarios for training and testing and the electronics unit which generates the acoustic signals.

The Mk II variant is designed for integrated sonar systems and uses a central computer controlling several simulators, each linked to a separate sonar. PASSIM (Passive Sonar Array Simulator) is a variant which simulates signals received by towed arrays.

Operational status
A number of systems is in service with the Royal Navy and a NATO navy at the Type 23 Frigate Weapon Test facility at DERA Portsdown.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester. ***UPDATED***



AS 2105 sonar stimulator

AS 2107 sonar trainer

Type
Sonar training and system test for surface ships and submarines.

Description
The AS 2107 onboard sonar trainer has been developed from the AS 2105 sonar stimulator (see AS 2105 entry), and will generate set-piece or free-play exercises with either real or simulated own ship parameters.

By synthesising the narrowband, broadband, Demon and aural emissions of platforms, the AS 2107 can describe complex signatures, together with vehicle dynamics, weapon configuration, environmental characteristics and other parameters, which would normally be recalled from the user's data library. Alternatively, the AS 2107 allows offline generation to permit the user to develop or modify data. The scenario author/command can perform a fast time review of the scenario using the built-in tactical display, this facility being particularly useful for the initial construction of scenarios and for debriefing.

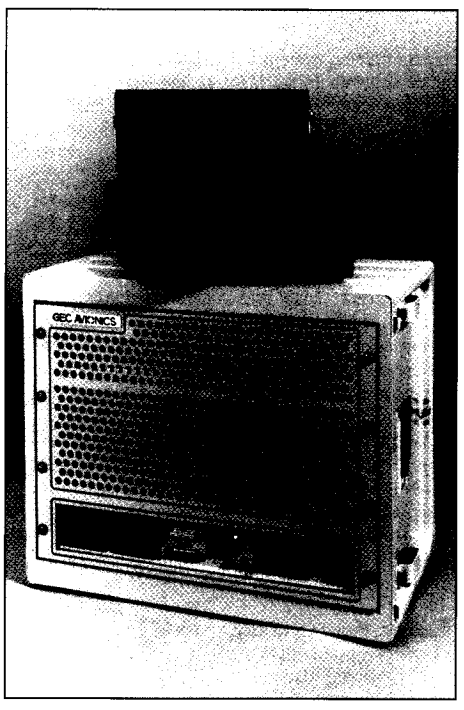
The AS 2107 consists of two parts; a laptop computer which provides the man/machine interface allowing the user to construct scenarios for training and testing, and the electronics unit which generates the acoustic signals.

The AS 2107 is intended primarily for onboard continuation training of sonar operators, target motion analysis teams and command teams, in conjunction with towed and hull-mounted sonar processing systems. It may also be used for extensive testing of sonar systems, particularly within a shore development establishment.

Operational status
In service with the Royal Navy, Canadian Forces Maritime Command and the Royal Netherlands Navy.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED



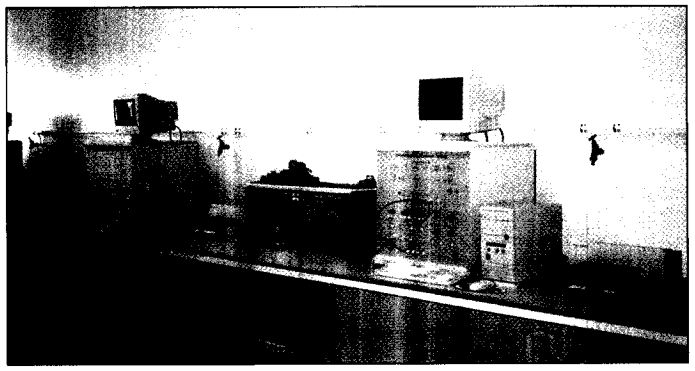
AS 2107 sonar trainer

AST

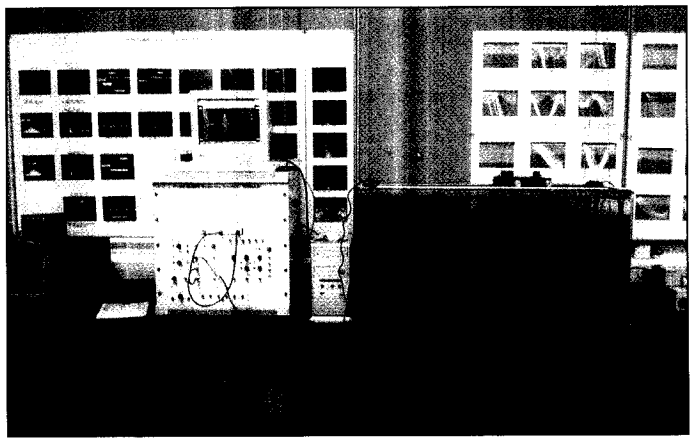
Type
Acoustic Systems Trainer (AST).

Description
The AST is a commercial hands-on training system designed to teach real-time sonar principles and techniques in a laboratory. Previously this subject has been confined to verbal instruction and simulation due to the need to use large water tanks to achieve measurable results. By using a modest increase in transducer frequency (and hence shorter wavelength), iTP has enabled the demonstration of a wide range of sonar techniques.

The transparent acoustic tank is constructed from acrylic material and measures just over 1 m in length and half as deep and includes a heater to show the effects of temperature on the speed of sound, a variable speed transport mechanism for moving targets and a number of resin encapsulated reversible electrostrictive HF (192 kHz resonant frequency, 8° beamwidth at –3 dBs) transducers for transmitting and receiving signals. Hydrophones are used to pick up the very low-level noise and signatures of the passive targets.



The AST workstation and acoustic tank (iTP Ltd) 0009874



The AST workstation set up at BRNC (Britannia Royal Navy College) Dartmouth (iTP Ltd) 0097460

A selection of active and passive targets with different cross-sections and spectral signatures are included with the AST. The passive targets presented include:

- variable speed turbine
- four-bladed propeller
- five-bladed propeller
- bubble generator

These allow experimentation on the following topics:

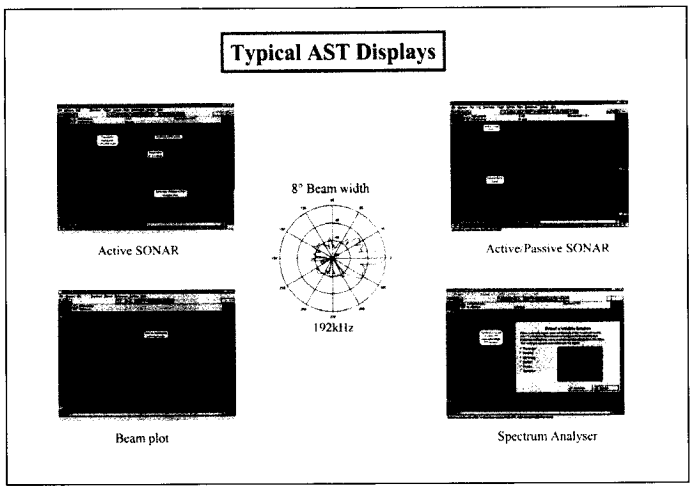
- speed of sound in water
- temperature effect on the speed of sound
- range measurement
- single element transducer
- transducer resonant frequency
- transducer beamwidth
- passive and active sonar
- depth finding
- three-element array
- passive target FFT signatures
- active target profiles
- interference effects
- beam formation and steering
- scattering
- target signatures
- jamming
- cavitation
- noise
- reverberation
- Refraction
- PRF/TX pulse and timing signals
- Doppler effect
- Dielectric phase shift

The system comprises a robust 19 in control console containing power supplies, signal sources and the sonar signal analyser connected to a PC remaining under a Windows® OS such as Me, NT or 2000. The analyser provides a data acquisition interface through a number of virtual digital instruments, for measuring and analysing the system signals.

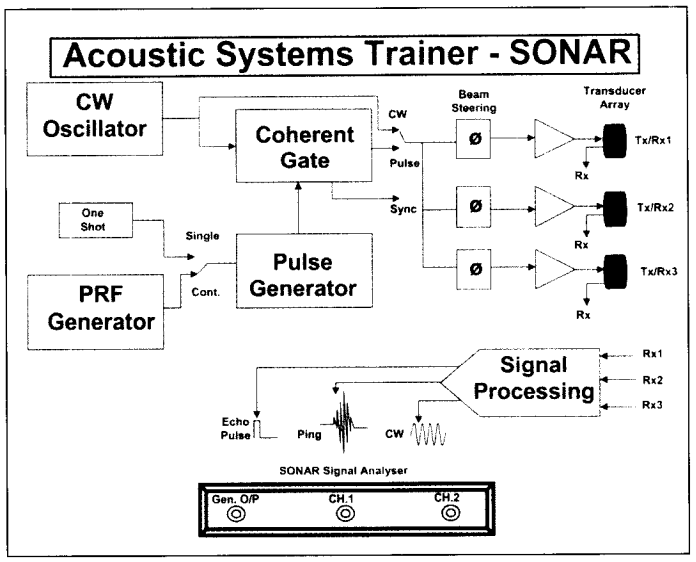
The instruments include:

- dual-channel digital oscilloscope
- dual-channel spectrum analyser
- dual-channel digital multimeter
- dual-channel transient recorder
- arbitrary waveform generator with sweep

These enable the student to investigate and condition all the signals associated with acoustics and sonar. The oscilloscope displays the change of speed and sound due to increase in water temperature while the spectrum analyser displays passive target signatures in the frequency domain. Multimeters display frequency peak to peak, true rms, dBm, power and duty cycle. Beam steering circuitry controls the phase drive to the transducers. Connections to the transducers are made via standard BNC connectors and the front panel allows access to all test points and signals.



Various displays of AST (iTP Ltd) 0114955



Block schematic of the AST showing the arrangement of the various elements (iTP Ltd) 0114956

Operational status

The AST is in service with the Royal Navy at BRNC Dartmouth and HMS *Collingwood*, and the Singapore Navy as well as the University of Plymouth.

Contractor

Feedback Instruments Ltd, Crowborough, East Sussex.

VERIFIED

SAINT

Type

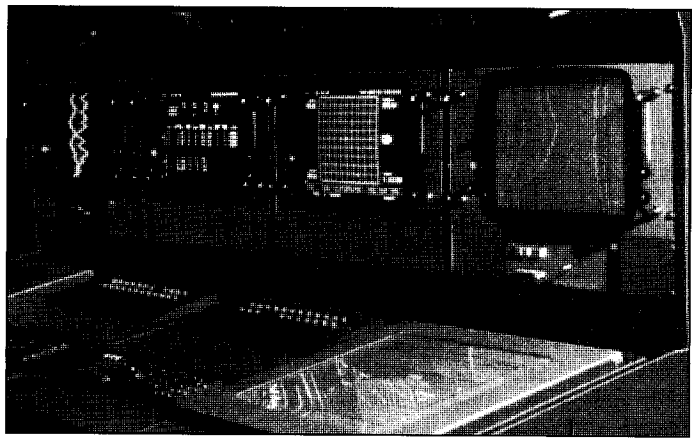
Initial training system for sonar operators.

Description

The Sonar Analysis INitial Trainer (SAINT) is intended to train operators in the principles of underwater noise generation, signal display presentation and narrowband analysis from basic principles to advanced levels. The system consists of a dual-position instructor's console linked to as many as 12 students' positions, each for two students. As a result of this organisation, each instructor can carry out independent exercises with six positions.

Each instructor position has two video monitors, one for monitoring the trainer control menu and the other to repeat any picture seen by the students. There is also a joystick-controlled pointer to identify important features on any video seen by students, a digitiser pad and a stylus for repositioning of frequency lines in a Lofargram, or hand-free graphics 'sketching' on to video pictures. Video record facilities and communications with the students are also provided.

Each student position has a paper chart recorder with numeric display to identify the frequency window covered by the Lofargram being recorded. The positions also have a video monitor and cursor generation electronics. Cursors can be superimposed on a picture relayed by the instructor to allow the student to identify both frequencies and harmonic relationships. Numeric display can also be incorporated.



The SAINT (Sonar Analysis INitial Trainer) in operational mode

Operational status
Fully developed.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Sonar principles trainer

Type
Operator trainer.

Description
The sonar principles trainer assists sonar operators to understand the elements of sonar signal and target aspects.

The trainer is reconfigurable to various types of sonar and equipment.

Up to 10 consoles for operator training are available, each incorporating a multipurpose display unit, a sonar control panel, simulated audio reception and communication facilities.

Operational status
In service with the navies of Brazil and the UK.

Contractor
AMS, Frimley.

VERIFIED

Sonar principles trainer

Type
Comprehensive sonar operator training system.

Description
The Sonar principles trainer has been designed to provide comprehensive facilities for the training of sonar operators in understanding the various elements of complex sonar signals and the skills associated with detection, evaluation and tracking of targets in a variety of scenarios and environmental conditions.

Consisting of an instructor's console and up to 10 identical trainee operator consoles, the system offers a standardised hardware concept which can be customised by software to meet the specific training needs of the user. Each trainee console consists of a multipurpose display unit, a sonar control panel, sonar aural facilities and communications facilities. Each trainee has control over his own sonar with respect to mode of operation, frequency, pulsewidth and beam training, and the sonar pictures and aural effects are responsive to individual trainee actions.

The trainer provides the sonar instructor with a flexible training tool which can be used to prepare trainee operators for sonar operations across the range of equipments existing in his particular fleet. Through the means of a user-friendly console, the instructor can prepare, execute, monitor and debrief exercises. The instructor has full control over the ocean environment, movement of 'own ship', selection of sonar types for training, selection and movement of target vessels and weapon deployment.

A repeater monitor and audio system at the console allows the instructor to select any trainee operator's sonar picture and associated sonar aural for online monitoring of individual sonar performance. Each trainee operator's use of the relevant functional controls is also monitored as part of the performance analysis.

Operational status
A system is in service with the Pakistan Navy.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Sonar procedures trainer

Type
Basic and advanced trainer for sonar operators.

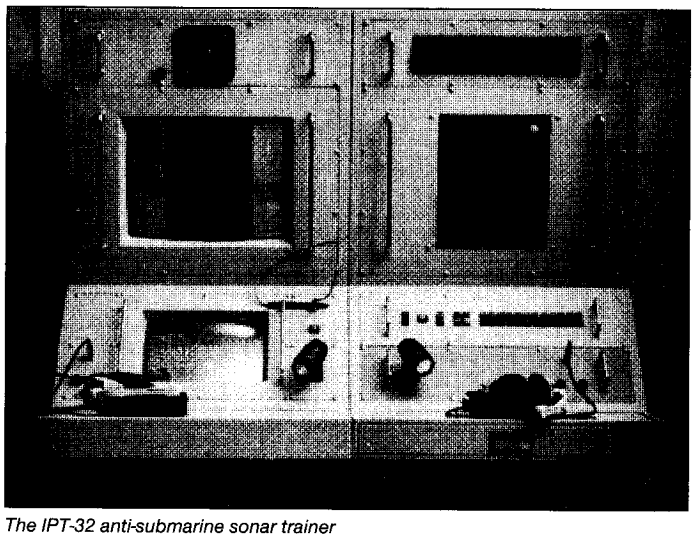
Description
These are intelligent procedure trainers, providing students with a full range of training facilities from basic to complete tactical and weapons operations. Each student is guided automatically by verbal and visual commands in accordance with a predefined training programme. The system features high-resolution animated graphic presentations, full touchscreen control operations, complete emulation of main system displays and operating control panels, together with emulation of targets and the environment.

Two dedicated products have been produced: the IPT-32 and the IPT-2022. The first of these is an anti-submarine warfare sonar simulator for training operators of the PHS-32 hull-mounted sonar, while the IPT-2022 is a minehunting sonar and mine disposal system trainer for operators of the TSM 2022 sonars. Both systems have been supplied to STN ATLAS for use with its training systems.

Operational status
The IPT-32 is in service with the Indonesian Navy and IPT-2022 with the Indonesian and Nigerian Navies.

Contractor
Digital Systems and Design Ltd, Eastleigh.

VERIFIED



The IPT-32 anti-submarine sonar trainer

United States

AN/SQQ-89(V) trainer

Type
Onboard sonar trainer.

Description
The OnBoard Trainer (OBT) is designed to provide individual and team proficiency training and skill reinforcement to embarked combat system personnel. The trainer uses simulated targets to stimulate the hull, towed array, sonobuoys and electronic sensors of the AN/SQQ-89 surface ship ASW combat system. The OBT allows personnel to carry out realistic training exercises both in port and while at sea.

The system uses electronic synthesis to generate realistic high-fidelity active and passive, three-dimensional moving acoustic contacts. To achieve this the OBT features front end injection and sonar system stimulation.

The trainer interfaces with the AN/SQS-53B/C active and passive hull-mounted sonar, the AN/SQR-19 tactical towed array system, the AN/SQQ-28 and LAMPS Mk III systems, and the Mk 116 fire-control system.

Realistic passive and active targets stimulate these while underway and without interfering with the ability of the sensors to detect, classify and track naturally appearing targets. The OBT provides stimulation of the LAMPS Mk III sensors with the helicopter's navigation information for heading, altitude and speed. The trainer is provided in four configurations to support the different AN/SQQ-89 configurations aboard the various ship platforms. Together with ASW training capability, the device supports training activities for AN/SLQ-32 operators, AN/ALQ-142 operators, EW supervisors and other ESM personnel.

Using an Acoustic Signal Generator (ASG), the 14E35 device trainers for the AN/SQQ-89 provide up to 20 dynamic surface and subsurface targets simultaneously in a tactical environment for sea level to 15,000 ft and an ocean depth of 50,000 ft.

The ASG simulates signatures of diesel, diesel/electric, steam, turbine, nuclear and auxiliary machinery.

Operational status
In service with the US Navy for Ticonderoga class cruisers, Kidd and Spruance class destroyers and Oliver Hazard Perry class frigates.

Contractor
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

UPDATED

AN/SQQ-T1 sonar training set

Type
Training equipment for ASW sonar operators.

Description
Designed to provide passive and active acoustic training for teams and subteams, the AN/SQQ-T1 stimulates sonar systems to generate high-fidelity acoustic signals resembling those of actual targets under various sea and environmental conditions. It provides sonar operators with the ability to improve their skills in target identification, analysis and classification during long periods at sea or at ground-based stations.

The system can be operated on an individual basis using preprogrammed scenarios, or on an interactive team basis with an instructor. Up to 64 preprogrammed scenarios may be stored within the system and displayed on the instructor control unit. Two modes are available to the instructor; one with all simulated data and the other with live sensor data overlaid with simulated data. In addition, the instructor can select from 16 preprogrammed ocean areas and sea state and shipping density levels. All databases are stored on a removable hard disk unit to facilitate update. The gaming area covered is 512 n miles^2 with depths to 3,000 m and altitudes to 6,000 m.

The AN/SQQ-T1 simulates up to four high-fidelity acoustics simultaneously, selected from the US government-based Common Acoustic Database, or from other acoustic databases. This extensive library is expandable and can accommodate up to 40 acoustic target types. Each acoustic contact has both passive and active signatures, which can be modified by the instructor for added realism.

The set supports onboard training by providing high-fidelity simulated data separately or simultaneously to the AN/SQR-17A and AN/SQR-18A. The inputs to the AN/SQR-17A are two selectable sonobuoy channels, eight beams for the AN/SQS-26CX PEC and a DIMUS channel. In addition, the AN/SQQ-T1 provides hydrophone group data for injection into the beamformer of the AN/SQR-18A.

The instructor interfaces with the AN/SQQ-T1 via a graphics terminal, keyboard and colour display. The set can simulate own ship data under preprogrammed scenario or instructor control, or use live own ship data. Information available to the instructor for training scenarios includes own ship course and speed and AN/SQR-18A array depth.

Operational status
The system is fitted in Knox class frigates now in service in various navies around the world.

Contractor
DRS Technologies Inc, Gaithersburg, Maryland.

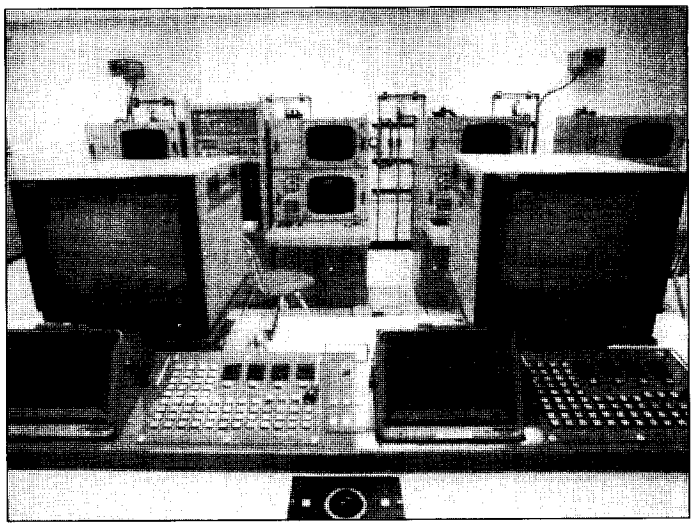
VERIFIED

Device 14E35

Type
Acoustic Operator Trainer.

Description
A number of acoustic operator trainers have been produced in support of the sensor systems in the AN/SQQ-89 underwater combat system. These training devices have four components: the AN/SQQ-28 LAMPS Mark III sonobuoy signal processor, the AN/SQR-19 Tactical Towed Array System (TACTAS), the AN/SQS-53B hull-mounted sonar and the AN/UYQ-25 Sonar In-situ Mode Assessment System (SIMAS). The training device allows for training in the crew configuration, or the four trainee stations can be configured to one of the three sonars for individual operator training. The trainer also provides reduced capability for training in the casualty modes of the operational AN/SQQ-89 Underwater Sensor System. Later production trainers have incorporated an improved AN/SQS-53B sonar together with an interface with the Mark 116 Underwater Fire-Control System.

The trainer simulates the performance of the operational systems and can also provide a variety of exercises from simple target identification and location to complex tactical operations. Each device comprises an instructor station, four trainee stations, the computer system (based upon Harris Series 800 and 1200 mainframe computers with Fortran language software) and an acoustic signal generator. The acoustic signal generator is a special purpose digital signal generator utilising data pipelining and parallel processing techniques to produce



Device 14E35 acoustic operator trainer

the target composite digital time waveform which can generate up to 20 dynamic air, surface and subsurface targets to depths of 4,572 m (15,000 ft) and to altitudes of 15,240 m (50,000 ft). It can also generate the signatures of diesel, diesel-electric, steam, turbine, nuclear and auxiliary machinery. Each device is configured to a class of ship, such as the 'Ticonderoga' (CG47) class cruiser, 'Spruance' (DD963) and 'Kidd' (DDG993) class destroyers, or 'Oliver Hazard Perry' (FFG7) class frigates.

Operational status
The first contract for these systems was received in 1982 configured to the Spruance and Oliver Hazard Perry classes. The first two units entered service with the Fleet Anti-Submarine Training Center at San Diego, California, late in 1987 and two more followed by 1990. The fifth unit was shipped to San Diego in February 1993. Two of the San Diego devices are designated 14E35C and are used to train operators of the AN/SQS-53C. Five systems have been supplied to San Diego in a programme which cost approximately US$107 million.

Contractor
L-3 Communications, Link Simulation and Training Division, Arlington, Texas.

VERIFIED

Device 14G1 sonar trainer

Type
Sonar operator and diagnostic basic trainer.

Description
The sonar and diagnostic trainer, Device 14G1, is designed to provide student sonar operators with familiarisation training on the AN/SQQ-89(V) sonar.

It consists of four student stations, each of which simulates the appearance and operations of the AN/UYK-21 console associated with the AN/SQQ-89(V) sonar. The students receive 6 hours of fully automated, self-paced, computer-controlled instruction. The instructor selects either individual exercises or a common exercise for all the students. Each includes recorded narrations and visual presentations of the selected exercise.

Operational status
In service with the US Navy.

Contractor
EMS Development Corporation, Yaphawk, New York.

VERIFIED

DS1200 Series Trainers

Type
Training systems for both surface ships and submarines.

Development
The prototype DS1200 system was first used by the US Navy's submarine forces to successfully demonstrate an onboard sonar training capability for a passive subsystem. The production version, designated the DS1210, now provides ASW target training capability on 31 fleet ballistic missile submarines.

Two production DS1210 trainers, modified and designated DS1213, were later applied by US Navy submarine forces to totally integrated sonar suites. Although installed for test purposes and on a temporary basis, overall performance proved so effective that both trainers remain in service to this date aboard US Navy ships.

The Submarine Active Detection System – Transmit Group (SADS-TG) was developed and produced by Raytheon for the US Navy's advanced submarine combat system. SADS-TG contains a fully integrated onboard trainer which supports training for all shipboard sonar arrays and provides a moving contact for fire-control team training.

In addition to the SADS-TG OBT capability, the company has developed a shore-based Multiple Array Test Set (MATS). It uses the same technology applied to the onboard trainers and will interface with the acoustic sensor group for these new submarine combat systems. MATS provides acoustic sensor stimulation and simulation of the high-frequency array, top and bottom sounders, sound velocity and noise monitoring systems and acoustic communications during system level performance and operability testing.

The Generalised Simulation/Stimulation (GSS) system was developed to facilitate the US Navy's programme of preplanned product improvements to the fast attack submarine Combat Control System (CCS). GSS necessitated development of facilities and tools to support the evolution, certification, life cycle support and training for major CCS components.

Description
Raytheon Company manufactures many trainer systems incorporating distinct simulation techniques to provide controlled, tactically 'real' training that is dynamic and highly effective.

The trainers provide operational and maintenance support to shipboard sonar and combat systems. They function at sea, in port, on shore or in the air and address the training needs of surface ship, submarine and airborne platforms.

These trainers interface with the acoustic sensors of widely varying systems, both aboard multiple ship platform classes and in shore-based training facilities. They rely on advanced techniques for sonar stimulation and target simulation to generate, for both individuals and teams, the most realistic ASW training exercises available anywhere.

The entire ASW trainer series is based on established concepts of proven value. Expandable system architecture; the use of common hardware and software modules; programmable, functional partitioning of system processing – these techniques enhance realism and ensure design flexibility and manageable system upgrades in the future.

The trainers feature high-fidelity, electronically synthesised active and passive contacts that are manoeuvrable, three-dimensional and ultra-realistic. The multiple targets found in systems are sensor co-ordinated. Onboard trainers feature 'front end' target injection and sonar system stimulation.

Operational status
In service. Over 40 trainers from the company's DS1200 Trainer Series, representing four system generations, have collectively logged in excess of 80,000 operating hours.

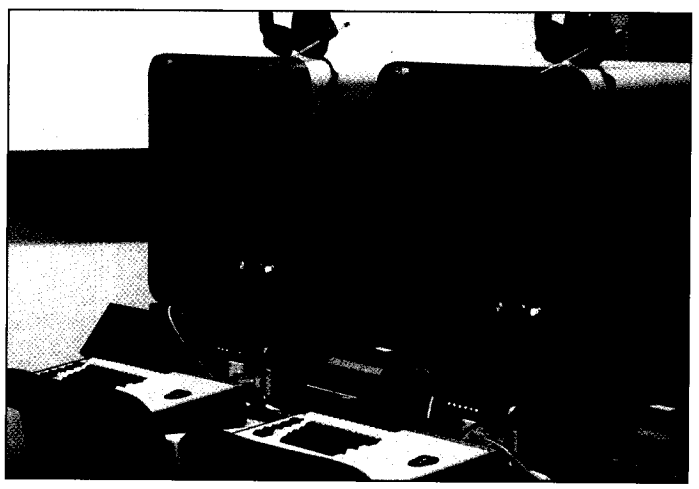
Raytheon has delivered nine GSS laboratories for use with CCS components and two trainers which allow a shore-based CCS to function as it would aboard an operating submarine.

Contractor
Raytheon Systems Company, Naval and Maritime Integrated Systems , Portsmouth, Rhode Island.

UPDATED

Passive acoustic analysis trainers

Type
Analysis and classification trainers for sonar operators.



Two Passive Acoustic Analysis (PAA) trainer student displays

Description
The US Navy Passive Acoustic Analysis trainers (Devices 14E40 and 21H14) are designed for use by sonar operators for both surface vessels and submarines. They are used for training in analysis and classification of various surface ship, submarine and commercial ship contacts, both aurally and visually. The displays include Lofargram, Demon and Vernier frequency data, together with a student worksheet. The displays are time synchronised with raw and processed audio signal presentation. The worksheet data entered by each student provide a record of performance for training feedback and course grading.

The trainer generates realistic sonar audio and visual displays by preprocessing user-supplied acoustic analogue tape recordings from a variety of user-deployed tactical sonar systems. The preprocessing facility produces VHS tape cassettes for audio signals and computer disk files of synchronised generic visual displays for replay on the trainer. The trainer includes hardware for up to 12 student stations, a single instructor station and a preprocessing facility.

Operational status
In service with the US Navy.

Contractor
Ship Analytics, North Stonington, Connecticut.

VERIFIED

Sonar simulator

Type
Sonar and radar simulator.

Description
The sonar simulator is a generic sonar and radar simulator that may be configured to represent specific displays such as the AN/SPA-25F or the Canadian Marconi LN-66. The unit duplicates all the functions of the real display and can also simulate an Automatic Radar Plotting Aid (ARPA) including the touchscreen technology found in many modern shipboard ARPA radars. The simulator can be easily configured to simulate other specific radar units.

The system consists of a simulation unit based on a personal computer, a display unit and a date acquisition subsystem with controls. The simulator may be configured as either an air search or a sea search unit and can display tactical contacts, weather, chaff, sea return, jamming and landmass features. The simulator sonar is active, operating in either a steerable sector or an omni mode. The radar simulator can be interfaced with any host simulator.

Operational status
The simulator is used in Ship Analytics' full mission ship handling simulator systems and action speed tactical trainers. Over 70 units are currently in operation throughout the world for both military and commercial applications.

Contractor
Ship Analytics, North Stonington, Connecticut.

VERIFIED



A radar simulator in an ARPA configuration

TSMT FES

Type
Shore-based trainer.

Description
TSMT FES (Trident Sonar Maintenance Trainer Front End Simulator) will offer personnel basic, intermediate and advanced instruction in sonar system troubleshooting, repair and calibration. Realism will be achieved through the injection of TSMT-generated signals into the front end of AN/BQQ-6 and AN/WLR-17 sonar systems.

The system is totally integrated and will initiate and control the exercises, providing the required signal generation, propagation processing and sonar interfacing.

The trainer has four electronically synthesised manoeuvrable, active and passive three-dimensional, realistic targets.

The system can be modified to provide personnel with operational training in addition to maintenance training. It can be further developed into a compact, onboard trainer for all submarine classes or can be used to establish a realistic fully capable standard evaluation facility.

Operational status
In service with the US Navy.

Contractor
Raytheon Company, Naval and Maritime Integrated Systems, Portsmouth, Rhode Island.

UPDATED

TARGETS

Finland

TSS

Type
Towed sound source.

Description
The TSS is a VLF broadband sound source, which is used for training and target simulation. It can also be used for passive sonar and fixed surveillance array testing as well as for acoustic MCM studies. The system is designed for deployment from small vessels.

TSS accurately replays the input signal, regardless of whether it is a recorded, modified or synthetic target signal. The system can contain all kinds of waveforms, including noise and transients. The input signal is fed into the TSS deck unit through a standard analogue interface. The system's conditioning electronics and linear power amplifiers guarantee a flat frequency response and high-quality input signal repetition. The beam is omnidirectional in the horizontal plane and omnidirectional up to 300 Hz in the vertical plane.

The wet end unit incorporates two sound sources and is fitted with depth and temperature sensors for selecting the optimal operating depth.

Specifications
Weight: 370 kg (in air)
Frequency: 20-1,500 Hz (optionally 5,000 Hz)
Source level: >160 dB ±3 dB @ 1m/μPa (30-1,000 Hz)
Dynamic range: >80 dB

Contractor
Patria Finavitec, Tampere.

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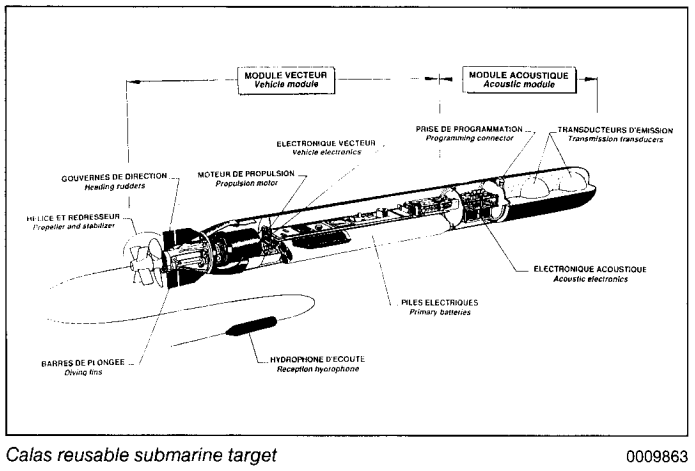
France

Calas

Type
ASW training target vehicle.

Description
The Calas expendable underwater vehicle is designed to provide realistic submarine simulation in navigation, acoustic signature and sonar responses for the training of active and passive sonar operators. It is a torpedo-shaped vehicle which tows a small hydrophone and which is easy to use and requires no maintenance.

The vehicle consists of a forward section with elliptical and flat nose, moulded in polyurethane which contains two spherical transducers. The forward section is attached to the central section by an aluminium flange. This is a watertight pressure resistant compartment about 1 m long and constructed of carbon fibre. This section houses the electronics and processing unit. The rear section houses the power supply (60 V DC lithium primary battery) which feeds an electric DC motor driving a single propeller rotating around a fixed rear shaft through a mechanical transmission. The motor torque is compensated by a fixed rear stabiliser acting hydrodynamically as a contrarotating propeller. Attitude is controlled by a pair of diving fins and a pair of directional rudders actuated by electric servo-motors.



Calas reusable submarine target 0009863

The vehicle is easy to program prior to launching using a laptop computer interface. Signature transmission is one to three tonals within the 300 to 800 Hz frequency band. It offers the simultaneous processing of two active sonars within the frequency band 4 to 33 kHz.

Launch from the surface platform is automatic and the vehicle, towed by an 18 m cable, has an endurance of up to 2 hours. Pinger functions are incorporated for location by a tracking range.

Calas can navigate at depths between 20 and 300 m at speeds selectable in the 7 to 10 kt range for a duration of up to 2 hours. A navigation pattern is programmed as a looped 10-segment trajectory in which the segments are determined in length and azimuth. Water current can be programmed as an estimate and the navigation algorithms automatically correct the effects of the estimated current on the shape of the pattern.

Operational status
In service with the French Navy.

Specifications
Length: 1.85 m
Diameter: 150 mm
Weight: 30 kg (in air)
Speed: 7 to 10 kt
Operating depth: 20 to 300 m

Contractors
Thales Underwater Systems, Sophia Antipolis.
Constructions Industrielles de la Mediterranée (CNIM), La Seyne sur Mer.

VERIFIED

STAR

Type
Submarine training target for torpedoes.

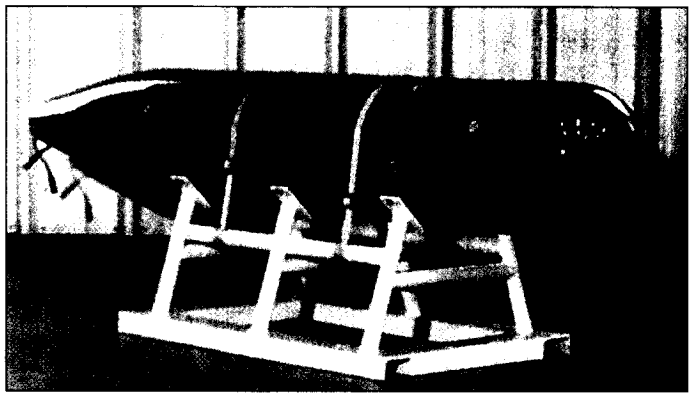
Description
STAR (an acronym for Submarine TARget) is an artificial towed target system designed to replace the use of padded submarines targets for torpedoes when the weapon is fired for test and training purposes. It simulates the acoustic behaviour of a real submarine when under attack from an active torpedo. It has been developed for both the training of naval forces and for the training, test, qualification and evaluation of torpedoes.

STAR consists of two main parts, the towed body (the 'fish') with acoustic repeater modules and hydrodynamic depressor and the towing ship installation incorporating a hydraulic winch, and electronic rack with control, monitoring and recording instruments.

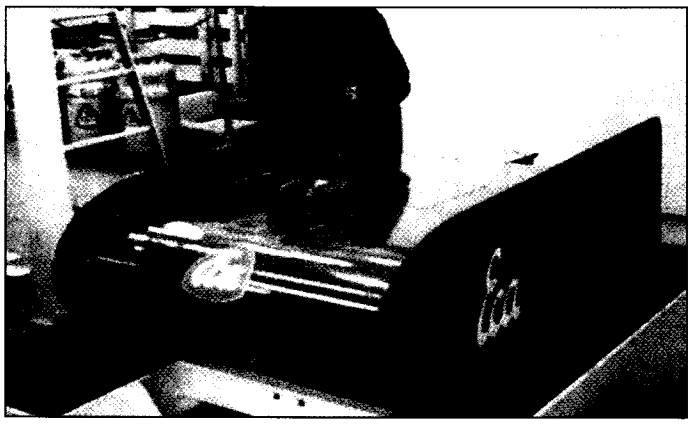
The submerged part of the system comprises five parts:

- the target made up of a linear chain of between 5 and 15 acoustic repeater modules in a 75 m long antenna and a tail module trailed behind the towfish
- the underwater body (towfish) containing the electronics, battery, and navigation sensors
- a passive hydrodynamic 350 kg depressor, which sets the depth of the target and the repeater modules.
- a 400 m towing cable which links the depressor to the towed body.
- a 600 m cable which tows the underwater elements and which is attached to a 1-tonne 15 kW hydraulic winch mounted on the towing ship.

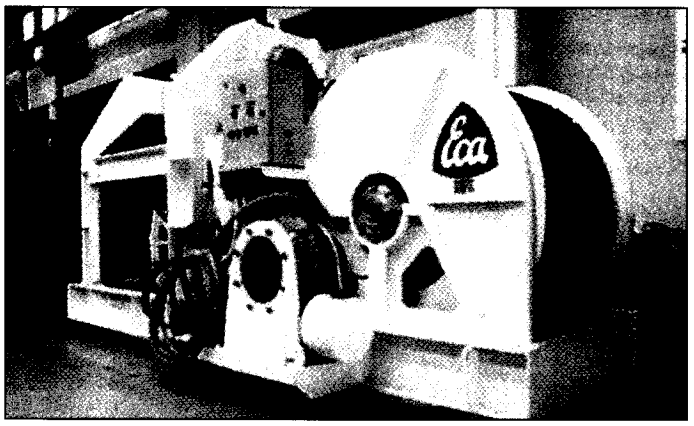
STAR is a rugged system that can be launched in up to Sea States 3 or 4 and will remain operational in up to Sea State 5. The target can be towed at speeds from 3 to 20 kt at depths varying from 20 to 400 m. A minimum speed is necessary for the



The towed body of the STAR submarine target, which trails the acoustic repeaters (ECA) ***NEW***/0038105



The depressor of the STAR submarine target system. The depressor is towed ahead of the target and maintains the set depth. (ECA) ***NEW***/0038106



The hydraulic winch towing system of the STAR submarine target (ECA) ***NEW***/0038107

hydrodynamic depressor to perform its function. In the event of cable breakage, the tail module ensures hydrodynamic stability of the antenna, as well as its recovery.

Sensors in the towfish transmit the heading and depth to the surface ship. When the target's antennas receive the torpedo sonar signals, each of the repeater modules retransmits the signal received at the appropriate level, to simulate the acoustic return from a submarine. The simulation operates within a wide frequency band to protect the confidentiality of the torpedo's exact frequency. The torpedo's signals are also retransmitted by each module to the towing ship and recorded on board.

Operational status
Available and in service with several navies.

Specifications (towfish)
Length: 2 m
Diameter: 300 mm
Weight: 160 kg
Operating depth: 20-400 m

Contractors
ECA Boulogne-Billancourt.

UPDATED

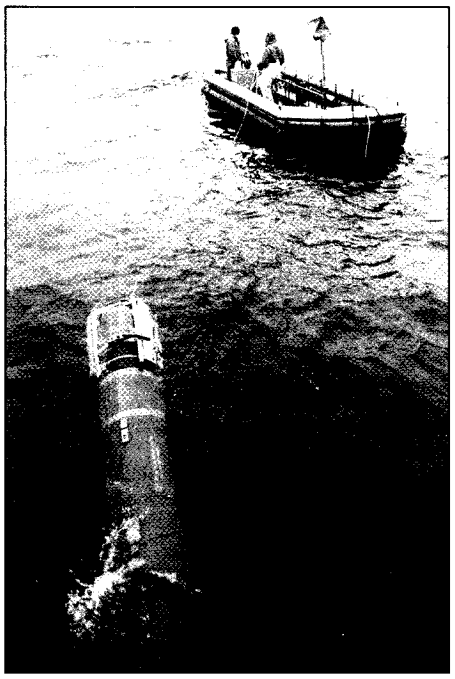
Germany

Subtas

Type
Submarine target simulator.

Description
Subtas is designed for fleet Anti-Submarine Warfare (ASW) training in the open ocean and can replace the need for an instrumented range.

The system operates in preselected run patterns designed according to customer requirements, simulating the dynamic behaviour of a specific submarine and its acoustic characteristics. A variety of run patterns is available for selection prior to launching the vehicle. The predicted run can be monitored on the control unit aboard the launch vessel. Preset operational characteristics include prerun



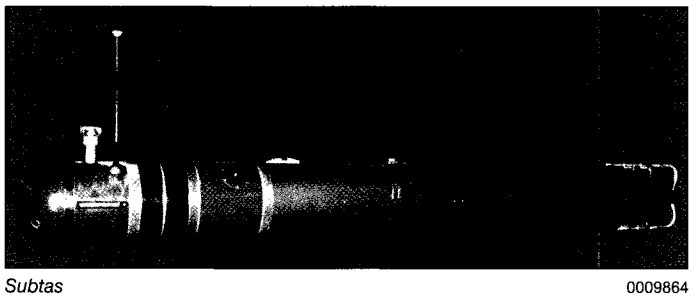
Recovery of Subtas unit (L-3 Communications ELAC) 0038855

parameters, run pattern, speed, depth limits, run time, acoustic mode/levels, carrier course/speed and latitude/longitude.

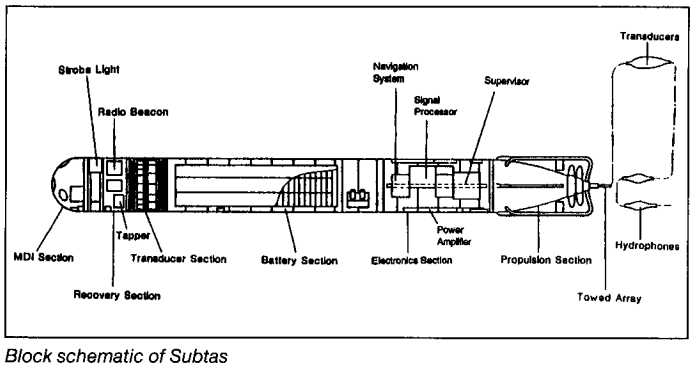
Three microprocessor-controlled main units supervise the entire system: a navigation computer; an acoustic computer; and a supervisor unit. The navigation computer is a guidance and control system, which uses solid-state digital technology. The computer-controlled acoustic system is especially designed to operate in both passive and active mode. It provides sophisticated true simulation characteristics which are detectable by all types of sonar systems, including homing heads of torpedoes, dipping sonars and sonobuoys. The acoustic performance is achieved by sensors and underwater sound projectors (formed from two transducer rings) situated on the vehicle itself and within a 40 m towed array (in which five sound projectors are mounted) enabling a 225 m long target to be simulated with up to 16 highlights by generating time-delayed echoes.

The acoustic simulation provides two independent noise bands for each mode (active and passive) simultaneously. Each noise band can be preset with either 2 kHz or 10 kHz bandwidth. The sound projectors simulate a submarine's low-frequency propulsion noise and sonar echoes (the LF section provides up to six tonals between 200 to 400 Hz and 5 to 60 kHz). Four hydrophones are mounted in the head of Subtas with two more mounted at the end of the array. These latter hydrophones provide a miss-distance indication system. In passive mode the target emits an AM propeller noise which is adjustable during the run. The target strength of the pulses can also be varied, commands being transmitted by underwater telephone. The main computer controls the overall performance of the system and its functionality. All guidance and control functions are software supported allowing subsequent alteration as required.

The hull and propulsion system of Subtas is taken from the Mk 37 torpedo. To reduce acquistion costs and enable multiple recharging, a nickel cadmium battery has been installed instead of the silver-zinc batteries of the Mk 37, which can only be recharged a limited number of times. Recharging is carried out on deck without the need to remove the batteries.



Subtas 0009864



Block schematic of Subtas

Several comprehensive test functions are incorporated in all systems, providing prelaunch tests as well as continuous failure monitoring of all systems during the run which is carried out by several BITE functions.

Operational status
The system is in production and service with the German Navy and has carried out more than 500 runs. The system is also available for export.

Specifications
Length: 5.2 m
Diameter: 483 mm
Preset speeds: 6-8 or 10-13 kt
Operating depth: 300 m
Operation time: 2.5 h

Contractor
L-3 Communications ELAC Nautik GmbH, Kiel. ***UPDATED***

Italy

BSS

Type
Underwater mobile target.

Description
The BSS has been conceived to provide a high-fidelity emulation of the real dynamics and acoustic signatures of all types of submarines. It is a self-propelled, multispeed, deep running active and/or passive acoustic target, suitable for any type of acoustic torpedo. The BSS is derived from the A184 exercise torpedo and tows an advanced acoustic array tail providing physical dimensions equivalent to the emulated echo. The system comprises the towed array canister and deployment system and a 49 m towed array with 16 independent transducers. The propulsion system consists of two contrarotating propellers, a three-speed 110 kW DC motor, speed commutators and a servo system to contol the fins. Power is derived from a rechargeable silver oxide/zinc 110 kW battery system. The synchronised acoustic transmitter is used for three-dimensional underwater tracking range. The target can perform a wide selection of preprogrammed patterns and automatically can initiate evasive manoeuvres when under torpedo attack. Remote-control is exercised by means of an acoustic underwater telephone link.

An upgrade of the existing BSS, which includes the function of active and/or passive acoustic sonar target emulator and a digital data recording system, will be delivered during 2004. The functions of sonar and torpedo emulators can be activated at the same time in order to allow both submarine hunting (detection and tracking) as well as dynamic trials and the torpedo's operational evaluation. The upgraded BSS simulates a submarine's echoes and/or radiated noise in presence of sonars by means of a devoted spherical transducer, housed in the nose section, while the receiving transducer is located in the towed array

The system is designed for use in ASW training scenarios, for advanced operational evaluation, development proving trials of weapons and sea acceptance trials.

The BSS can be deployed from 533 mm surface air-pulse tubes, 533 mm underwater swim-out or water pulse tubes, or by gravity from tiltable slides.

Operational status
In service with the Italian Navy. Being used for the operational evaluation of the MU 90 torpedo.

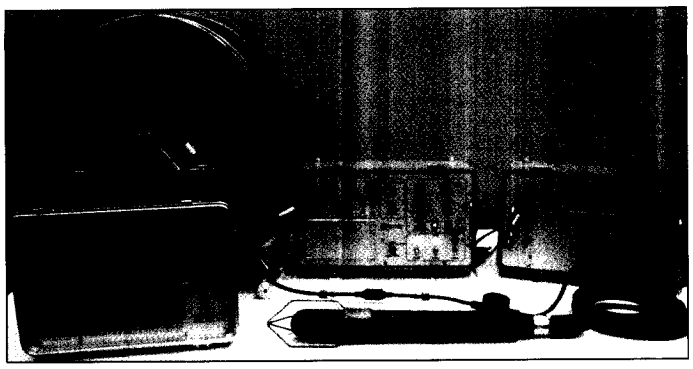
Specifications
Length: 6,085 mm (6,000 mm upgraded BSS)
Diameter: 533 mm
Weight: 1,122 kg (in air) (1,193 kg upgraded BSS)
Speed: 14, 21 or 28 kt
Endurance: 7, 15 or 30 min
Operating depth: 10-400 m
Radiated noise: 116 dB/μPa/√Hz @ 1 m @ 4 kHz (max)

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno. ***VERIFIED***

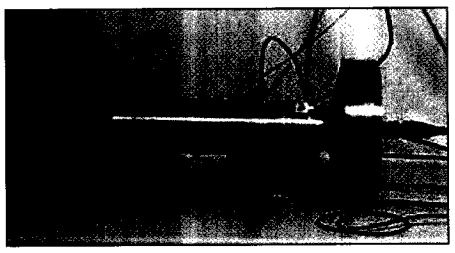
CTS 106

Type
Dual-purpose acoustic target for torpedoes.

Description
The CTS 106 is a stationary/towed manually controlled artificial acoustic target suitable for any type of acoustic torpedo and designed to provide a high-fidelity emulation of the real echo of all types of submarine. Applications include ASW training, operational evaluation, sea acceptance trials and war stock surveillance of torpedoes.



CTS 106 artificial target with stationary underwater body (Whitehead Alenia Sistemi Subacquei) ***NEW***/1022773



CTS 106 towed body (Whitehead Alenia Sistemi Subacquei) ***NEW***/1022766

The stationary version of the target consists of:
- A 76 mm cylindrical underwater body that contains the projector, power amplifier, and pressure sensor
- A receiving section including a hydrophone and preamplifier
- A manual winch with 200 m of underwater cable
- A control console housing the electronics rack including a sophisticated DSP unit, HMI and graphic recorder
- A battery pack to power the stationary underwater unit
- A microcontrolled charge/discharge battery manager

As an alternative to the stationary transducer section, the towed version uses a 127 mm underwater body of fusiform shape with stabilising ring, internal battery pack and power supply, an armoured connecting cable for towing and for transmitting electrical communications, a handling winch and the control console housing the electronics rack, processing units, man/machine interface and graphic recorder.

The device is able to respond to any torpedo time/frequency codified pulse and emulates: target strength; target length; target highlights; target Doppler with coherent range rate and target radiated noise. The CTS 106 operates on a frequency between 12 to 70 kHz; the target strength ranges from –5 dB to +15 dB. The device uses a time/frequency code which can be received by a 3-D tracking range. Maximum towing speed is 16 kt with an operating depth of 20 to 50 m. In stationary mode the vehicle can operate down to 200 m.

Operational status
In service with the Italian Navy.

Specifications
Length: 820 mm
Diameter: 124 mm
Weight: 38 kg
Operating depth: 200 m (stationary); 50 m (towed)
Acoustic transmitting level (max): 130 dB//μPa/√Hz_1 m @ 15 kHz
Receiving sensitivity: –167 dB//V/μPa
Transmitting response: 173 dB//μPa/V @ 1 m
Pressure: 180 dB//μPa @ 1 m
Directivity: omnidirectional

Contractor
Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

MIST

Type
Mobile sonar/torpedo target.

Description
The MIST (Multi-Influence Self-propelled Target) is a recoverable, self-propelled target (with presettable and real time modifiable run) suitable for complete ASW training with such different ASW platforms as:

- Surface ship sonar
- Submarine sonar
- ASW helicopter sonar
- Active and passive sonobuoys
- Fixed-wing aircraft MAD systems (optional)

MIST gives the opportunity to conduct, at low cost or when a submarine is not available, co-ordinated ASW exercises. Using MIST as a submarine emulator, these are carried out from detection to attack under the most realistic operational conditions the vehicle simulating a sonar target, torpedo target as well as the submarine's magnetic signature (MAD capability).

When preset to emulate a torpedo, MIST simulates, according to the preset data, a torpedo in active acoustic search making it possible for submarine torpedo detection and localisation and the consequent submarine counter-manoeuvre training.

The MIST target can be used for:

- Tactical development firings aimed at operational evaluation of torpedoes
- Sea acceptance trials
- Torpedo warstock surveillance
- ASW crew training
- Submarine crew training

MIST, being compatible with the majority of existing sonars in the 0.5 to 10 kHz band and with all modern torpedoes (both heavyweight and lightweight) and other existing systems whose acoustic frequency range is between 10 and 80 kHz, allows both submarine hunting (detection and tracking) as well as the dynamic trials and operational evaluation of torpedoes.

The MIST cinematic, reflecting and acoustic characteristics are such as to emulate within the above-mentioned bandwidth and in the most realistic way a conventional or nuclear (first generation) submarine.

For this exercise the target tows a distributed array composed of a number of receivers and transmitters arranged along an electric cable connected to the stern of the body.

MIST can be equipped with a pinger capability for the real time trajectory tracking within a 3-D test range.

MIST is designed for launch using two different surface systems such as slide launchers or swim out launcher. In the case of deployment from a submarine, MIST is designed to be launched using both swim-out and, upon customer request, water impulse techniques.

Some acoustic and cinematic parameters can be modified during the sea mission by means of coded signals transmitted in the 8 to 11 kHz band through a dedicated underwater telephone.

The characteristics of MIST allow it to be launched from different systems installed on surface ships using different launch techniques, or from submarines:

- Using the swim-out technique from a submerged tube on a surface ship. The target is loaded on the swim-out launcher (installable on a wide range of surface platforms). The towed array is stored in a dispenser, which is fixed at the rear side of the launcher
- Using a gravity release system on a surface ship. The target is loaded on a slide launcher (installable on a wide range of surface platforms), which mainly consists of a tiltable guide which allows MIST to be launched. The towed array is suspended from the upper part of the system, from which it is automatically deployed during the launch
- Using swim-out or water impulse techniques from a submerged tube on submarine. The towed array is stowed in a dispenser fixed at the rear side of the tube

The MIST system is composed of three main groups of materials and equipment:

- The underwater mobile target together with its towed array
- A set of operational equipment to pre-set, control and launch the target
- Sets of workshop equipment to control, maintain, prepare and evaluate the MIST launch

The underwater mobile target MIST comprises:

- The vehicle
- The towed array (acoustic transponder, noise generator and MAD)
- Fittings for protection and launch

The vehicle is derived from the Whitehead BSS underwater mobile target, and retains as far as possible the same dimensions, configuration and components.

From fore to aft the target consists of the following subsystems:

- Nose
- Exercise head
- Battery
- Control and guidance
- Motor
- Towed array
- MAD section

Specifications

Overall length: 6,089 mm
Diameter: 533 mm
Weight: 1,122 kg
Towed array length: 42 daN
Stabilised length: 7 m
Towed array and stabilised weight: 16 daN
Vehicle buoyancy: >10 daN

Contractor

Whitehead Alenia Sistemi Subacquei SpA, Livorno.

UPDATED

Netherlands

Socrates

Type

Towed acoustic underwater source.

Description

Socrates (Sonar CalibRAtion and TESting) is a sophisticated and versatile towed acoustic underwater source designed to perform in a number of varying applications including:

- Simulation of a submarine in the testing and evaluation of ASW active sonar systems
- Operation as a submarine target simulator in naval exercises
- Acting as a target for navy torpedo launch exercises
- Providing a convenient and easy-to-handle sound source as part of an ASW active sonar system
- Operation as a versatile towed acoustic source for oil exploration

The towed body is fitted with a very high power and broadband state-of-the-art LF transducer with excellent acoustic characteristics.

The vehicle is controlled from an PC carried by the parent vessel and based on dedicated digital signal processing hardware. This allows the generation of a wide variety of acoustic pulses and different operation modes, including acoustically triggered Doppler-shifted multiple highlight submarine target strength simulation.

A large number of pulses are pre-defined, but specific user defined pulses can be downloaded, even when the vehicle is in operation.

Socrates consists of a towed body with excellent hydrodynamic properties, a faired tow cable, a deck cable, an operator interface on a PC based on Microsoft Windows and a power amplifier rack containing power amplifiers, power supply interface and transformer.

The stainless steel towed body contains the acoustic source, a pressure box for a transformer and non-acoustic sensors and some spare room for a smaller HF sound source. The Thales Underwater Systems Free Flooded Ring (FFR) broadband transducer can be replaced by other types to allow operation in different frequency ranges.

Operational status

Used by the Royal Netherlands Navy for development and testing of LF active sonars. Socrates can be rented for customer defined sea trials.

Specifications

Weight: 600 kg (in air)
Length: 2 m
Frequency: 950 - 2,100 Hz (-3 dB)
Transmit level: 210 dB re 1µPa/m (max)
Doppler: ±40 kt

Contractor

TNO-FEL, The Hague.

NEW ENTRY

United Kingdom

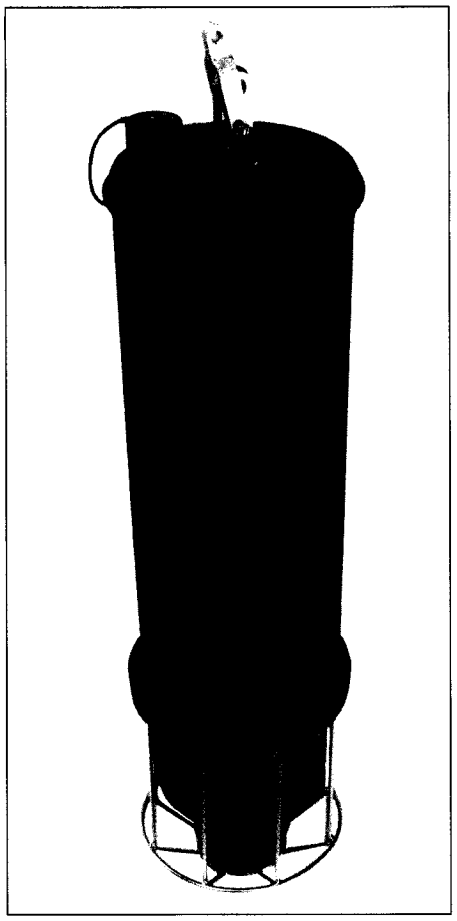
RASAT

Type

Underwater sonar target.

Description

RASAT (Radar And Sonar Alignment Target) is a programmable, self-contained transponder sonar target which is compatible with a wide range of modern, high-technology sonars, including hull-mounted and dipping types. It can be used for the alignment of surface ship or helicopter systems, can act both as a transponder for active sonar and as a CW noise source for passive sonar and it can be deployed from a ship or helicopter. Operating depth is selectable from 15 to 50 m and bandwidth is 3 to 12.5 kHz for the basic model; other operating depths and bandwidths are available.



RASAT sonar target

Operational status
Many systems in service with the Royal Navy and other Asian navies.

Contractor
Ultra Electronics Ocean Systems , Weymouth, Dorset.

VERIFIED

SLUTT/G 733

Type
Programmable Ship-Launched Underwater Transponder Target (SLUTT).

Description
SLUTT is designed to simulate underwater targets enabling both active and passive functional testing of a wide range of surface ship, submarine and helicopter sonar systems checking sonar range and bearing accuracies. The transponder can also be used for sonar/radar alignment checks and operator training and as a sea acceptance trials target.

It features user-programmable sonar parameters, multiple output signals in FM or CW for realistic sonar simulation, provides a noise source for checking passive sonars and may be used as a transponder or a free-running pinger.

SLUTT is a self-contained unit suspended at depths of between 10 and 120 m beneath a free-floating buoy fitted with a radar reflector. This method of deployment allows interrogation of the transponder by both surface duct and variable depth sonars. A towed version can be supplied where accurate Doppler measurements are required.

All incoming acoustic signals are monitored and SLUTT responds to signals which have the correct frequency and continuity. A suitable time-simulated output echo pulse is then transmitted. SLUTT is immune to the reverberations set up by the transponder pulse and to incorrect inputs. SLUTT simulates a typical beam aspect submarine target or an incoming torpedo, by providing suitable FM, CW and pulsed noise outputs to enable both active and passive sonars to be checked for range and bearing accuracy against relevant radar readings.

The system is provided with a battery charger, hand-held programming unit and lead, handbook and stowage case.

Operational status
In service use with the Royal Navy and many other navies.

Contractor
MARCOM Defence, Chichester, West Sussex.

UPDATED

Subtrack

Type
Sonar target system.

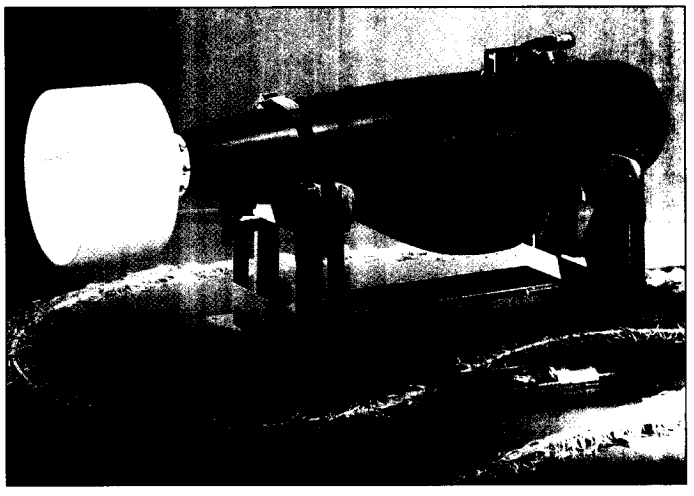
Description
Subtrack is designed for training sonar operators and complete command teams projecting simulated target spectra at sea for operation with all types of passive sonar and passive ranging systems. It also generates pulses for exercising intercept sonars and includes an echo repeat subsystem for use with active sonars. It can also be used to prove sonar systems and aid new developments, prove new installations and post refit installations for all types of sonars - including hull mounted arrays, towed arrays, flank arrays, intercept sonars and active sonars. In addition, it has applications in mine warfare - as part of an influence minesweeping system, including a very low-frequency sound source producing outputs from as low as 4 Hz at high power. Other applications include acoustic and oceanographic research, range calibration and pop-up targets on tactical ranges.

Subtrack essentially comprises the following system components: a low-frequency acoustic projector (hydrosounder) to generate frequencies from <30 Hz to as high as 4 kHz; additional ceramic transducers can be used to operate from 3 up to 100 kHz, or higher. A computer controlled signal generator is used to produce multiple narrowband spectra, broadband noise, modulation and transient effects for use with passive sonars; software and processing to produce an echo repeat facility for use with active sonars; power amplifiers to drive each transducer; and acoustic monitoring and measurement facilities.

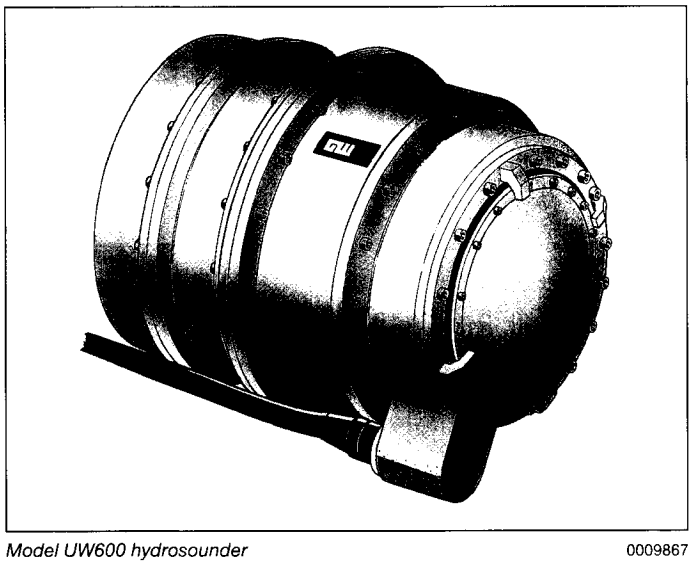
A hydrodynamic body housing the mechanics is towed between 600 and 1,000 m astern of a vessel at depths of up to 186 m in up to Sea State 3 and higher.

Subtrack may be supplied in the following configurations: towed system for deployment from COOP; surface ship hull-mounted system; submarine hull-mounted system to augment the submarine signature, thus providing a submarine target with variable acoustic components; minesweeping variant for towing configuration below an otter, or hull-mounted in a drone; statically deployed system for research applications; seabed mounted systems for use on underway and tactical ranges; free swimming systems with integral GPS, battery operated, deployed below a buoy to provide a single or multistatic sound source.

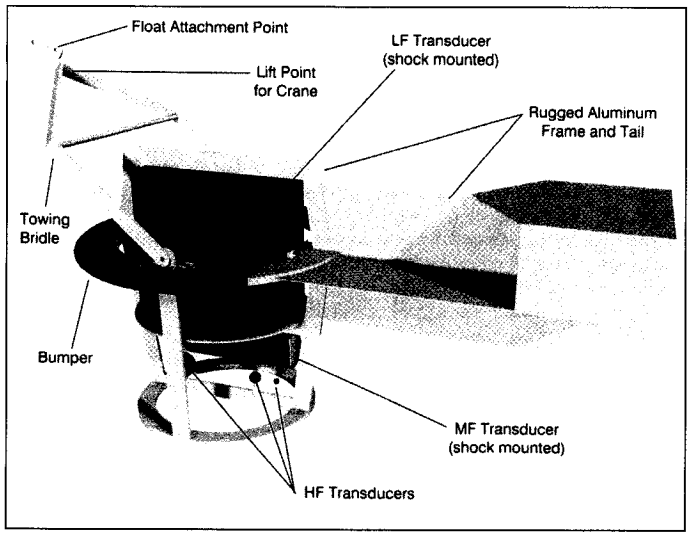
The low-frequency capability and output source level have recently been enhanced by the introduction of a new transducer. Hydrosounder model UW600 is able to generate output signals at frequencies as low as 4 Hz and as high as 2 kHz, with source levels as high as 190 dB re 1µP @ 1 m. Variants of the UW600 include a shock rated device for minesweeping activities, as part of an influence sweep system a VLF version and a LF version.



Typical Subtrack towfish 0009866



Model UW600 hydrosounder 0009867



Typical minesweeping towfish 0009868

Operational status
The UW350 covers the 20 Hz to 20 kHz band with a source level of 165 dB/1µPa @ 1 m. With the UW600 this projector is used in many Subtrack systems.

The UW300 projector operates in a lower frequency band and is used by the UK Royal Navy in Sonars 2071 and 2058. Variants of Subtrack systems are in use with the navies of 10 countries, throughout the world including Australia, France, Japan, South Korea, Netherlands, Spain, Sweden and the UK. Subtrack systems are also specified by many defence associated research agencies.

Contractor
Gearing & Watson Electronics Ltd, Hailsham, East Sussex.

UPDATED

Type 2058/SoundTrak series

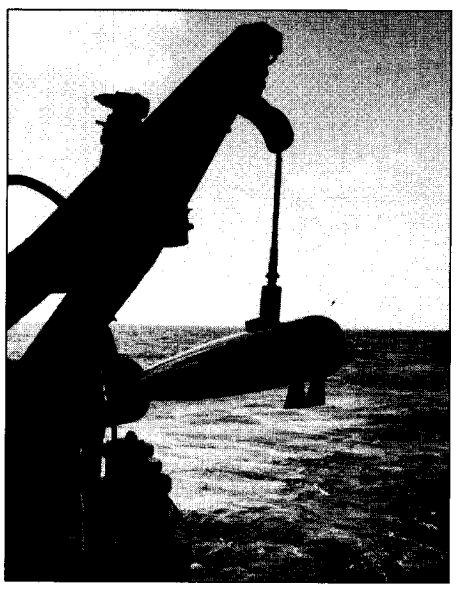
Type
Sonar target simulators.

Description
The Type 2058/SoundTrak family of acoustic target simulators is designed to be used with surface ships, submarines and aircraft in ASW training, system performance assessment and other operational applications, which require a versatile, acoustic source.

The system consists of a hydrodynamic body, containing the electro-acoustic transducers, which is towed behind a surface ship and is connected to an inboard electronics rack containing the signal generation and drive circuits.

The system is able to produce realistic acoustic target signatures, transmitting simultaneously a mixture of narrowband tones and broadband noise.

The nature of the output, in terms of narrowband frequencies, noise bands, signal amplitudes, modulation, can be programmed manually and the system can store up to eight preprogrammed pages of data. Additionally, the system can transmit acoustic signatures which have been previously recorded or which have been generated using computer simulations.



Type 2058 towed sonar source

- SoundTrak features exceptional LF performance in relation to its very small physical size and has been designed to operate with ships' and submarines' passive sonar systems.
- SoundTrak II, as well as providing low-frequency performance, also includes both narrowband and broadband high-frequency signals and is able to echo-repeat signals received from ships' or submarines' active sonars.

Systems can be supplied to specific requirements either as an enclosed body capable of being towed at high speed, or as an open frame structure.

The SoundTrak target simulators reduce the need to deploy ships and submarines as targets in exercise roles. They may also be used in applications which include acoustic countermeasures, own signature confusion, force countermeasures/decoys and so on.

The reliability of the acoustic source, provided by the SoundTrak target simulators, is also well suited to assessment of the performance of sonar systems, sonobuoys and noise ranges.

The SoundTrak target simulators can be deployed from a variety of vessels using standard winch systems.

Operational status
SoundTrak is currently in service with the Royal Navy (as Sonar 2058) and other European (French) and Asian navies. SoundTrak II is also currently in service in Asia.

Contractor
Ultra Electronics, PMES Rugeley, Staffordshire.

VERIFIED

United States

Mk 30 Mod 2

Type
ASW Training Target.

Description
The Mk 30 Mod 2 is designed to provide surface ships, submarines and aircraft with an effective ASW training aid that can simulate the acoustic, magnetic and dynamic performance of a submarine for ASW sensors and torpedoes to detect, classify, track and pursue in a realistic operational training environment. The Mk 30 features programmable realistic acoustic and dynamic attributes of nearly all submarine classes and the capability to automatically respond to and evade interrogating sonars. The target is based on a reliable and easily maintainable UUV. The active sonar operates in three concurrent sonar bands.

The vehicle has been designed using a combination of COTS and unique electronics integrated with embedded software. The target provides a closed-loop system of mission performance, self diagnostics and adaptability for future mission needs, including test and evaluation of other units and technologies such as torpedo proofing and so on.

The system provides the user with a complete suite of support and test equipment, which allows full maintenance of the target. The launch control system provides the user with all pre-launch diagnostics and data retrieval capabilities. The mission preparation and analysis system provides a wide array of submarine simulation characteristics as well as post-mission data analysis. The test equipment provides the capability for complete target turnaround and test in one unit. The acoustic command link shore-based controller provides up to 25 underwater communications commands at ranges in excess of 9,145 m with the target during a mission exercise.

Operational status
The system underwent rigorous OPEVAL and TECHEVAL with the US Navy in 1999. Full rate production is planned for FY04.

Specifications
Passive broadband: 140 dB (max)
Active sonar: 180 dB, 8 temporal highlights
Active torpedo: 190 dB, 8 temporal highlights
MAD: 0.5 gamma at 450 m – selectable per leg
Speed: 5 to 20 kt
Endurance: 12 h at 5 kt (without MAD)
Operating depth: 15 to 305 m

Contractor
Raytheon Company Naval & Maritime Integrated Systems, Portsmouth, Rhode Island.

UPDATED

Mk 39 EMATT

Type
Expendable Mobile ASW Training Target (EMATT).

Description
The Mk 39 EMATT is easily deployed from surface ships or ASW aircraft. EMATT offers ASW forces the opportunity to practise the complete ASW problem from detection to attack in the open ocean in any area of operations.

The capability for launch from ASW aircraft gives EMATT an added dimension previously lacking in ASW training. The Mk 39 also has the capability to simultaneously interact with all sonars, towed arrays, dipping sonars and sonobuoys, both active and passive. Operational commanders have the opportunity to conduct co-ordinated exercises with several different air and surface ASW platforms.

EMATT contributes to fleet readiness by:

- increasing ASW tactical proficiency in anticipation of actual submarine operations
- providing a means to complete readiness exercises when submarines or trainers are not available, especially on deployment
- being compatible with most major acoustic underwater ranges
- giving operational commanders the option to conduct ASW training anytime, anywhere, under demanding, at sea conditions.

EMATT is a versatile all-weather, day and night target. The new programmable upgraded Mk 39 is the same size as a standard 36 in sonobuoy and may be loaded in any sonobuoy chute for deployment. For surface ships, it may be slipped over the side by hand. Additional programmable features include: field programmability; passive tonal level; speed; course; depth; integrated pinger and autonomous manoeuvre. The program is a Windows 95/98/2000/NT and is designed for a PC or laptop with at least a Pentium processor or better, with VGA capacity.

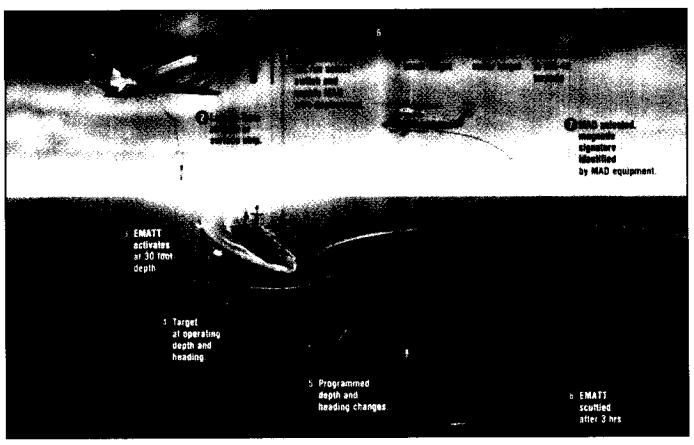
These features enhance ASW training at all levels for both surface ship and air crews.

Prior to launch, one of three preprogrammed run geometries may be selected. Each run may be set for operation with or without the MAD capability. After deployment, the vehicle runs for up to three to six hours depending on the speed selected. Acoustically, it generates four discrete frequencies. It has a unique echo repeat system which receives, stores, then retransmits active sonar signals enhanced to simulate the echo from an actual submarine. It is also compatible with the Mk 46 torpedo to provide acquisition and homing response.

For use with MAD-equipped aircraft, EMATT deploys a 100 ft wire through which DC power is pulsed to create a magnetic field around the vehicle. The signature is unique and provides excellent tactical training for aircrews.

Operational status
Over 14,000 Mk 39s have been produced for the US and foreign navies. The target has been purchased by 17 nations and navies in service worldwide.

Specifications
Length: 900 mm
Diameter: 122 mm
Weight: 10 kg
Operating depth: 23-183 m
Operating time: 3 to 6 hours (depending on speed selected)



Sequence of operation of Mk 39 EMATT

Contractor
Sippican Inc, Marion, Massachusetts. ***VERIFIED***

SPAT

Type
Self-Propelled Acoustic Target (SPAT).

Developments
The SPAT underwater vehicle was originally developed in the late 1970s for the Israeli Navy. Development of the Mod 1 was initiated in the early 1990s to expand the passive and active frequency spectrum, improve the fidelity of the passive emissions and add highlights to the repeated emissions to give a truer representation of a submarine echo. Other upgrades include a new battery and motor to extend the operating range.

Description
SPAT simulates the acoustic and dynamic characteristics of a diesel electric submarine responding to torpedo and sonar activity to provide a realistic training target for surface ships, submarines, helicopters, fixed-wing aircraft and acoustic homing torpedoes. The target tows an echo repeater mounted at the end of a 12 m long cable.

Among the features incorporated in SPAT are programmable acoustic signature (broadband emission power bands, levels and peak frequencies, and narrowband) and vehicle dynamics (modulated flow tonal power and frequency-multiple bands and propeller noise), together with training levels, all of which can be prepared in advance on any PC. The transmission response features various types of signal including FM, swept FM and pulse coded. The outputs vary according to the speed of the vehicle to provide a realistic response. A true echo repeater is incorporated with programmable characteristics such as frequency (between 4-85 kHz) and pulse width (1 ms to 1s). Course plots can be generated for run verification and are available on CRT or plotter. An optional MAD capability is available.

SPAT contains an eight-hour solid state data recorder with 14 data channels, active acoustic analysis, three programmable band pass filters and programmable thresholds. Acoustic activity and vehicle data versus time is recorded together with automatic run identification showing date, time and vehicle serial number and vehicle status shutdown. It has a graphics output for easy post run analysis.

The vehicle can be deployed from the deck (gravity slide, automatic or manual), submarine (torpedo tube launch) or helicopter deployment and incorporates a portable, lightweight fire-control unit. It is compatible with most ranges and incorporates retrieval aids for use in open water.

For submarine launch the torpedo tubes are fitted with liners which can accommodate two SPATs and each torpedo tube can be fitted with two liners. The vehicle swims out of the tube.

Operational status
The SPAT Mod 0 is operational in three navies and SPAT Mod 1 is operational in one navy and has entered service with the UK Royal Navy.

Specifications
Length: 3,937 mm
Diameter: 254 mm
Weight: 181.5 kg
Speed: 4 to 12 kt
Operating depth: 3-300 m
Operating time: 2-6 h
Target strength: –12 to 21 dB
Output (max): +185 dB/1µPa/m
Dynamic range: 60 dB
Broadband
Frequency: two bands (user defined) range in each band 1 to 85 kHz
Levels: band 1-90 to 130 dB/1µPa/m at lowest frequency; band 2-80 to 125 dB/1µPa/m lowest frequency
Narrowband
Frequency: 100 Hz to 2 kHz
Number of tones: 6
Tonal level: 100 to 150 dB/1µPa/m

Contractor
Northrop Grumman Corporation, Electronic Sensors and Systems Division, Oceanic and Naval Systems, Annapolis, Maryland. ***VERIFIED***

GENERAL NAVIGATION EQUIPMENT

Australia

MCS

Type
Minesweeping control system.

Description
This multipurpose navigation system has been designed specifically for MCM operations. It can be used for general navigation as well as for route survey, minehunting and minesweeping operations.

The system comprises two operator workstations – a tactical and a helm station – each of which acts independently offering redundancy in the case of equipment failure. The helm display enables the operator to drive the ship accurately along the planned route. The display is controlled through a touch-screen monitor – no keyboard and trackball being provided.

The system uses the latest graphical user interface (GUI) technology and software developed for the Windows NT™ operating system.

The MCS can read and simultaneously process both ECDIS and raster electronic chart data while displaying vessel position and planned route in a large number of chart survey datums. A large number of navigation tools are included for navigators, while easy-to-use software allows non-navigators to plan and navigate Q-routes following NATO practice. The navigation tools allow a navigator to import updates to electronic charts to maintain them up-to-date while chart information about navigation aids and hazards (including photographs and video footage) can be displayed. Manual position fixes can be entered onto the charts as well as additional notes, symbols and range and bearing data.

For additional safety and as an aid to training the system, allows an operator to plan and simulate a voyage and/or mission without leaving port and to interrogate the ECDIS database to view a wide variety of information about chart objects.

All software generated alarms and vessel position at time intervals selected by the operator are saved to disc. This information can be replayed by the tactical station while underway to ascertain if parts of the mission need to be repeated or following completion of a mission to review and assess the operation. Playback speed is selected by the operator and can be many times faster than the data recorded.

Operational status
Fully developed and available.

Contractor
ADI Limited, North Ryde, New South Wales.

VERIFIED

Denmark

Navigation Data Management

Type
Navigation data management systems.

Description
The navigational systems, often referred to as Navigation Data Management Centres (NDMC) or Reference Data Distribution Systems (RDDS), provide the link between navigation sensors and the users of navigational information onboard a naval platform.

The systems perform tasks comprising:

- Initialisation, monitoring and control of navigational sensors
- Data acquisition and recording of navigation sensor output
- Preconditioning of sensor data
- Data fault detection
- Internal data distribution within the navigation system.

Given valid navigational sensor data the following tasks are performed:

- Navigation data processing
- Data formatting
- Navigation data distribution

Finally the systems also typically provide functions for:

- Supervision of operational status
- Simulation functionality

Contractor
Eiva a/s, Hasselager.

NEW ENTRY

France

Minicin

Type
Submarine and surface vessel inertial navigation system.

Description
Minicin has been developed for submarines and ships requiring high-accuracy position and attitude information. It was therefore designed to provide continuous heading and position (latitude and longitude) data for navigation purposes as well as attitude (roll and pitch) and velocity (north, east and vertical) readings required as inputs by modern combat and weapon systems. Each system consists of: an inertial platform with its adjustable support; an electronic unit; and a remote-control unit.

The inertial platform comprises three gimbals. It is fitted with three dry gyros (each having two degrees of freedom) and two high-accuracy accelerometers. The essential feature of the system is the 'gyro monitor', an effective continuous gyro drift supervisor.

The inertial system's electronic package comprises a set of replaceable cards and modules. It uses standardised components designed to meet military standards and specifications and relies heavily on efficient microprocessors. The remote-control unit provides the interface between the operator and the system. This element, which can be installed at the most appropriate point in the vessel, provides the operator with a simple yet effective means of dialogue (use of menus and function keys) and provides all the resources required for system initialisation, recalibration, monitoring and hardware status, display functions and so on.

Operational status
No longer in production (replaced by SIGMA 40 XP). Minicin is currently in service on numerous vessels in the French Navy, including nuclear-powered attack submarines, the *Charles de Gaulle* nuclear-powered carrier (three systems), anti-aircraft and anti-submarine frigates and destroyers, aircraft carriers and so on. Units are also operational on board different foreign navy submarines including the Swedish Gotland class and the new Agosta 90 B of the Pakistan Navy.

Contractor
SAGEM Navigation and Aeronautic Systems Division, Paris.

UPDATED

SIGMA 40 XP

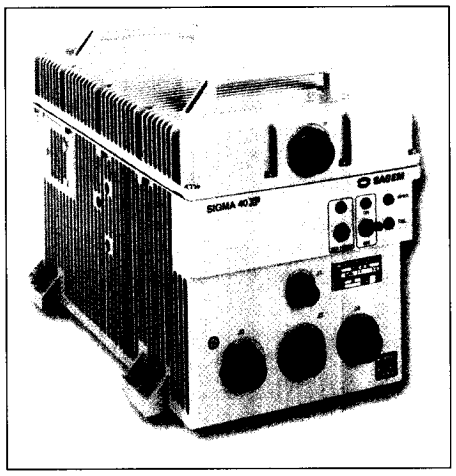
Type
Submarine inertial navigation system.

Description
SIGMA 40 XP (eXtended Performance) is a strap-down ring laser gyro inertial navigation system specifically engineered for submarines, either new or at modernisation stage.

With its 1 Nm/24h free inertial performance, SIGMA40 XP provides long submerged endurance. Being compact and lightweight, it offers the answer to the weight and volume challenge of submarine design.

Entirely developed and manufactured by SAGEM, it elaborates and distributes the following information:

- Attitudes: heading, roll and pitch, and their angular rates
- Position: latitude, longitude and depth
- Horizontal and vertical linear velocities



Sigma 40 XP
(Sagem)
NEW/1067158

The equipment includes:
- The Inertial Navigation Unit (INU) integrating the inertial sensor block and computing modules with enhanced filtering software
- The control and display unit
- The alignment support (SDI) fixed to the vessel, which allows quick installation or removal of the INU. It is provided with a specially designed shield that gives higher magnetic protection to the INU.
- An optional support (with same magnetic shield) offering higher resistance to shocks can be proposed to meet extreme requirements.

Besides its high MTBF (12,000 h) SIGMA 40 XP is a fully solid state device with no moving parts and no preventative maintenance requirements. It thus offers improved operational availability and reduced life cycle cost.

Operational status
SIGMA 40 XP uses the same functional units as SIGMA 40, which is in full production for surface ships. Over 100 SIGMA 40 are in service in more than 20 navies. To date contracts for SIGMA 40 XP have been signed with three navies.

Specifications
Dimensions: 285 × 225 × 410 mm (INU)
426 × 450 × 580 mm (SDI)
Weight: 24 kg (INU); 51 kg (SDI)
Power: <60 VA (24 V DC)
Heading: <3° arc minute Sec Lat (RMS)
Roll and pitch: <1° arc minute (RMS)
Inertial navigation: 1 Nm/24 h TRMS (autonomous)
Interface: RS 422, synchro
Data availability: 3 min (full accuracy 15 m) at dockside
6 min (full accuracy <30 min) at sea

Contractor
SAGEM, Navigation and Aeronautic Systems Division, Paris.

NEW ENTRY

TSM 5750/TSM 5740

Type
Doppler log for surface ships/submarines.

Description
These two logs, respectively for installation on surface ships and submarines, provide Doppler measurement of speed relative to the seabed. The systems can measure up to 40 kt in longitudinal direction and up to 20 kt in transverse. Operational depth for the two systems is: 2 to 200 m for the TSM 5750 and 1.5 to 150 m or 0.5 to 80 m for the TSM 5740 unit. Speed accuracy as measured is 0.01 kt at speeds up to 9.99 kt and 0.1 kt between 9.99 and 40 kt. Depth accuracy is 0.1 m down to 99.9 m and between 99.9 m and 200 m accuracy is 1 m.

Contractor
Thales Underwater Systems, Sophia Antipolis.

VERIFIED

Germany

Alpha

Type
Doppler log.

Description
The Alpha Doppler log DLO/DLU high precision underwater acoustic navigation sensor, is designed for surface vessels and submarines to measure speed over ground and through the water, as well as water depth. It displays track distance over ground and through water and water currents. The system is designed for integration into complex navigation systems, but is also capable of fully autonomous operation.

A number of outputs are available including:
- Speed and distance sailed over ground and through the water simultaneously
- Speed and direction of current relative to the vessel's along axis with selection of depth of current layer by control
- Vertical speed (for submarines)
- Water depth below the transducer and
- Drift angle of the vessel

The log provides rapid bottom recognitions in harsh environments such as high ambient noise emanating from propellers or high sea states. Enhanced measurement accuracy is provided using non-linear evaluation procedures. It offers good low speed precision, and measurements are independent of the pitch and roll of the vessel as well as its trim state. There is also a minimal transmission power available for silent ship mode for submarines.

Two frequencies are available, 125 kHz and 260 kHz. The transducers are suitable for both submarine and minehunter application and are flush mounted with the ship's bottom. The transducers are underwater pluggable to allow exchange by a diver, and no gate valve mount is required. The system provides automatic compensation for temperature and salinity variation.

Operational status
In service on minehunters, frigates, submarines and civilian vessels.

Specifications

	125 Series	260 Series
Transducer		
Frequency	125 kHz	260 kHz
Beam angle (from vertical)	34°	33°
Beam configuration	5 beam	5 beam
Max operating/diving depth	500 m	500 m
Speed range		
Along (ahead)	0-50 kt	0-35 kt
Along (astern)	0-5 kt	0-5 kt
Transverse	0-10 kt	0-10 kt
Vertical	0-10 kt	0-10 kt
Bottom track (ground speed)		
Range of depth	2-500 m	1-200 m
Water track (relative speed)		
Water track layer	4-30 m	2-24 m
Ping rate		
Water depth dependent	1-25 Hz	2.5-25 Hz
Transmission power		
Adjustable	180-210 dB rel. µPa/1 m	176-206 dB rel. µPa/1 m

Contractor
SAM Electronics GmbH, Hamburg.

UPDATED

VE 5900

Type
Naval echo-sounder.

Description
The VE 5900 is a naval navigation echo-sounder system of modular design, based on the VE 59 series of echo sounders.

The basic version of the system consists of a control and display unit (SEB 5900) including the transceiver with processor, power supply, interface and the integrated control and display components; one or two transducers with single or dual operating frequencies can be connected according to requirements. The system can be operated with transducers of other manufacturers. In an extended version the system can be fitted with up to four transducers using two different frequencies and offers the possibility to integrate, process and display environmental data (pressure, temperature, density, salinity and sound velocity of the water). For use on submarines both water depth and diving depth are recorded.

All depth data recorded by the system are displayed digitally and graphically on a flat colour TFT monitor and are stored internally for at least 168 h and can be recalled for analysis. The data can be passed on to further processing equipment (computer, printer, mass storage medium and so on). Interfaces and protocols in NMEA format are available for data transfer and integration into other onboard navigation systems including log, compass, sound velocity, DGPS, ECDIS and heave sensors.

Modern digital signal processing enhances the system's bottom detection capability and can also process bottom structure information. Better resolution of the monitor (256 colours) compared to coventional B/W paper recordings offers a more differentiated presentation of bottom structures. These features combine with a wide range of selectable operating frequencies (12.5; 30; 50; 200; 400; 1,000 kHz, with others on request). The system is thus able to cover any possible requirement for all water depths.

There are three printing options available: printing the screen, printing out of the storage memory and compressed printing (recording the depth data over compressed time scale).

Specifications
Frequencies: LF: 12; 12.5; 30; 50; 200 kHz
HF: 400; 1,000 kHz
Maximum standard scale settings: 0 to 1,000; to 3,000; to 6,000; to 10,000 m
Units: metres, fathoms, feet selectable
Power supply: 160 to 330 V DC, or 88 to 264 V AC, 47 to 440 Hz
Power consumption: approx 150 VA

Contractor
L-3 Communications ELAC Nautik GmbH, Kiel.

NEW ENTRY

United Kingdom

Electronic Chart display unit (ECDIS)

Type
Electronic chart display system.

Description
The ECDIS is a high-resolution display for bridge navigation and operations room planning purposes. It is capable of displaying official chart data from hydrographic offices including the international S57 format and the UK Hydrographers Admiralty Raster Chart Service.

User facilities allow navigation tasks such as position plotting, passage planning, visual fixing and route monitoring to be carried out using graphical symbology overlaid on the chart display. The system can be self-contained with direct interfaces to the navigation sensors and will meet the International Maritime Organisation (IMO) requirements for Electronic Chart Display and Information System (ECDIS) which provides it with the legal status equivalent to a paper chart.

In addition, the radar interface can be enhanced to allow both ARPA or combat system tracks to be overlaid on the chart and to have the complete radar picture superimposed.

The database of navigation chart information can be added to at any time and updated easily to incorporate the latest notices to mariners. Data and corrections can be supplied either on a CD-ROM or electronically via communications satellites direct to the ship.

Operational status
The unit is currently in production and running the ARCS application. Trials are continuing of the ECDIS upgrade awaiting IMO regulations regarding functionality and test methods.

Contractor
Kelvin Hughes Ltd, Hainault, Essex.

VERIFIED



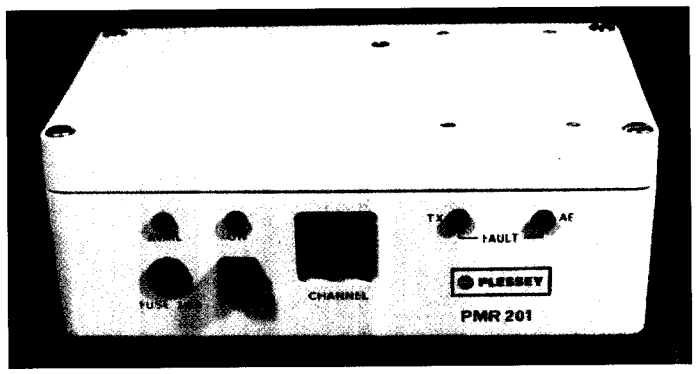
Electronic chart display unit

Honeypot beacon

Type
VHF location beacon.

Description
Honeypot is a VHF location beacon operating at standard sonobuoy VHF frequencies which provides the ASW aircraft with a direction-finding location capability to its home base or ship.

The beacon is indistinguishable from normal Lofar sonobuoy transmission to provide a tactical navigation aid in support of anti-submarine warfare operations. It is a low-cost system designed for high reliability and minimum maintenance, and gives the ship's ASW commander flexibility in the choice of navigation aid to recover the ASW helicopter.



Honeypot VHF location beacon

Honeypot operates over the VHF frequency band 136 to 173.5 MHz, to transmit 1 W as an omnidirectional beacon. A channel switch on the transmitter unit allows transmission on any of the 99 sonobuoy channels. The unit is powered from the standard 24/28 V DC supplies.

Honeypot is a portable system, the transmitter unit is designed for installation in a shipborne, naval enclosed environment. The unit is a sealed splashproof housing which may be fitted in any suitable compartment. The system can be supplied complete with a coaxial feed cable and antenna, which may be clamped to any suitable point on the ship's structure.

Operational status
In service with the Royal Navy.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

INTPS

Type
Automatic plotting table with integral navigation computer.

Description
The INTPS (Integrated Navigation and Tactical Plotting System) is a DRT, DDRT, Mk 19 and NC-2 plotter replacement solution for all surface ship and submarine horizontal display requirements. The system is an electromechanical X-Y plotter which projects a light spot cursor through a transparent top surface to illuminate ships or target positions onto a standard navigation chart or plot sheet.

It incorporates a computer system which carries out a range of navigational calculations and presents the results on a hand-held keyboard display unit.

It is capable of accepting navigation data from a wide range of sensors and processing the information to provide accurate position information. It is also capable of combining these with visual fixes from the navigator to allow calibration of the navigation aids.

Comprehensive navigation facilities include passage planning, waypoint calculation, great circle or rhumb line sailing, passage of intended movement, closest point of approach, pool of errors, station-keeping and sea area control.

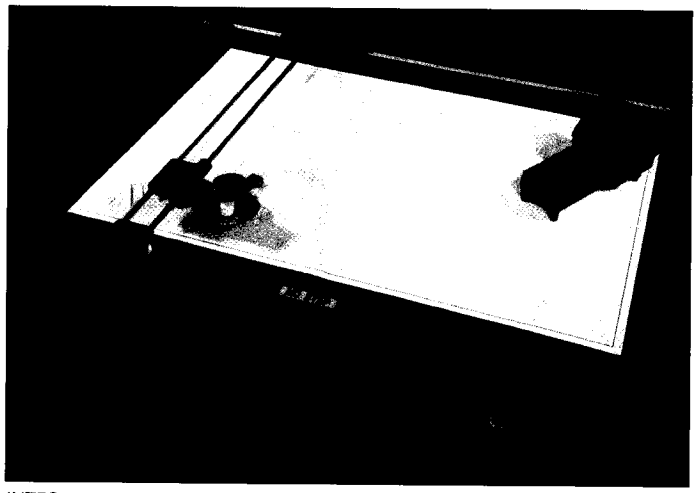
Positions are maintained internally in World Geodetic 84 Datum but compatible data may also be accommodated. Positions may be plotted on chart projections such as mercator, transverse mercator, polyconic, polar stereographic or gnomonic.

A database of tracks is maintained which can be updated either automatically from sensors such as radar, periscope, sonar or manually via the keyboard. Track positions can be held to an accuracy of better than 6 m worldwide and used for preparing the tactical plot. Positions may be entered and displayed in either latitude/longitude, range and bearing or grid co-ordinates. A relative velocity calculation is provided to assist in tactical manoeuvres.

Tactical functions include track projection (forward in time), moving havens, combat system navigation support, missile waypoint planning, naval gunfire support, target localisation (target motion analysis) and maintenance of Economic Exclusion Zones.

An optional data logger may be connected to record position and track information for the purposes of the operational report, mission debrief or training. Passage plans or navigation marks may be stored on magnetic tape for reuse on regular passages such as port egress.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
juws.janes.com



INTPS automatic plotting table on order for the US Navy

Equipment maintenance is organised through self-contained test facilities which include background (non-interruptive) tests and interface tests. Comprehensive maintainer tests are also provided to allow fault isolation down to individual replacement modules.

Facilities are built-in to allow navigation training to be carried out in port or at fixed shore establishments.

Operational status
Currently in production for the US Navy (AN/WSN-6) for installation on board Seawolf class submarines and already in service with a number of NATO navies.

Contractor
Kelvin Hughes Ltd, Hainault, Essex.

VERIFIED

Master Yeoman

Type
Electronic chart table.

Description
Master Yeoman integrates electronic and conventional navigation on the nautical chart, combining the labour saving of electronics with the safety of manual plotting and pilotage.

Having fixed and referenced his chart to the chart table, the navigator has all the vessel's electronic aids output data at his fingertips on the chart.

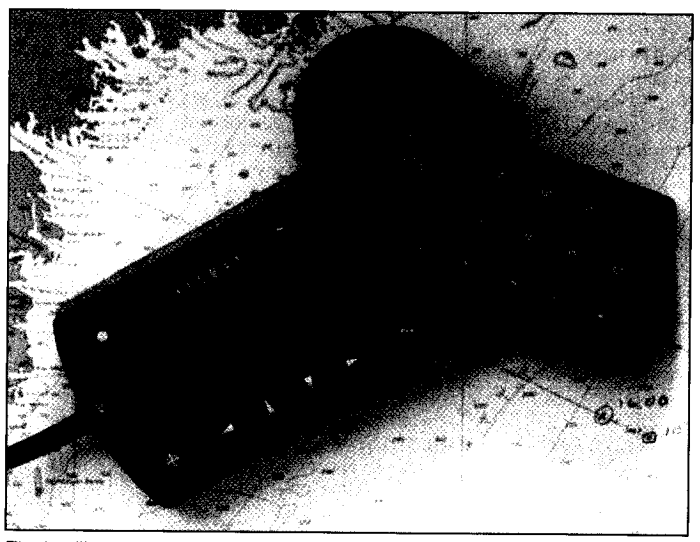
The user interface is the puck, which acts as the system control and display unit. Around the window of the puck are four cardinal point lights indicating the direction the puck needs to be moved on the chart to locate the position or other locations, depending in which mode the puck is activated. To assist speed of plotting, two colours are used — red when larger distances are involved and green when the puck is close to the target radius. When the lights are extinguished the target position is located and plotted.

Master Yeoman operates on latitude and longitude and in its basic form takes output data from a selectable single navigation aid, GPS, Loran, Decca and so on, which is displayed in the puck window. Whenever the puck is moved across the chart the position is displayed and with the press of a key, range and bearing to and from navigation position, a mark position or waypoint is displayed.

Master Yeoman provides the navigator with all information required for position plotting, route planning, waypoint acquisition, range and bearing calculations and multiple chart navigation.

Master Yeoman can be expanded to take in speed, log and gyro outputs, range and bearing from an ARPA radar and is able to download all information to video plotter or printer.

An alarm card can be inserted into the system which includes both plot and polygon alarm features allowing up to 350 'no go' areas to be geographically defined and alarmed.



The intelligent puck of Master Yeoman

Operational status
In service with the Royal Navy, Commonwealth navies, NATO, Middle East and Asian navies, as well as many commercial users.

Contractor
Kelvin Hughes Ltd Hainault, Essex.

VERIFIED

TRAC and CHART systems

Type
Integrated navigation, hydrographic survey and data logging system.

Description
The TRAC and CHART systems are a family of automated data acquisition and processing systems used extensively by navies and commercial organisations for a wide variety of operational tasks such as mine warfare, maritime patrol, multibeam hydrography, oceanography, trials and evaluations, fisheries protection and offshore engineering.

TRAC, which is available as a portable system for survey launches through to a fully integrated network data system for research vessels, provides integrated navigation, data logging, and precise and dynamic positioning for vessel control. It can provide real-time data in a variety of formats directly from the vessel's sensors. To provide full data processing capabilities TRAC uses the industry standard CARIS system.

TRAC is a self-contained system which uses an advanced position computation algorithm to handle up to 20 position lines which may be any combination of hyperbolae, ranges, bearings or latitude/longitude lines. The system can operate on any spheroid and projection and takes into account the various geodetic reference systems.

Control of TRAC is through a keyboard, rollerball and colour display. The system supports a wide range of peripherals, including remote colour displays, plotters and printers.

CHART is a complete data processing system which complements TRAC. It may be supplied as a stand-alone unit or networked to TRAC. The system design supports multiple TRAC and CHART workstations networked together to create an integrated multi-user system. CHART may be used afloat or ashore for data analysis and the production of fair sheets, and contains all the necessary processing facilities to carry out these functions.

Operational status
TRAC and CHART systems are in service with the Royal Navy, Royal Australian Navy, Italian Navy, Royal Navy of Oman, Republic of Singapore Navy, Turkish Navy and Venezuelan Navy. TRAC and CHART systems equip the survey boats of the Italian Navy's hydrographic survey vessel *Ammiraglio Magnaghi* and the Antarctic survey vessel HMS *Endurance*. TRAC is also fitted to the NATO ASW research vessel *Alliance*.

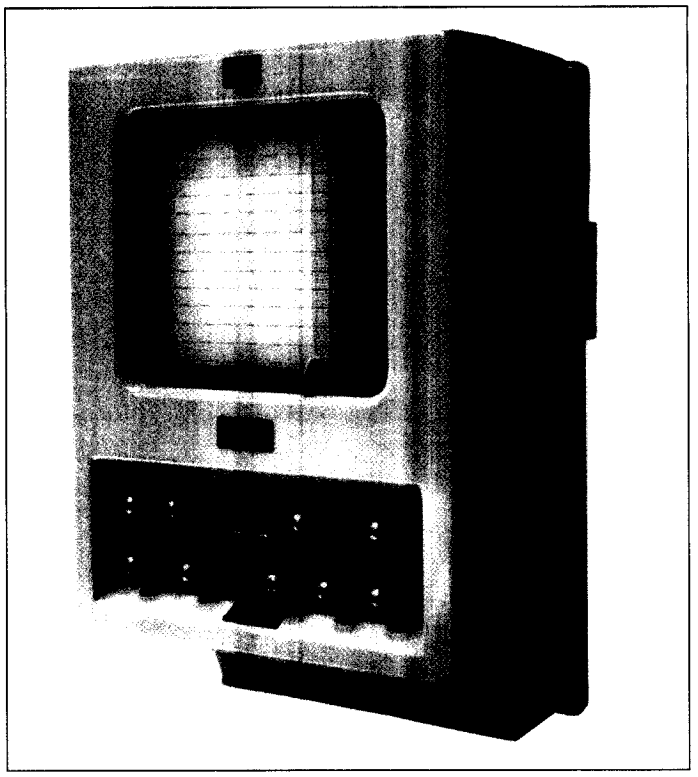
Contractor
Kelvin Hughes Ltd, Hainault, Essex.

VERIFIED

Type 778 echo-sounder

Type
Echo-sounding depth recorders.

Description
This equipment has been designed to meet the requirements of all vessels from coastal minesweepers upwards. It consists of a general service depth recorder operating with a single 10 kHz transducer; a bridge unit with numerical depth display as an optional fitting, which operates with its own two-element 48 kHz transducer; and a precision depth recorder for oceanographic survey purposes which operates with the transmitter of the depth recorder and its associated transducer.



Type 778 echo-sounding equipment

Operational status
In operational service.

Contractor
AB Precision (Poole) Ltd, Poole, Dorset

UPDATED

Type 780 echo-sounder

Type
Echo-sounding depth recorders.

Description
This is a high-definition shallow water echo sounder fitted in surface ships and submarines. Its maximum depth capability is 1,000 m. The set is available in the following versions: 30 kHz (surface vessels), 48 kHz (reduced magnetic signature for surface ships) and 48 kHz (for submarines). The sounder consists of a chart recorder digitiser and remote display.

Operational status
In operational service.

Contractor
AB Precision (Poole) Ltd, Poole, Dorset

UPDATED

Type 786 echo-sounder

Type
Echo-sounding depth recorders.

Description
The Type 786 has been developed for use with flat-bottomed landing craft and vessels operating in shallow water. Main features are that the transducer is extendable below the layer of aerated water, which forms beneath a flat-bottomed craft, to give good performance, and rapid automatic high-speed retraction of the transducer as the craft beaches. The system consists of a main recorder unit with chart facility and digital display which operates with a single 200 kHz transducer, a remote digital display, and an automatic transducer raise and lower mechanism with its control panel.

Operational status
In operational service.

Contractor
AB Precision (Poole) Ltd, Poole, Dorset

UPDATED

Type 787 echo-sounder

Type
Echo-sounding depth recorders.

Description
The Type 787 is intended to meet the requirements for all vessels in the Royal Fleet Auxiliary Service and the Maritime Auxiliary Service. The system is similar to the Type 786, but without the lower-retract mechanism. It consists of a main recorder unit with chart facility and digital readout which operates with a single 50 kHz transducer and remote digital readout(s).

Operational status
In operational service.

Contractor
AB Precision (Poole) Ltd, Poole, Dorset

UPDATED

United States

C-100 sensor

Type
Miniature digital compass sensor.

Description
The C-100 miniature heading sensor is a very small, extremely accurate heading sensor, ideal for use in systems where space is at a premium and where direction information is essential. Typical applications include oceanographic equipment, underwater warfare systems, vehicle navigation and mapping systems, night vision devices, and weapon aiming systems. The C-100 provides heading information with ±0.5° accuracy.

The digital flux gate compass sensor, which uses no moving parts, measures the earth's magnetic field electronically, thus eliminating card movement which makes conventional compasses inaccurate and unstable. It comprises a remote sensor coil and electronics board featuring a microprocessor-controlled calibration system. The sensor is compatible with multiple floating ring coil sensors which allow gimballing from ±16° to ±45° of tilt. The modular design enables sensor coils and electronics to be separately mounted in different locations. The sensor communicates with other electronics with a variety of analogue and digital interfaces.

Operational status
In service with ROVs, hand-held and mounted optical devices and commercial and military vehicles.

Specifications
Input voltage: 8-18 V DC or 8-28 V DC (user selectable)
Current drain: 40 mA DC (max)
Accuracy: ±0.5° or ±10 mils RMS (SE-25 coil assembly and digital outputs)
Repeatability: ±0.2° or ±0.5 mils (SE-25 coil assembly and digital outputs)
Resolution: 0.1° or 1 mil
Dip angle: ±80° (maintains stated accuracy after auto-compensation up to ±80° magnetic dip angle)
Tilt angle: ±16°; Dev = ±0.3° RMS (SE-25): ±45°; Dev = ±0.5° RMS (SE-10)
Declination/variation: ±180° adjustment range (offset) (user selectable)
Index error correction: ±180° adjustment range (offset) (user selectable)

Contractor
KVH Industries Inc, Middletown, Rhode Island.

UPDATED

DSN-450/DSL-250

Type
Doppler sonar speed log.

Description
The DSN-450 is a dual-axis Doppler speed log for application on board ships to measure speed along course and distance travelled, as well as measuring thwart ship speed when docking. It provides true speed over the ground from 0 to 40 kt in depths to 300 m. It automatically switches from bottom track mode to watermass mode when poor bottom returns are received using the water column 15 to 50 m below the transducer for its calculation.

The DSL-250 is a single-axis model for measuring speed along track.

The bridge control unit has large, easy to read digital displays, with depth readout selectable in feet, fathoms or metres. An adjustable depth warning provides visual and aural alarms whenever the actual depth goes to less than the

selected minimum limit. Speed values and depth alarm output signal are available to provide speed and depth to other ships' systems. Digital speed and depth repeater displays can be installed in any shipboard location.

Contractor
Ocean Data Equipment Corporation, E Walpole, Massachusetts.

VERIFIED

GyroTrac

Type
Digital gyro compass.

Description
KVH's GyroTrac is the successor to the Azimuth Digital Gyro Compass and the Digital Gyrostabilised Sensor System. The compact GyroTrac combines the digital magnetic compass technology pioneered by KVH with the company's patented three-axis gyro sensor. Its rate gyro corrects for short-term acceleration errors while the digital magnetic compass and inclinometer provide long-term, drift-free pitch, roll and yaw. Proprietary software uses navigational data from the gyroscope, compass and inclinometer sensors to calculate stabilised azimuth, pitch and roll output. By stabilising or eliminating the negative effects of pitch, roll and yaw, GyroTrac outputs heading with 1° accuracy. This stabilised data can then be output to other equipment, including autopilots, radar and satellite communications products.

Among the key features of GyroTrac are:

- Three axis gyro stabilisation and automatic self-calibration
- Data outputs covering NMEA, Cetrek, 3- and 4-wire Sine/Cosine, Furuno AD1OS, and KVH 3-axis proprietary
- Advanced digital control unit (ADCU) LCD user interface
- Provision of true or magnetic north

Operational status
In service on board vessels worldwide.

Contractor
KVH Industries Inc, Middletown, Rhode Island.

UPDATED

Mk 6 Dead Reckoning Tracer

Type
Plotting table.

Description
Two types of Dead Reckoning Tracers (DRT) are available to match equipment requirements. The digital Mk 6 Mod 4D DRT (DDRT) accepts distance inputs in digital NTDS slow format while the standard Mk 6 Mod 4C DRT operates from distant north and east step inputs. Both DRTs trace 'own ship' track and compute and display position (latitude and longitude) on counters. A compass rose is projected upward on to a glass plotting surface so that 'own ship' and target ship locations may be plotted.

Operational status
In service.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

VERIFIED

Model 3040

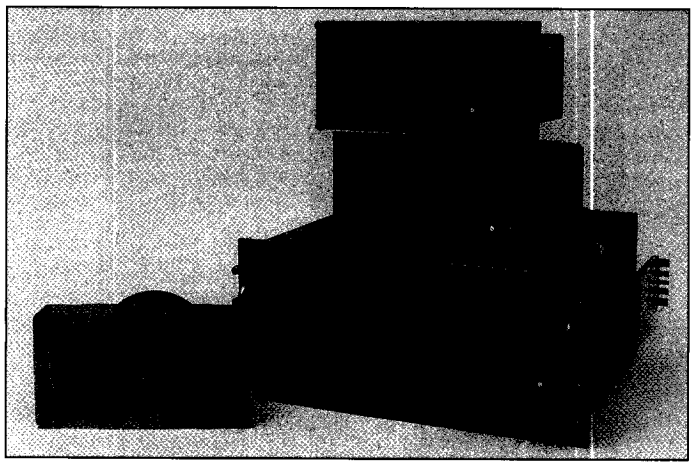
Type
Doppler sonar velocity log system.

Description
The Model 3040 Doppler sonar velocity log is EDO's fully MIL-Spec Doppler sonar system.

Digital signal processing results in the least variance estimate and eliminates the need for periodic alignment and calibration. The system is microprocessor-controlled, and automatically selects its operating parameters for optimum bottom tracking performance. The log provides real-time measurement of both bottom and water mass tracking and distance travelled.

The Model 3040's main features are:

- full MIL parts selection, environmental testing (EMI/RFI, shock, vibration) and electrical interface
- simultaneous, three axes, water and bottom tracking, providing measurement of platform set and drift



Model 3040 Doppler velocity log

- BIT functions to circuit board level
- accurate to 0.2 per cent using phased-array beam-forming provides automatic compensation for sound velocity variations. The transducer face forms a flat surface which installs flush with the hull.

The system is crystal-controlled and completely coherent. All system frequencies are derived from a common source. Minimum velocity variance is achieved through the use of an optimal (maximum likelihood) digital spectral estimator (called the Rummler estimator). Bias errors are suppressed through the use of a phased-array flat-faced transducer, an unbiased pulsed Doppler frequency discriminator and platform trim compensation. High reliability is achieved through a substantial reduction in card count as compared to analogue designs.

Operational status
In service with Australian and Turkish navy submarines and surface ships. Also used in US Navy projects.

Contractor
EDO Electro-Ceramic Products, Salt Lake City, Utah.

VERIFIED

Model 4240

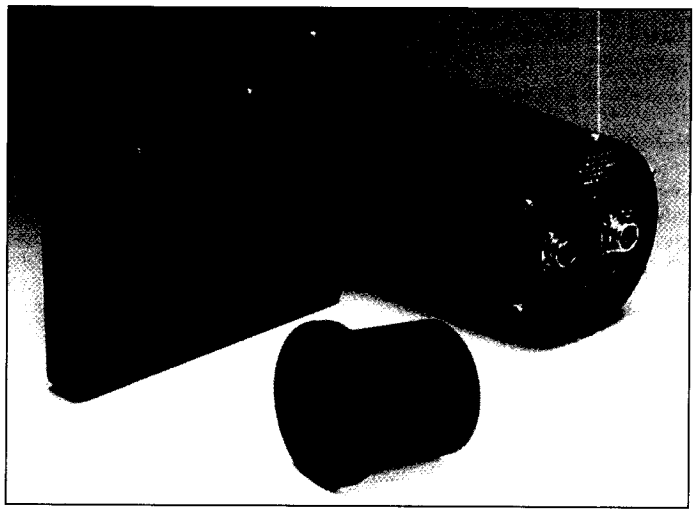
Type
Doppler sonar velocity log system.

Description
The Model 4240 Doppler sonar velocity log system provides accurate navigational data that eliminates velocity of sound measurement using new technology phased-array design with pulsed Doppler techniques. It is a self-contained system that uses the Doppler principle to measure velocities of a submersible or surface platform in three axes plus water depth, current profiling and intensity information.

Operational status
The Model 4240 and its precursor, the Model 3050, is used in a number of US Navy manned and unmanned underwater vehicle programmes.

Contractor
EDO Electro-Ceramic Products, Salt Lake City, Utah.

VERIFIED



Model 3050 Doppler system

Speed log system

Type
Electromagnetic (EM) speed log sensor and associated indicator/transmitter.

Description
EM speed log sensors include retractable 3 in and 6 in widths with lengths up to 10 ft and fixed 6 in and 10 in sensors up to 46 in long. In operation, the sensor coil is energised with AC current and establishes an AC magnetic field in the water. Because the water is a conductor, the water flow past the sensor cuts the magnetic field and generates a voltage that is directly proportional to speed. This AC voltage is picked up by two electrodes in the sensor and sent back to the indicator/transmitter where it is converted for display and transmission to remote indicators, navigation, sonar and fire-control systems.

Operational status
EM logs, together with the associated Mk 4 series indicator/transmitters have been in service with the US Navy for many years and are installed on most major ships. A commercial version of the indicator/transmitter, designated the UL-100-4, which employs solid-state, no moving parts construction, is also available.

Contractor
Lockheed Martin Naval Electronics & Surveillance Systems, Syracuse, New York.

VERIFIED

VMS-ECDIS

Type
Automated navigation and electronic chart system.

Description
The VMS-ECDIS (Voyage Management System and Electronic Chart Display and Information System) features two operator stations with additional display stations fitted in the commanding officer's cabin and on the bridge. The system takes digital inputs from the submarine's radar, inertial gyrocompass, speed log, GPS and other sensors to provide a constantly updated picture showing the boat's precise position and movement on a colour electronic chart display.

In the submarine *Hyman G Rickover* the system incorporates the new Sperry direct chart reader, which permits the system to access Digital Nautical Charts™ from the cartographic database of the National Imagery and Mapping Agency (NIMA).

The VMS-ECDIS is being integrated with the AN/BPS-15H radar system that equips the Los Angeles class submarines.

Operational status
Successful sea trials aboard the USS *Hyman G Rickover* (SSN-709) completed in late 1998. The system will retrofit all Los Angeles class submarines over the next one to two years as part of the AN/BPS-15H radar system.

Contractor
Litton Marine Inc, Charlottesville, Virginia.

VERIFIED

SUBMARINE RADAR

Denmark

Scanter

Type
Family of modular navigation radars.

Description
The family of modular Scanter navigation radars is designed to facilitate configuration and future system expansion options. The radars are said to be specifically tailored for applications where traditional marine radars cannot fulfil the required level of performance, the specific tactical requirements and/or the environmental stress of the particular installation. To meet these goals the Scanter family includes complete 36 Hz to 9/10 GHz systems incorporating various types of antenna and a range of transmitter frequency and pulse-width options. Other system features include digital signal processing and functional feature/interface flexibility.

Among the features incorporated in the systems are:

- Frequency diversity (to reduce effect of sea clutter, lobing effects and improve long-range detection)
- Extremely wide dynamic range
- Pulse-to-pulse integration (to improve signal/noise ratio)
- Circular polarised antennas (to reduce clutter resulting from rain or sea spray)
- Programmable pulse repetition frequency and random stagger

The radar comprises:

- An antenna unit with a slotted wave guide RF radiator and a turntable housing. Polarisation is either horizontal or circular and narrow beam; high gain and low slide lobe levels are held to ensure reliable target detection even in the most severe weather conditions.
- A transceiver unit in which transmission is undertaken using a pulsed magnetron controlled by a solid-state modulator. The PRF is staggered and programmable. Pulsewidth values can be selected individually and a trigger assembly provides system synchronisation together with automatic selection of appropriate internal or external synchronisation mode.

The radar workstation integrates and exchanges data with the submarine's command and control system. It can also display data from external sources such as datalinks, ESM, GPS and optical sights. As a navigational display, the workstation includes basic ARA facilities, three independent radar interfaces and functions such as automatic target tracking, track data readouts, history plots and alarms. The monitor is a high-resolution raster scan colour unit incorporating a graphics engine to generate symbols.

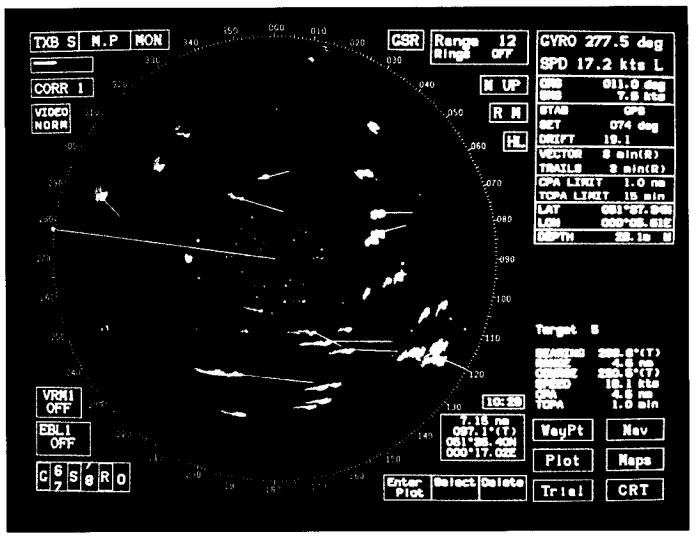
Other features include:

- The capability to display raw radar video, graphics, test totes and red/green/blue video
- An artificial afterglow to enhance moving target detection
- Day/night display backgrounds
- 2-D constant false alarm rate
- Sweep-to-sweep correlation
- Frequency and sensitivity time control

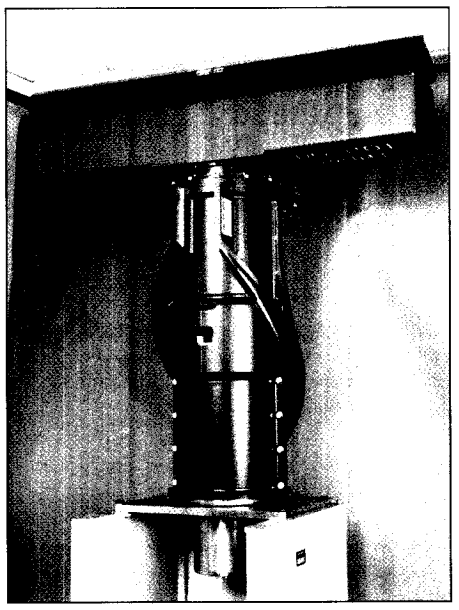
Operational status
Scanter radar systems are installed in the Brazilian Tupi class submarines and on order for the *Tikuna*, Swedish Gotland class submarines, and Venezuelan Sabalo class submarines.

Contractor
TERMA Elektronik AS, Tastrup.

UPDATED



CSR navigation radar display (Kelvin Hughes) 0064616



CSR navigation radar antenna (SAGEM SA) 0064614

International

CSR

Type
Compact Submarine Radar (CSR).

Description
Kelvin Hughes in the UK and SAGEM SA of France have produced a new concept for submarine navigation radars. The I-band ARPA radar can track up to 50 targets and features mapping facilities. In the design the transceiver is housed in a watertight pod, directly beneath the antenna to which it is rigidly fixed. Both transmitter and antenna rotate together at the top of the radar mast which functions in the normal manner. As a result of this design, the conventional peak power of 25 kW can be reduced to 5 kW, ensuring the same performance but with an important gain in reliability. This arrangement eliminates the need for a complex waveguide and its associated drawbacks (waveguide hull penetration, and losses due to waveguide length, condensation and the need for a rotary joint), allowing the entire system to be mounted outside the pressure hull. Furthermore, the antenna height above sea level is very easy to command and adjust. Finally, only one cable penetrates the pressure hull, the rest of the equipment (display monitor and processor unit) is installed within the submarine control room.

The CSR is suitable for installation on board small, as well as larger submarines.

Operational status
The CSR is being installed on board French nuclear attack submarines and has been ordered by the Chilean Navy for the 'Scorpene' programme and by other foreign navies.

Contractor
SAGEM Optronics and Airland Division, Paris, France.
Kelvin Hughes, Hainault, Essex, UK.

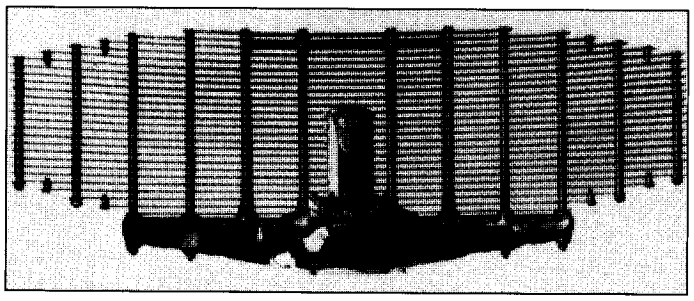
UPDATED

Italy

MM/BPS-704

Type
Submarine search and navigation radar.

Description
The MM/BPS-704 I-band (8 to 10 GHz) is a naval search and navigation radar for use aboard submarines. The general characteristics are similar to the MM/



MM/BPS-704 antenna

SPN-703 surface ship version, using the same 20 kW transmitter and pulse length/PRF combinations. A specially designed high-pressure-resistant antenna (up to 60 kg/cm²) mounted on a telescopic mast, is part of the equipment. The principal differences are indicated in the specifications.

Operational status
No longer in production. In service with Italian Navy Sauro class submarines.

Specifications
Antenna span: 1 m
Beamwidth: 2.2° (horizontal); 11° (vertical)
Gain: at least 27 dB
Noise figure: better than 11 dB

Contractor
Galileo Avionica SpA, Florence

VERIFIED

MM/BPS-804

Type
Submarine navigation radar.

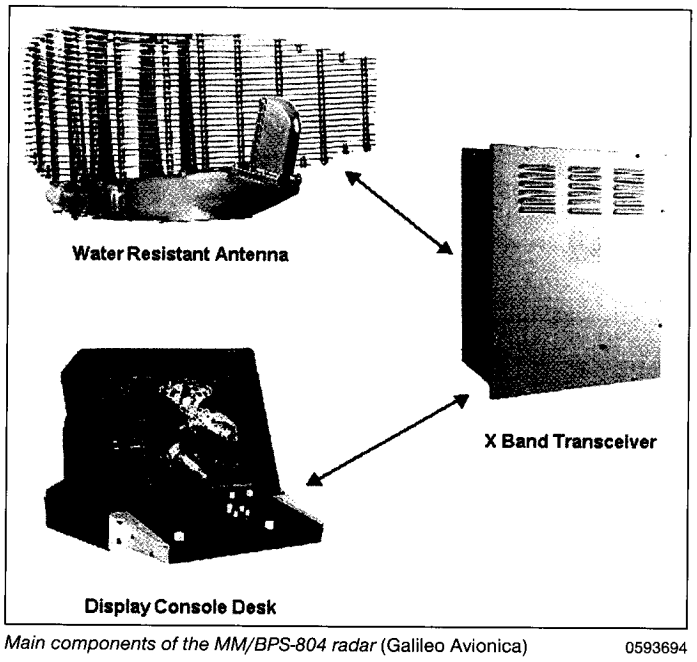
Description
To meet the requirements for a reliable submarine navigation radar, incorporating anti-collision capabilities, the MM/BPS-804 radar has been developed by Galileo Avionica. The radar has been expressly designed to obtain the highest performances fitting the reduced spaces available on submarines.
The radar features:
- high resolution
- microcomputer controlled operations
- target designation to weapon systems or naval/air units for relevant interception
- collision avoidance.

The radar is a 25 kW X-band system designed for optimum propagation over this frequency range and a carefully designed water-resistant antenna characterised by resistance to high pressure (up to 60 atmospheres).

The modular, solid state radar incorporates a long-life, third generation ceramic magnetron. Among the operation characteristics are:
- PRF jittering
- Option to select a different PRF set
- CFAR processing
- clutter suppression processing
- display with expansion/compression/logic processing
- digital sweep to sweep processing
- Scan to scan processing.

The radar incorporates a serial line communication link with display and ARPA features are standard.

The sensor is associated with an operation display console, which carries out the required tasks of command and control associated to the area under surveillance and anti-collision techniques and processing.



Main components of the MM/BPS-804 radar (Galileo Avionica) 0593694

Operational status
In production.

Contractor
Galileo Avionica SpA, Surface Systems Business Unit, Campi Bisenzio

VERIFIED

Netherlands

ZW07 submarine radar

Type
Surface search and navigation radar.

Description
The ZW07 is one of the family of the ZW series radars produced by Thales Nederland. This particular model is designed for use by submarines for navigation, distance measuring, surface search and limited air warning. A single-shot mode has been adapted for a range of surface targets. Other operational features include: surface coverage up to the radar horizon, limited air warning and high resolution for navigation. Anti-clutter measures and ECCM provisions include sector-scan facilities, logarithmic receiver with pulse length discriminator, suppression of non-correlated pulses, and a tunable transmitter.

Operational status
No longer in production.

In operational service on board Netherlands Navy Walrus class submarines and Taiwanese Hai Lung class (ZW06 type).

Specifications
Frequency: 8-10 GHz (I-band)
Polarisation: horizontal
Transmitter: tunable magnetron
Power output: 60 kW (peak); 100 W (average)
Maximum range: 22 km (against small surface craft)

Contractor
Thales Nederland, Hengelo.

UPDATED

Russian Federation

MRK-50 Series (NATO code name Snoop Type)

Type
Submarine surface search radars.

Description
A number of surveillance radars have been fitted to Russian submarines since the Second World War, some of which have been given a NATO designation starting with Snoop. The early submarines were equipped with a small antenna designated Snoop Plate. Snoop Plate is fitted in export Romeo class submarines and has a range of 25 n miles against aircraft and 12 n miles against surface vessels. Snoop Plate was succeeded by the larger and more powerful I-band radar known as Snoop Tray which entered service in the early 1960s. Later variants were fitted in the Victor III class SSNs while Snoop Tray 2 is fitted in export Kilo class submarines and is linked into the combat system. It also equips Delta class submarines.

Two other Snoop class radars are the Snoop Pair fitted to 'Typhoon' and Akula class submarines, and Snoop Head fitted to the 'Oscar' and Alfa classes. Snoop Pair is probably a dual-beam radar with the two antennas mounted back-to-back.

Snoop-Tray radars operate in the I-band (8 to 10 GHz).

Operational status
In operational service. Virtually all Russian-built submarines are fitted with a MRK-50 type surveillance radar. Also operational on Chinese Golf, Han, Kilo, Ming, and Xia classes and Yugoslav Sava class of submarines and Romeo class submarines (except Russian naval units).

VERIFIED

United Kingdom

AZL mast

Type
Radar submarine mast.

Description
This mast outfit is spigot-mounted in a cylindrical pressure pod, built into the free-flooding area of a submarine fin. A hydraulically retractable mast supports the antenna head which is rotated electrically and connected to the ship's radar system via a waveguide.

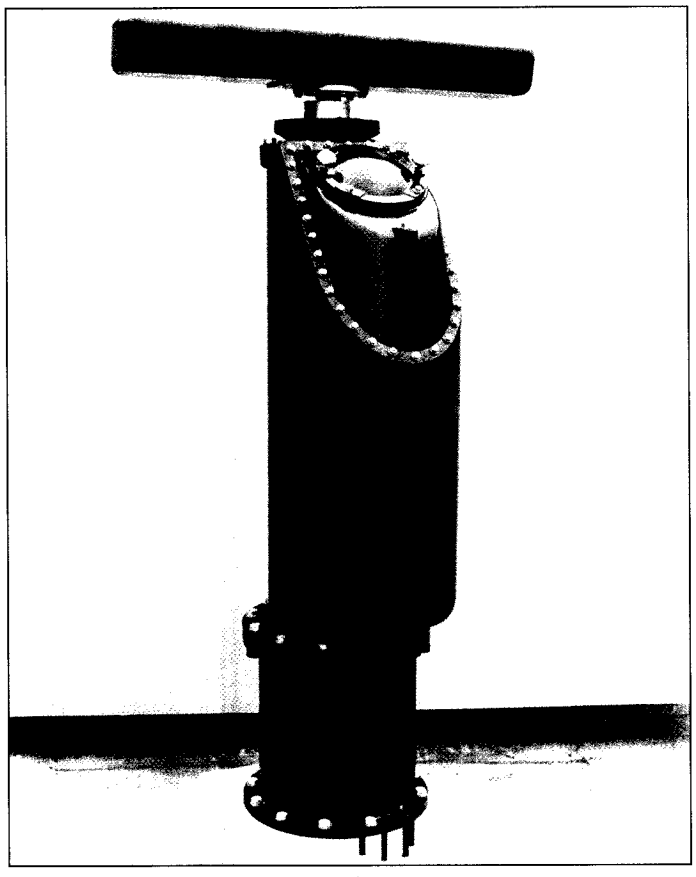
The outfit does not penetrate the pressure hull of the submarine. Waveguide and electric connections are made via a service pipe at the bottom of the pod. Hydraulic connections are made via a casting casing forming the upper end of the pod. Remote indications of mast, drive and antenna status are provided. If water enters the pod, a detector signals the ship's alarm system.

If the mast shares the fin with other masts where fouling could occur, interlocking is included in the control circuits. Interlocking also ensures correct operation of the indexing mechanism, mast and antenna operating gear, including antenna head alignment.

Operational status
The AZL radar submarine mast is in service with all submarines in the Royal Navy.

Contractor
MSI-Defence Systems Ltd, Norwich, Norfolk.

UPDATED



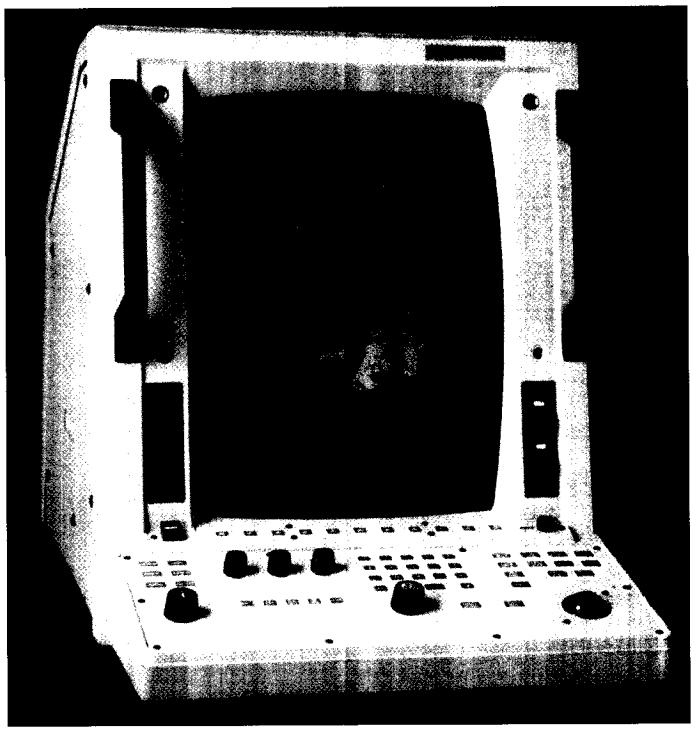
AZL mast as fitted on Royal Navy submarines

Type 1007

Type
F- (3-4 GHz) and I-band (8-10 GHz) navigation and surface/air search radar.

Description
The Type 1007 is the standard I-band navigation radar of the Royal Navy. It consists of a range of navigation, surface and air search equipments for naval use with a choice of antennas, I-band and F-band transmitter/receivers and a range of displays. Reduced magnetic signature variants are available for use on MCMVs.

Three versions of the antenna outfit are available for surface vessels: a 2.4 m single array; a 3.1 m single array; and a 2.4 m dual array for use with helicopter transponders and outfit RRB. All are horizontally polarised, end-fed slotted line arrays, incorporating vertical polarisation filters to give low sidelobe and back radiation levels. The 3.1 m array has a horizontal beamwidth of 0.75°. Surface ship antenna outfits can operate in winds up to 185 km/h and withstand funnel gas temperatures up to 120°C, as well as gun and shock effects of blast. De-icing systems are available. A 4.1 m single array is used with the F-band transmitter/receiver radar and an Identification Friend-or-Foe (IFF) antenna can be surmounted as an option. A fully pressure-tested submarine antenna is also available for fitting to a variety of submarine masts.



The Type 1007 colour tactical display

The transmitter/receivers are solid-state, with the exception of the magnetron and operate at frequencies of 9,410 MHz and 3,050 MHz (F-band) with a transmitter power output of 25 kW. A wide dynamic range logarithmic receiver is provided. A built-in monitoring system is included to check that the equipment is operating at peak performance. A low-leakage dummy load allows for system testing during periods of radar silence. Centralised emission control circuitry enables the command to inhibit transmission immediately. Sector transmission is also incorporated with direct control from the main display (optional for the F-band radar). Blanking pulses are incorporated to safeguard sensitive ESM equipment.

The full colour rasterscan (1,360 × 1,024 pixels) tactical display (CTD) is a highly capable navigation display with a wide selection of operational/tactical facilities. It has a built-in tracking capability of up to 50 automatically tracked targets and 20 manually tracked targets. The display offers comprehensive mapping facilities with an internal 200 map memory plus unlimited external maps. Maps and tracks are alpha/numerically labelled and sector screens can be drawn and up to 16 auto-acquisition or exclusion zones set. The CTD gives the operator a clear, sharp, colour tactical picture out to over 300 km with the ability to label tracks with ships' names/numbers. Symbology and a choice of colours are used to indicate hostile/friendly/neutral/unknown, and whether air/surface or subsurface. Display modes featured include: relative motion (head up, north up, course up) and true motion (off-centre or centred display).

Range scales are: 0.25, 0.5, 0.75, 1.5, 3, 6, 12, 24, 48, 96 and 192 n miles.

Standard interfacing includes most log, gyro and GPS equipment. The CTD can receive four radar video inputs and three auxiliary inputs. Optional facilities include the control and display of frequency modulated continuous wave radars, ability to receive plot-extracted data, VESTA, carry out IFF active gate interrogation and interfacing to most combat systems, fire-control systems, infra-red and ESM equipments. A high-speed air tracking facility is available as an option.

The CTD displays can be networked to share track data and form a highly cost-effective command system.

A weatherproof auxiliary raster scan display is available as an option. This unit is portable and is designed for use on an open bridge or submarine fin.

A built-in simulator package allows onboard training to be carried out in the minimum of time.

Operational status
The Type 1007 radar associated with the colour tactical display is in service throughout the world with over 30 navies on all sizes of vessel, including submarines and MCMVs. Submarine fitments include Australian Collins class, Canadian 'Victoria', French 'Amethyste/Rubis', German and Italian Type 212A, Norwegian Ula class, Pakistani 'Khalid' (Agosta 90B), Polish 'Sokol' (ex-'Kobben'), Portuguese Daphné class, UK Swiftsure, Trafalgar and Vanguard classes. MCMV fitments include: Malaysian 'Lerici' type, Pakistani 'Al Munsif' ('Eridan' Tripartite type), Saudi Arabian 'Sandown' type, Spanish Segura, Turkish Aydin, and UK Hunt and Sandown class

Contractor
Kelvin Hughes Ltd, Hainault, Essex.

UPDATED

United States

AN/BPS-15

Type
Submarine surface search and navigation radar.

Description
The AN/BPS-15 is a submarine radar designed for surface search, navigation and limited air warning facilities. It operates in I to low J-band using a horn array antenna. The radar is being upgraded to the AN/BPS-15H version with the VMS-ECDIS system (see VMS ECDIS entry).

Operational status
No longer in production. In widespread use on US Navy Los Angeles class and some Ohio class SSBNs submarines.

Specifications
Frequency: X-band
Peak power: 35 kW
Pulsewidth: 0.1; 0.5 µs
PRF: 1,500; 750 pps
Scan rate: up to 9.5 rpm
Antenna dimensions: 101 cm (aperture)
Antenna weight: 76 kg
Range resolution: 10 m (in short pulse mode); 30 m (in long pulse mode)

Contractor
Litton Marine Systems Inc, Charlottesville, Virginia. ***VERIFIED***

AN/BPS-16

Type
Submarine navigation and surface search radar.

Description
The AN/BPS-16 (previously known as the AN/BPS-XX) is a submarine I-band (8 to 10 GHz) radar designed to provide nuclear-powered fast attack and ballistic missile submarines with a navigation and search radar capability when operating on the surface. The AN/BPS-16 features a new 50 kW frequency-agile transmitter in I-band and the latest in signal processing techniques to enhance operational performance in heavy weather. Unlike the AN/BPS-15, the new system is supplied with a new unique radar mast assembly to raise and retract' more effectively and reliably a state-of-the-art antenna. Range is understood to be in the region of 50 km.

The latest variant is the AN/BPS-16(V)4 which has been ordered for the 'Virginia class SSNs. The AN/BPS-16(V)4 is an X-band navigation radar which presents a clutter-suppressed real-time picture of surface radar targets and geographic features.

Operational status
The AN/BPS-16 radar equips the Ohio class SSBNs (SSBN 741 to 743), the Seawolf and Los Angeles class SSNs. Two systems, AN/BPS-16(V)4, have been ordered for the third and fourth Virginia class submarines, USS *Hawaii* and USS *North Carolina*.

Contractor
Northrop Grumman Electronic Systems, Sperry Marine, Charlottesville, Virginia.

VERIFIED

CONSOLES AND DISPLAYS

Canada

AN/UYQ-501(V) Shinpads display

Type
Multisensor display system.

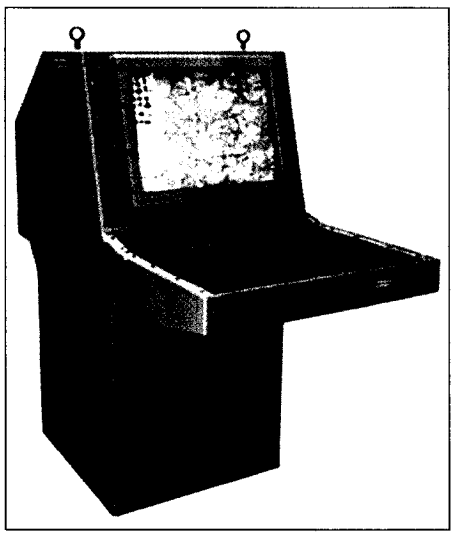
Description
The MSD-700, developed by General Dynamics Canada for the Canadian Department of National Defence as part of a distributed architecture processing system, is a true multifunction display that accepts inputs from all shipboard sensor systems and computers. In its naval configuration, it is designated AN/UYQ-501(V) (SHINPADS – SHipboard INtegrated Processing And Display System) and provides both sensor information and complex graphical overlays. It interfaces with any general-purpose NTDS-capable computer functioning as a display processor and hence communicates on any standard databus.

The MSD-700 is currently being updated with General Dynamics Canada's own state-of-the-art, UXGA, 1,600 × 1,200 high-resolution flat panel display systems. This eliminates CRT obsolescence issues and extends the life of the Shinpads display system dramatically.

Operational status
In service with the Canadian Forces Maritime Command.

Contractor
General Dynamics Canada, Maritime Systems,Ottawa, Ontario.

UPDATED



AN/UYQ-501(V) Shinpads display (General Dynamics Canada)
NEW/0583219

United Kingdom

Command Console

Type
Submarine command consoles.

Description
This console replaces a number of separate equipments currently supplied from a variety of sources, with a single purpose-designed ergonomic console that, through full interaction with the other systems, ensures that the command has a coherent centralised view of the tactical situation.

The commanding officer of a submarine requires fully integrated display and control facilities for the effective deployment and monitoring of the tactical weapons system. The console provides these in the following way:

- Access and monitoring of those aspects of sensor information that are time critical
- The ability to gain an overview of the tactical picture
- The effective deployment and operation of the equipment under the commanding officer's control

The console offers a flexible mapping of output displays through the use of modern video windows approach onto an array of flat-panel displays. The display surfaces are liquid crystal technology offering advantages in space, weight, wild heat, power and immunity to magnetic fields.

The console architecture takes full advantage of COTS hardware and software. It uses SPARC processors running Solaris UNIX. Additional cards for graphics, video and video distribution allow video to be displayed in windows superimposed on or alongside other windows. Analogue-to-digital and synchro-to-digital converters allow ship's data to be displayed in windows on the LCDs instead of bespoke electromechanical dials.

The system provides full and complete interaction with the following existing products in Royal Navy submarines:

- Type 2076 sonar
- SMCS
- UTV/PERITV
- Internal communications
- Navigation data display.
- Attitude and control data display

Negligible operator training is required because of the complete fidelity with the host system MMI. The command console provides an identical look and feel to the equipment to which it interfaces. When Type 2076 sonar or SMCS menu items are selected, the users are essentially using the system themselves, with exactly the same HCI and the added benefit of ship's data and video to hand.

Operational status
In service with the Royal Navy.

Contractor
AMS, Frimley, Surrey.

VERIFIED

OPUS 2

Type
Rugged multifunction console.

Description
The OPUS range of rugged multifunction consoles uses standard COTS architectures to provide computing and display technology for both new and existing technology insertion programmes. The range has been developed to host applications such as combat management systems, fire control, command and control, sonar, platform management and other processor and graphically intense tasks, and is designed to meet relevant military requirements for harsh environments. The basic design is capable of supporting a mix of compact PCI and standard VME processors and interface cards, removable hard disks, CD-ROM and associated peripherals. The unit can be configured for vertical or horizontal use with one or two high-resolution (up to 1,600 × 1,200 pixels) active matrix LCD flat panel displays (15, 18 or 20 in) which are stand-alone devices that can be used either as an integral part of the multifunction console or as separate desktop or bulkhead-mounted display consoles. A dual redundant power supply system is provided.

Operational status
In December 2001 a contract was announced for the installation of OPUS 2 consoles in the Royal Navy's Type 23 frigates as part of the Sonar 2087 project. Delivery was expected to start in 2002 and to be complete by 2004. In April 2002 two further contracts were announced for the Turkish Navy for the display of the NAUTIS 3 combat management system (see NAUTIS entry) with delivery due for completion in 2006 and the other for the display of the Thales Type 2093 sonar with delivery due for completion in 2005. In May 2002 Thales awarded a further contract for the supply of a single-display bulkhead-mounted variant for the Type 2193 sonar for the Royal Navy Hunt class minehunter mid-life update. Delivery was due to begin in September 2002.

Contractor
DRS Rugged Systems (Europe) Ltd, a unit of DRS Technologies, Farnham, Surrey.

VERIFIED

United States

AN/UYQ-65

Type
Data processing and display workstation.

Description
The AN/UYQ-65 workstation which is compatible with the US Navy's AN/UYQ-70 Advanced Display System is the first totally commercial-off-the-shelf (COTS) based workstation packaged to comply with the stringent environmental requirements of

the AEGIS Arleigh Burke class guided missile destroyer shipbuilding programme. The workstation has been designed to replace the tactical and acoustic sensor displays in the AN/SQQ-89 ASW combat system. Using modern open systems architecture, with two VME backplanes and dual processors, the AN/UYQ-65 workstation provides a UNIX/POSIX-compliant operating system with X-Windows for graphics and a Motif Windows manager for ease in operator control.

The system fully supports the US Navy's Joint Maritime Command Information System/Unified Build programme for TAC-3/4 software applications and is available in HP 743 processor configurations.

The system hosts the US Navy's Sonar In-situ Mode Assessment System (SIMAS), developed by the Navy's Advanced Systems Technology Office, which uses in-situ and real-time data, models, and predicts sonar sensor performance. SIMAS II systems will be installed on all Ticonderoga class cruisers and Arleigh Burke and Spruance class destroyers. In its SIMAS II configuration, the AN/UYQ-65 has over 20 spare VME slots available for other applications.

The AN/UYQ-65 is being further developed to host the US Navy's Tactical Data Support System (TDSS) offering passive sonar management, MSTRAP (torpedo alert), active intercept system, bistatics, onboard trainer, EC-16 and the SQS-56 upgrade.

The workstation incorporates a high-performance, high-resolution, dual monitor with integrated touchscreens, colour, raster, and multiprocessor capable of supporting both tactical graphics and acoustic sensor display formats. It can accept all AN/SQQ-89 sonar sensor (SQS-53C, SQR-19 and SQQ-28) display, tactical and alert data over its interfaces, performing all display updates in less than 100 ms. It is available to replace existing OJ-452 display stations when the AN/SQQ-89 system architecture evolves sufficiently to allow insertion of modern computers and UNIX-based workstations.

Operational status
Being manufactured under a US$65 million contract for the US Navy. Fitted to Tarawa and Wasp class amphibious vessels and Kidd and Spruance class destroyers. Also being sold to foreign navies, including the Royal Norwegian and Spanish navies.

Contractor
DRS Technologies Inc, Gaithersburg, Maryland. ***VERIFIED***

AN/UYQ-70 ADS

Type
Advanced display system.

Description
The hardware and software architecture of the AN/UYQ-70 is supported by high-performance commercial-off-the-shelf (COTS) and modified COTS modules and is housed in militarised racks and cabinets to provide the foundation for a complete system. Using state-of-the-art open system architecture, the modular high-performance system offers a flexible, rapid deployment, cost-effective system.

The AN/UYQ-70 uses a 100 MHz HP 743 single-board 6U VME processor with 64 Mbytes of error-correcting RAM which can be expanded to 256 Mbytes. ROM is user-definable and interfaces include integrated SCS-II, Ethernet, RS-232 and Centronics. Onboard graphics is available as an option.

The graphics system features a 1.5 million vectors/s capability with eight or 12 memory planes and eight or 12 overlay planes. The radar scan converter unit interfaces to a variety of naval radars.

The displays include 14 and 19 in units and the MMI includes keyboard and trackerball, a communications panel emulator, and Electroluminescent Category Select and CCAEP touchpanels.

The system is available in three configurations — a basic combat system console, rack-mounted console and an unattended equipment rack. The equipment is fully compatible with tactical surface and subsurface ship environments.

Operational status
Lockheed Martin awarded DRS Technologies further contracts worth approximately US$76 million in FY 1999 to manufacture additional quantities of AN/UYQ-70 tactical workstations. Initial deployment of the AN/UYQ-70 display consoles include the US Navy Arleigh Burke class DDGs.

Under a separate contract, DRS has developed a Horizontal Large Screen Display (HLSD) workstation to replace the current Mk 19 manual plotting table for the NSSN Virginia class. The display also equips the Los Angeles class SSNs.

Contractor
DRS Technologies Inc, Gaithersburg, Maryland.
Lockheed Martin, Tactical Defense Systems, Eagan, Minnesota. ***VERIFIED***

MDE

Type
Military Display Equipment (MDE).

Description
The MDE product line provides plug-compatible emulation of the US Navy standard AN/UYA-4 and AN/UYQ-21 display equipment at a very much reduced cost compared to the military equipment. The line includes commercial-grade equivalents of the fully militarised tactical and acoustic display equipment, video signal simulator and communication systems.

The display consoles are based on the modular design of the military OJ-535 terminal, digital TV graphics generator and radar scan converter. The MDE products provide command interpreter functions to support emulation of the military OJ-194, OJ-197, OJ-451 and OJ-452 consoles in a physical replication of the military OJ-535 terminal and base unit. The products feature reconfigurable operator panels that support multiple platform baselines in test and training applications.

The radar video simulator supports plug-compatible emulation of the SM-441 video signal simulator and features programmable radar parameters to simulate any surveillance or navigation radar in the Navy's inventory. Additional features include complex scenario generation and control of target, clutter and jamming environments which are anticipated beyond the year 2000.

The communication system offers connectivity to the military sound-powered interphone and radio-telephone switchboards. Both the AN/UYA-4 and AN/UYQ-21 communications panels are supported and may be interfaced to the patch panel to provide a stand-alone communication system.

Operational status
Under contract for the US Navy.

Contractor
DRS Technologies Inc, Gaithersburg, Maryland.

VERIFIED

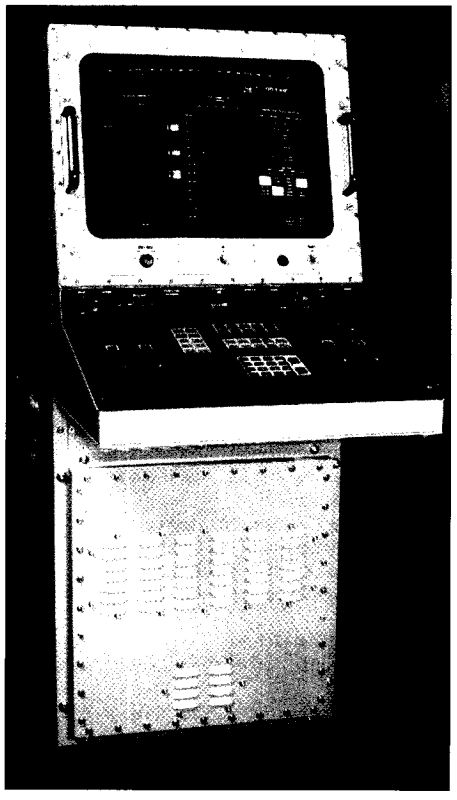
MMC

Type
Modular Multifunction Console (MMC).

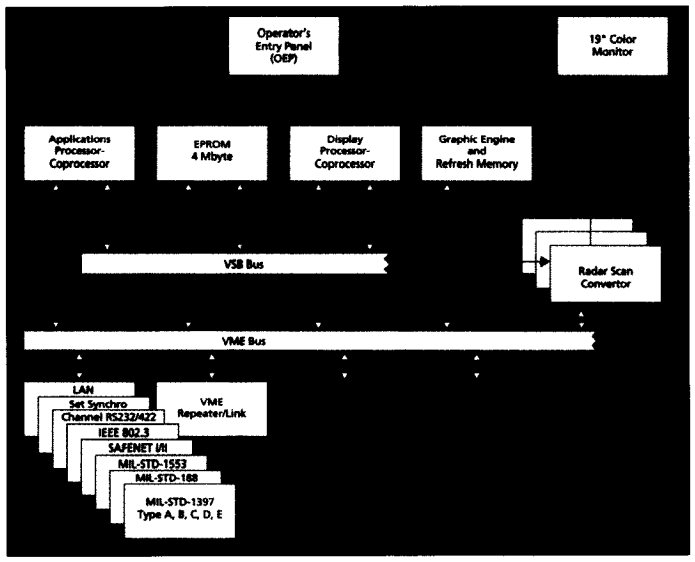
Description
This is a real-time, tactical, general purpose computer and high-resolution graphics system using the design philosophy of open systems architecture. The MMC design is based on the VME-VSB bus architecture, which allows the system to be easily configured to any application by integration of extra printed circuit cards in the VME Euro-card form.

The MMC's modular construction allows it to meet almost any customer requirement. It is configured in three basic units: the processor unit, the Operator Entry Panel (OEP) and the monitors. These units are capable of operation as a single integrated unit or of being split into its major sub-units, allowing the monitors and OEP to be operated remotely from the processor unit. This flexibility allows for a variety of configurations to be formed. These include installation and operation as a personal workstation, as a unit interface and node in a distributed system, or as an interface to a central mainframe.

The Monitor Unit is capable of displaying multicolour text, radar video, CCTV data, high-speed graphics such as Windows, overlays, cartographics, and tactical symbology on a militarised, high-resolution, 19 in raster scan, colour Cathode Ray Tube (CRT). The monitor unit also provides Finger On Glass (FOG) touchscreen



The MMC which can be used in a variety of configurations



MMC architecture

capability, interfacing with the graphics/display processors, which are components of the processor unit.

The processor unit is a self-contained, self-cooled unit that is capable of operating independently of the other MMC units. The processor unit houses the graphics processor, display generator, applications processor, and external I/O interfaces. The processor unit uses a RISC processor and/or processors from the 680X0 family, combined with an optional floating point co-processor to perform its application and graphics processing. Software packages presently in use include: X-Windows, GKS, CGI, CGM, C, Unix, and Ada.

External interfaces supported include: Synchro, RS-232C, RS-422, MIL-STD-1397 A to E, MIL-STD-188, MIL-STD-1553, SAFENET, IEEE 802.3, SCSI and Centronics.

The OEP is the primary device for operator control of the MMC. The OEP is tailored to meet customer requirements and MMI interfaces, and includes: FOG; trackerball/marble; electroluminescent panel with infra-red touch panel; QWERTY keyboard; fixed and programmable keys; audio and communication controls; and numeric keypad.

Operational status

Produced for the PISCES combat information system and in service aboard Egyptian Navy Romeo class submarines.

Contractor

Lockheed Martin, Naval Electronics & Surveillance Systems, Undersea Systems, Manassas, Virginia

VERIFIED

MRCS

Type

Militarised Reconfigurable Console System (MRCS).

Description

The MRCS is a tactical console capable of being reconfigured for a wide range of applications. The hardware has been designed and tested in accordance with stringent US Navy requirements for shock, vibration, EMI, humidity, sand, dust, salty fog, fungus and acoustic noise.

Up to four MC68020/68881 processors are built around the VME bus architecture, providing a large, commercial support base which is expandable in both processing power and memory. Processing speeds up to 6 Mips are possible and the system has a 4 to 24 Mbyte RAM memory. Up to 12 interfaces are available in the single display, depending on the configuration selected.

It provides a flexible I/O configuration which can be expanded or modified to fit the application. A powerful embedded graphics generator can provide multiple, independent graphics output and input video overlays and the system supports two independent monitor drivers with four graphics planes per driver (expandable to eight).

Operational status

The consoles were supplied under contract to the US Navy for the MHC-51 (Osprey class) programme where they are used in the navigation/command and control system, the AN/SYQ-13.

Contractor

Lockheed Martin, Naval Electronics & Surveillance Systems, Undersea Systems, Manassas, Virginia.

VERIFIED

TRANSDUCERS, HYDROPHONES AND PINGERS

Canada

Barrel Stave Projector (BSP)

Type
Acoustic projector.

Description
Built under licence from the Defence Research and Development Canada (DRDC), the BSP is a Class III flextensional transducer capable of providing high power and broadbandwidth in a very small unit. The unit comprises a stack of PZT ceramic rings bolted to end plates. Staves mounted in an inverted barrel configuration are also attached to the end plates. The unit is housed in a rubber boot which forms its outer shell. The expansion and contraction of the stack is transmitted to the staves and results in an enhanced volume velocity. With diameters of 10 to 30 cm, BSPs are able to radiate efficiently at frequencies below 1 kHz. The transducer is suitable for use in sonobuoys and for multi-element towed or volumetric arrays.

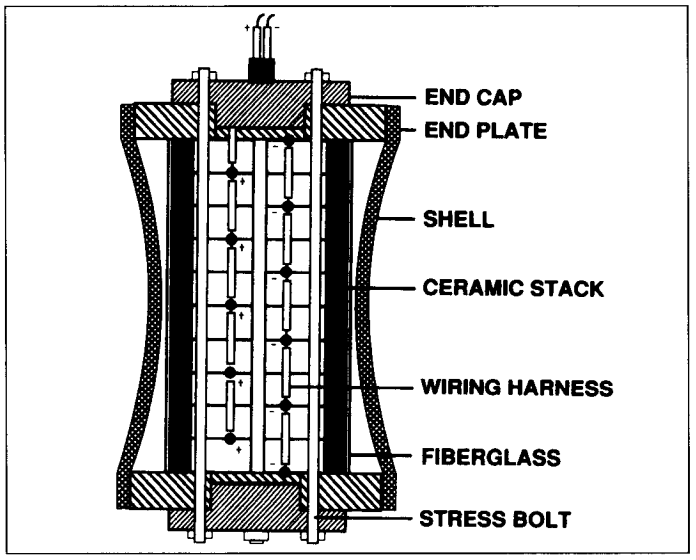
Operational status
In production.

Specifications

	Model 03BA1100	Model 06BA0800
Weight:	2.1/1.3 kg	18/12 kg
Frequency:	600-1,300 Hz	500-1,700 kHz
Resonant Frequency:	1,100 Hz	800 Hz
Bandwith (-3 dB):	200 Hz	200 Hz
Directivity at resonance:	Omni	Omni
Max sound pressure:	197 dB/1µPa/m	200 dB/1µPa/m

Contractor
Ultra Electronics Maritime Systems , Dartmouth, Nova Scotia.

VERIFIED



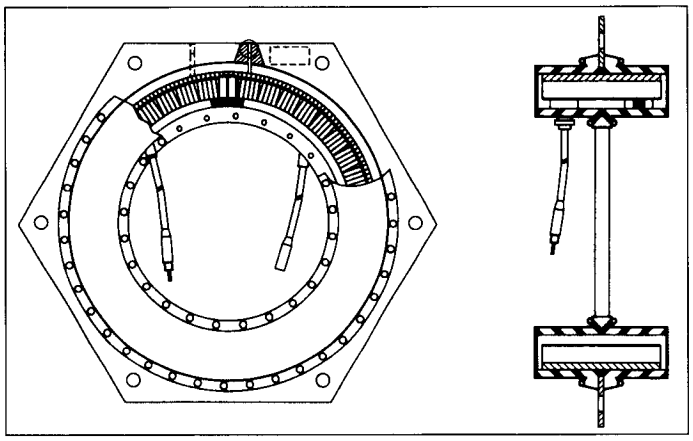
Cutaway of BSP

Free-Flooded Ring (FFR) projector

Type
Acoustic projector.

Description
The FFR projector is a high power, LF, broadbandwidth sonar transducer consisting of a ring of piezoelectric ceramics contained within a neoprene boot which produces a toroidal beam pattern around the horizontal plane. The unit has exceptional properties for low-frequency active sonar applications, very wide bandwidth, very high efficiency (greater than 90 per cent), and unlimited depth capability. The FFR projector operates in the 500 Hz to 8 kHz frequency band and can produce source levels in excess of 220 dB per element at around 1 kHz.

Operational status
In production. FFR projectors are used in Canadian LFA programmes (TIAPS) and UK sonars (Type 2087), and by other navies to support their basic naval research programmes.



Cutaway of FFR projector

Specifications

	Model 28FC1000	Model 18FA1800
Weight (dry):	270 kg	75 kg
Frequency:	900-2,000 Hz ± 5%	1,500-4,000 Hz ± 5%
Apparent bandwidth (-3 dB):	1,000 Hz ± 5%	1,900 Hz ± 5%
Max sound pressure:	222 dB/1µPa/1 m (±1 dB)	219 db/1µPa/1 m (±1 dB)
Directivity at resonance:	Radial - omni ±1 dB Axial - -20 dB @ 800 Hz	Radial - omni ±1 dB Axial - -20 dB @ 1,600 Hz
Electrostatic efficiency:	75% @1.5 kHz	75% @ 3 kHz

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.

VERIFIED

VERIFIED

Horizontal Projector Array (HPA)

Type
Acoustic projector.

Description
The HPA is a non-traditional approach to LFA (Low Frequency Active) sonar that has been the subject of active research and development in Canada. The HPA consists of an array of BSPs that can be integrated with a towed, horizontal line array receiver for deployment and recovery as a single in-line, critical angle tow. This results in advantageous handling, integration and performance features for both shallow and deep-water operation. Inherent in the performance of the HPA is an azimuthal steering capability.

Operational status
In service as a research tool.

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.

VERIFIED

Resonant Pipe Projector (RPP)

Type
Acoustic projector.

Description
The RRP is a high power, LF, underwater sound source designed for moored applications. The RPP consists of a ring of piezoelectric ceramics attached to the centre of a large pipe. The ring excites the pipe, which acts as an acoustic waveguide. Because of its free-flooding design, the RPP has unlimited depth capability and can operate at or below 250 Hz. The unit was developed specifically for the oceanographic community and is being used as a source for SOFAR (Sound Ocean Fixing And Ranging) experiments.

Operational status
In production.

Specifications: Resonant Pipe Projector (RPP)

	Frequency range*	Source level†	Dry weight	Efficiency	Maximum operating depth	Cavitation depth	Bandwidth at resonance‡	Outside diameter	Thickness
Free flooded ring									
13FA2000	2,000-4,000 Hz	216 dB		90%	Unlimited		2,000 Hz	31 cm	15 cm
27FA200	1,000-2,000 Hz	222 dB		90%	Unlimited		1,000 Hz	68 cm	
Resonant pipe projector									
22PB0260	260 Hz ±4 Hz	204 dB	242 kg	85%	Unlimited	111 m	3 Hz	71 cm	178 cm
Barrel stave projector									
03BA1,100	1,100 Hz	191 dB	2 kg	70%	200 m		260 Hz	8 cm	18 cm
06BA0550	550 Hz	200 dB	10 kg	70%	250 m		110 Hz	8 cm	26 cm

Nominal technical data and design parameters provided for guidance only.

Notes:
* at nominal 30 m depth
† at 3,500 V RMS drive
‡ at 3 dB points

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia.

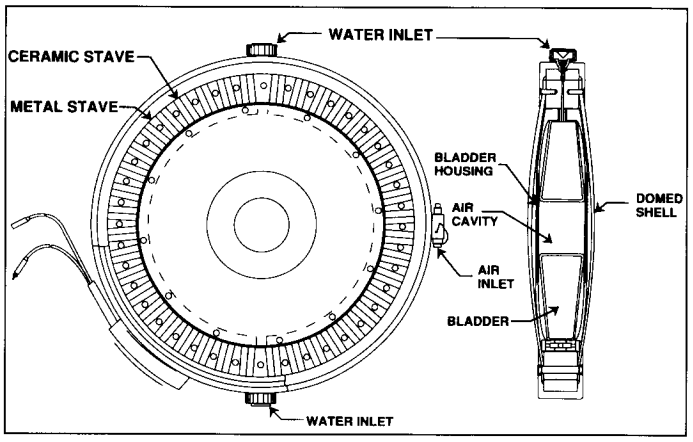
VERIFIED

Ring Shell Projector (RSP)

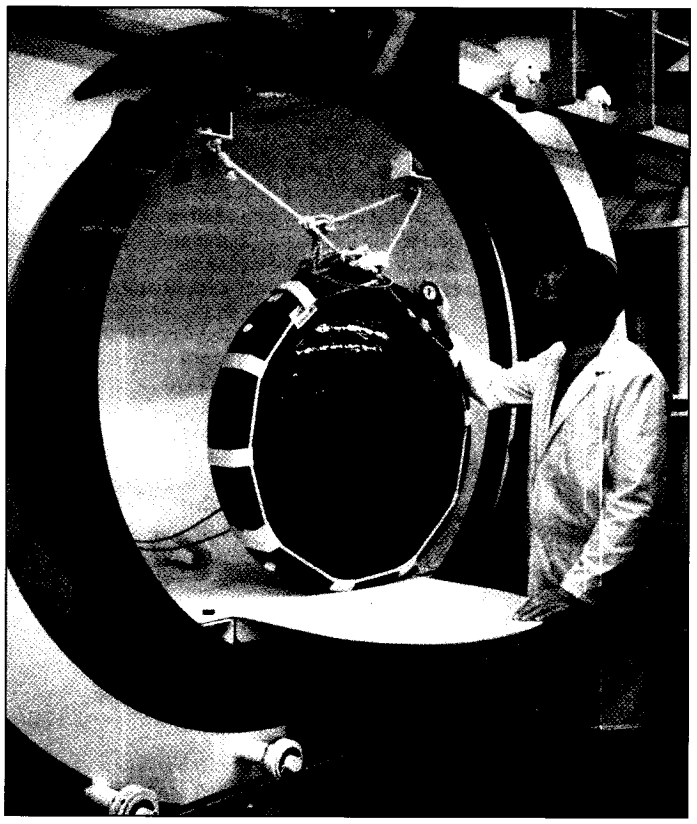
Type
ASW research and training device.

Development
The RSP underwater sound projector was originally developed by the Defence Research and Development Canada (Atlantic) in Dartmouth, Nova Scotia, Canada. Transfer of the technology to Ultra Electronics Maritime Systems was completed in 1999.

Models of various sizes, weights and performance characteristics have been produced incorporating industrial design improvements to increase the overall efficiency. Design for models resistant to underwater explosive shock are in development.



Depth-compensated ringshell projector



Cutaway of depth-compensated RSP

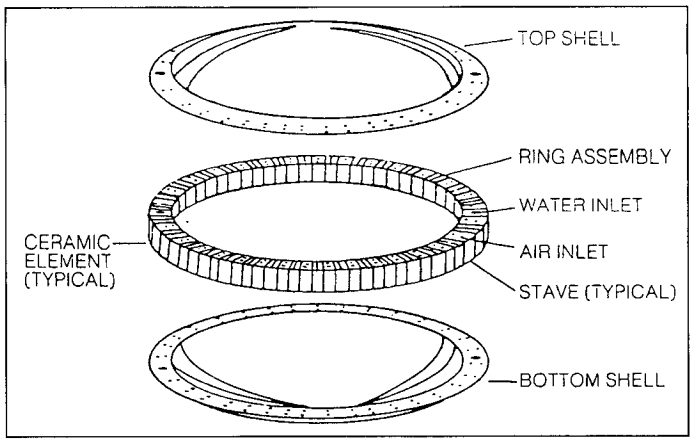
Description
The depth-compensated RSP is a Class V flextensional transducer that can efficiently produce a high acoustic output over a broad operating band. With its passive pressure compensation system, a ring shell projector has an operating depth exceeding 400 m and a safe immersion depth exceeding 500 m. The device can be designed to operate from frequencies below 150 Hz up to 3 kHz, producing an omnidirectional beam pattern. The RSP is used in LF towed active sonar applications.

Specifications: Ring Shell Projector (RSP)

Model number	Resonance Frequency*	Resonance frequency	Directivity	Source level†	Bandwidth at Resonance‡	Ring size diameters A	B	C	D	E Min	Comments
18SA0350	200 to 500 Hz	350 Hz	Omni ± 0.5 dB	203 dB	38 Hz	18.6 in (47.2 cm)	21.6 in (54.9 cm)	3.8 in (9.6 cm)	2.9 in (7.4 cm)	24.0 in (61.0 cm	219 dB possible at 3.6 kHz
18SA0950	600 to 1,300 Hz	950 ±25 Hz	Omni ±1.0 dB	206 dB	255 Hz	18.6 in (47.2 cm)	21.6 in (54.9 cm)	6.5 in (16.5 cm)	3.1 in (7.9 cm)	24.0 in (61.0 cm)	217 dB possible at 3.6 kHz
34SA0400	300 to 500 Hz	400 ±25 Hz	Omni ±0.5 dB	210 dB	>87 Hz	34.6 in (87.9 cm)	37.6 in (95.5 cm)	9.3 in (23.6 cm	4.5 in (11.4 cm)	24.0 in (61.0 cm)	220 dB possible at 2.5 kHz
34SA0610	500 to 750 Hz	600 ±25 Hz	Omni ±10 dB	212 dB	>140 Hz	34.6 in (87.9 cm)	37.6 in (95.5 cm)	12.2 in (30.1 cm)	4.7 in (11.9 cm)	24.0 in (61.0 cm)	220 dB possible at 2.5 kHz

Nominal technical data and design parameters provided for guidance only.

Notes:
* at nominal 30 m depth † at 3,000 V RMS drive, dB/ 1 µPa @ 1m ‡ at 3dB points



Ringshell component diagram

RSPs are being used in a variety of applications where high power and efficiency are required at relatively low frequencies. As a research tool, the projectors have been employed as single units or as part of large arrays. Further, passive ASW training is available without the use of a target submarine by generating signals of desired frequencies and levels. The projector can also be adapted for use as a separate active adjunct element to current passive arrays, or as part of a low-frequency, high-power, deep submergence sonar. Applications also involve using RSP-based systems to calibrate and evaluate the performance of towed arrays.

Because the Class V RSP has only two fundamental modes of vibration (ring and shell modes), its element-to-element interactions are minimised when compared to other technologies. Reduction of these interactions is extremely significant when operating projectors in large arrays, and allows for tighter projector spacing. In addition, the design results in low mechanical stresses in the shell and ring.

The RSP consists of a glass fibre-wrapped, piezoelectric ceramic ring fastened between two convex-domed spherical metals. Stimulation of the ceramic ring by an electrical signal causes vibration of the ring in the radial plane. The radial motion of the ceramic ring drives the shells in a flexure mode with a significant enhancement of the volume velocity at the shell surfaces.

The projector design is flexible and can be tailored to specific requirements for frequency, bandwidth and power. The resonant frequency can be adjusted for specific ring diameters over a three octave band, by altering the shell curvature and thickness. Acoustic power for a given ring size is controlled by the ceramic ring cross-sectional area. Bandwidth is adjusted by modifying the acoustic radiating surface.

Passive depth compensation is effected through the use of a bladder, housed within the inner shell of the RSP. The bladder is open to the sea and is allowed to expand or contract within the pressurised chamber of the RSP. Because of the depth compensating system and the pressurised air cavity, the depth capability of the RSP exceeds by three times the range of one without these features.

The design of ringshell projectors by computer is the result of extensive finite element modelling, of which the accuracy and correlation with test results have been confirmed over several years.

Good thermal contact between seawater and the ceramic ring, both outside and inside the projector, allows the use of projectors for extended durations. The standard operating drive voltage of 3,000 V provides a duty cycle of greater than 10 per cent.

The table lists some of the characteristics of units manufactured and delivered to various customers. These units tracked computer data with extremely good fidelity (model number codes list the diameter in inches as the first two digits and resonant frequency as the last four digits. Resonant frequencies are listed at 30 m depth and source levels are based on a 3,000 V RMS drive).

Operational status
In production. RSPs have been deployed from surface ships and submarines as hull-mounted or VDS transmitters, in single or multi-element arrays.

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia. ***VERIFIED***

Sonar Research Projector (SRP)

Type
Acoustic projector.

Description
The SRP has been developed from COTS components to support on-going research into active and passive sonar systems for the Defence Science and Technology Organisation of Australia. As a calibrated, high power, LF, wide band, towed sonar system, comprises a tow body containing an array of sonar transducers and sensors, a tow cable, a winch and handling system, a PC-based sonar controller and an ISO container. The array of active sonar transducers provides acoustic output capability over a frequency range from below 100 Hz to 10 kHz. The tow body includes a suite of wet-end sensors comprising monitor hydrophones and depth, temperature, pitch, roll and acceleration sensors. The PC-based controller handles all sonar functions including signal generation, echo repeat and so on, as well as display and logging of the wet-end sensors. The SRP fits within an ISO ICC container envelope and is transportable with a full-up system weight of 10 tonnes.

Operational status
In service in Australia with the DSTO.

Contractor
Ultra Electronics Maritime Systems, Dartmouth, Nova Scotia. ***VERIFIED***

France

ESAX-2A

Type
Sonar locator beacon.

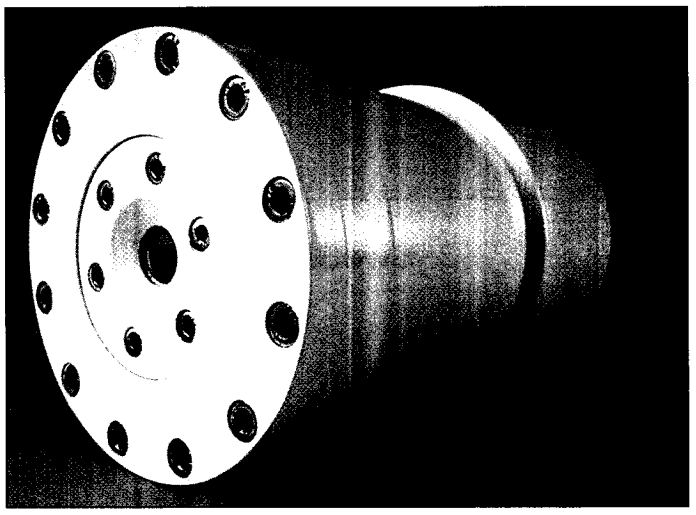
Description
The ESAX-2A is designed to provide for the detection and localisation of sunken aircraft in deep water. The device can be fitted to both fixed-wing aircraft and helicopters and is automatically activated when the downed aircraft reaches a depth of between 3 and 6 m. Lithium-Ion batteries power the device which produces an omnidirectional radiation pattern.

The emission pulse characteristics are compliant with STANAG requirements. All localisation systems using the NATO frequency such as underwater telephone TUUM-4 and the sonar intercept Velox may be used to locate the acoustic beacon.

Operational status
In service with the French Navy.

Specifications
Height: 160 mm
Diameter: 100 mm
Weight: 2.7 kg (in air)
Frequency: 8.8 kHz
Period: 50 s
Pulse duration: 50 ms
Acoustic transmission level: 180 dB/1μPa/m
Shock resistance: 1,000 g at peak, 1/2 sine pulse, 5 ms duration
Crash resistance: 22,500 N
Operational depth: ≤3,000 m (300 bar)
Autonomy: >30 days

Contractor
Thales Safare, Sophia Antipolis ***UPDATED***



ESAX-2A acoustic beacon (Thales Safare) ***NEW***/1035051

Germany

KE 8

Type
Passive sonar hydrophone.

Description
The KE 8 hydrophone has been designed for wideband passive sonar systems. The piezoelectric ceramic plates are installed in a metal housing protected against

water ingress by a rubber boot 3 mm thick. The 2-core connection cable is vulcanised. The mechanical design of the device exhibits an omnidirectional characteristic.

The hydrophone is made of lead-zirconium-titanate with a frequency range of 20 Hz to 20 kHz and a maximum operating depth of 600 m.

Operational status
In service.

Contractor
L-3 Communications ELAC Nautic GmbH, Kiel.

VERIFIED

KE 9

Type
Hydrophone unit.

Description
The KE 9 hydrophone is intended for use in wideband passive sonar systems. It consists of a piezoelectric ceramic tube that is connected electrically via a pressure proof connector. The active material is lead-zirconium-titanate with a frequency range of 10 Hz to 20 kHz and a maximum operating depth of 600 m.

Operational status
In service on German Navy Type 206A and German-built Type 209 submarines and the 'Gal' class submarines of the Israeli Navy currently up for sale.

Contractor
L-3 Communications ELAC Nautic GmbH, Kiel.

VERIFIED

LSE 800

Type
Frigate and submarine sonar transducer.

Description
The LSE 800 transducer has been specially designed for the DSQS-21/23 sonar. The lead-zirconium-titanate transducer operates at a frequency of around 8 kHz and is specified for a maximum operating depth of 600 m.

Operational status
In service on all German Navy frigates and submarines.

Contractor
L-3 Communications ELAC Nautic GmbH, Kiel.

VERIFIED

Sweden

BBT500

Type
Broadband transducer.

Description
The BBT500 broadband transducer is built around the powerful, direct liquid cooled Terfenol-D drivers with three flextensional mode displacers.

The active membranes comprise two carbon fibre pistons connected to the three drivers. The driver configuration with the three mode displacers results in a broadband transducer with a frequency range of 200 Hz to 5 kHz exhibiting a very flat spectrum. An intelligent control system ensures that the output signal is long-term stable and repetitive.

The transducer can be fully shock proofed for MCM applications.

Specifications
Frequency: 200 Hz – 5 kHz
Output level (peak): 205 dB/1 µPa
Weight: 195 kg

Contractor
CETUS Systems AB, Vasteras.

VERIFIED

BBT900

Type
LF broadband transducer.

Description
The BBT900 LF broadband transducer is based on three parallel liquid-cooled Terfenol drivers each containing 600 mm of Terfenol-D.

The drivers are connected to two carbon fibre pistons through a configuration of flextensional mode displacers. The combination of flextensional mode displacers transforms the power from the Terfenol drivers into piston movement. The mode displacers provide maximum stroke throughout the entire frequency range from 10 Hz to 200 Hz with a very flat frequency spectrum.

The transducer can be fully shock proofed for MCM applications.

Specifications
Frequency: 10 Hz – 200 Hz
Output level (peak): 195 dB/1 µPa
Weight: approx 400 kg

Contractor
CETUS Systems AB, Vasteras.

VERIFIED

Terfenol-D

Type
Flextensional transducer.

Development
Terfenol-D was invented at the Swedish Naval Ordnance laboratory and developed by Celsius to provide increased output power at low frequencies for use in acoustic minesweeping systems. The flextensional transducer was developed during the early 1990s for installation in the new Agate acoustic minesweeping system under development for the Norwegian Navy.

Description
The Terfenol-D transducer is a Class IV flextensional type. Terfenol driver actuators carry out electromechanical transduction. Terfenol-D is an alloy of highly magnetostrictive material manufactured from TERbium and FErro (Iron) in the form of rods. The strain developed by the material is up to 10 times greater than that developed by piezoceramics, which enables a higher power output to be obtained. The Terfenol-D actuator can also develop higher frequencies than a hydraulic system and is more robust than an electrodynamic system. As such it is well-suited as a driver for a low- to medium-frequency high power source.

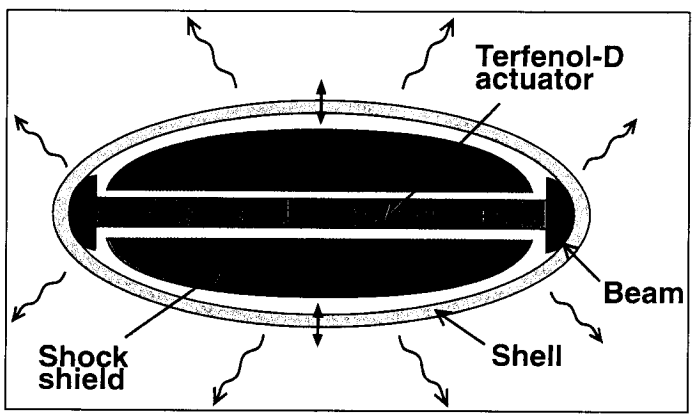
Terfenol-D is a brittle material and can only be used under compressive stress. The Terfenol actuators must therefore be prestressed before use and in the transducer this is achieved automatically during operation.

To transmit high acoustic power at low frequencies requires large volume water displacement. To achieve large volume displacement directly from the Terfenol rod movement would require very large transducers.

To overcome this the Terfenol actuators push on two beams inside the oval flextensional shaped shell, generating a coherent motion on the ends of the shell. The flexing of the shell transforms the motion of the Terfenol actuators so that the motion of the large sides of the shell is some three to five times greater than the motion of the actuator during quasi-static operation.

This mechanical transformation makes it possible to keep the transducer size reasonably small. The transformation factor during dynamic operation can be several times a factor of 10, due to resonances.

To provide protection against mine detonation in the vicinity of the transducer, mechanical shock shields that 'catch' the shell prevent it from imploding when detonation occurs.



Diagrammatic view of Terfenol transducer showing movement of shell and rod and resulting acoustic transmission
0059990

Terfenol-D flextensional transducers are capable of accurately generating ship signatures within the required bandwidth, and can simultaneously generate both single tones and noise.

Operational status
In service with the Agate acoustic minesweep of the Norwegian Navy.

Specifications
Length: 700 mm
Width: 700 mm
Height: 700 mm
Weight: 85 kg (in air), 70 kg (in water)
Operating depth: 5-200 m

Contractor
Saab Bofors Dynamics AB, Karlskoga.

VERIFIED

United Kingdom

Flextensional transducers

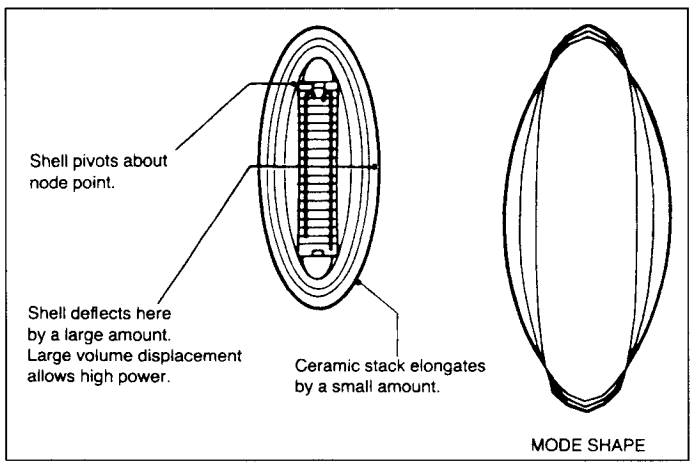
Type
Underwater acoustic transducer devices.

Description
BAE Systems has developed a range of flextensional transducers for underwater applications. These comprise a piezoelectric ceramic stack operating in piston mode and enclosed in an elliptical shell. The shell flextures mechanical advantage produces the large volume displacements required to generate low frequencies. These transducers can be built for operation at frequencies from 300 to 3,500 Hz, either from a range of standard designs, or designs tailored to meet individual requirements. The transducer weighs less than 3 kg and can be assembled into staves and arrays to provide beam patterns for customer-specified directivity requirements and can be modified to survive a wide range of depth requirements.

Operational status
BAE Systems has supplied low-frequency flextensional transducers to the US Naval Underwater Systems Center. Transducers have also been supplied to France, Japan, Korea, Norway and to the UK MoD. Flextensional transducers are a key component in the low-frequency ATAS (Active Towed Array Sonar).

Contractor
BAE Systems, Operations, Waterlooville, Hampshire.

UPDATED



The operating principle of Flextensional transducers (BAE Systems) 0143750

Model 2433A

Type
Submarine warning beacon.

Description
The Model 2433A submarine warning beacon is a heavy-duty underwater acoustic beacon designed to meet MoD specifications to protect oil/gas rigs operating in NATO authorised submarine transit lanes.

The pinger is activated by water immersion or manually using a shorting link and emits sufficient power to alert dived submarines of the rig's position, allowing safe submersible navigation past the rig without risk of collision.

The beacon operates for up to 60 days.

Specifications
Operating depth: 1,200 m
Frequency: 9.5 kHz
Coverage: omnidirectional
Pulse length: 115 ms
Pulse repetition rate: 0.5 pps
Dimensions: 89.5 cm (long) × 13.03 cm (diameter)
Weight: 16 kg (in air)

Contractor
Nautronix Ltd, Aberdeen.

VERIFIED

Pingers

Type
Underwater location devices.

Description
The Nautronix range of acoustic pingers allows valuable equipment, test apparatus, divers, torpedoes and ROVs to be marked and easily relocated using Nautronix surface diver, or ROV-mounted locators. The range of frequencies from 12 to 50 kHz allows easy differentiation between equipment in local areas.

A variety of models are available, with battery lives between four days and one year, as well as ROV power loss units which start pinging when power to the vehicle is interrupted.

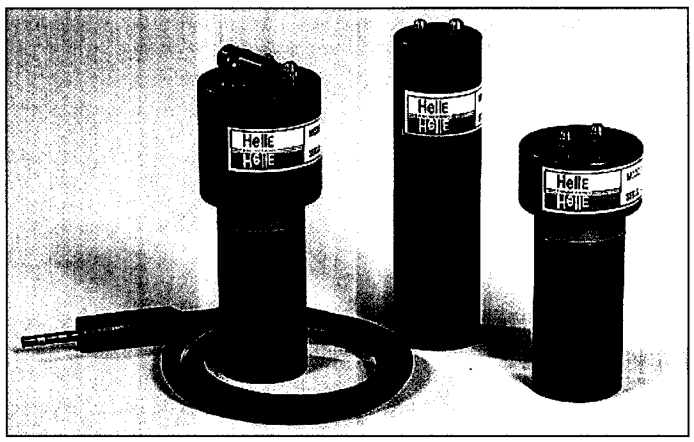
All units are switched on via through-water contacts which guarantees operation in all circumstances. An option is also available for manual switches if required.

All units have a minimum depth rating of 1,860 m with options beyond 4,000 m.

Operational status
In use with various navies' MCMVs, acoustic ranges, ROVs and subsea equipment marking.

Contractor
Nautronix Ltd, Aberdeen.

VERIFIED

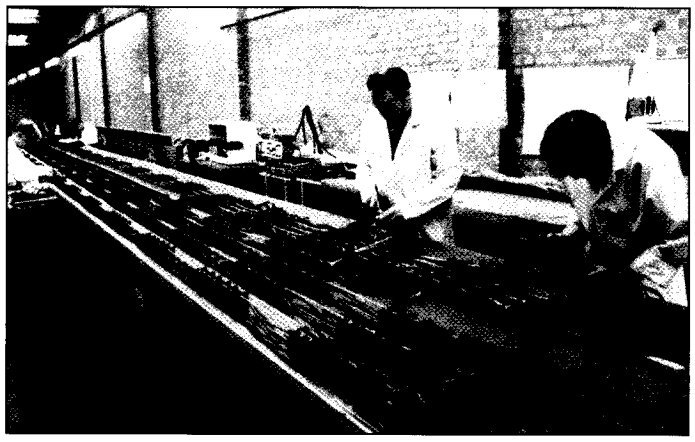


Pingers for ROV mounting

Thales Underwater Systems transducers

Description
Thales Underwater Systems manufactures a variety of transducers, arrays and acoustic devices. Many of the latest elements are modular devices designed to be configured into a variety of array shapes to meet individual needs. Emphasis has centred on the development of specialist polymer and ceramic techniques for sonar devices.

The design and manufacture of sonar systems and acoustic devices include large hull-mounted ship and submarine active/passive transducer arrays, as well as flank and towed arrays for the Royal Navy. The company manufactures a wide range of underwater transducers covering the frequency range from 1 Hz to 6 MHz, including barrel staves, piston stacks, tubular and spherical ceramic transceivers and omnidirectional wideband hydrophones.



Thales towed arrays being assembled

The latest transducer development concerns the use of fibre optic hydrophones for sonars. This technology is considered to offer a number of benefits over traditional ceramic hydrophones, depending on the particular application. Among benefits noted are a reduction in overall power requirements and the ability to feed power over long distances to wet end components (as in towed arrays) with reduction in strength of power.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

Transducers

Type
Spherical Transducers/Hydrophones.

Description
Gearing and Watson has available a complete range of transducers to cover the majority of applications.

Transducers for echo sounders, high- or low-frequency applications, dual-frequency devices, side scan applications, transponder/communications applications and spherical beam devices are available. The range is summarised below:

Operational status
In service.

Contractor
Gearing and Watson Electronics Ltd, Hailsham, West Sussex.

UPDATED

United States

ALP-365 Flexi-Pinger™

Type
Acoustic pinger.

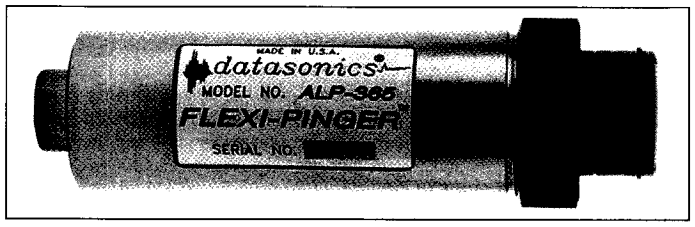
Description
The Flexi-Pinger™ uses state-of-the-art electronics which enables the user to quickly and easily customise the pinger for their own specific applications.

The electronics are protected by a tough, rugged, aluminium housing which ensures long operating life in a hostile marine environment. The unit is powered by two alkaline or lithium 9 V batteries (six with optional long-life housing for four additional batteries.

Specifications
Length: 19.25 cm
Diameter: 4.80 cm
Weight: 0.53 kg
Frequency: 25-40 Khz (user selectable)
Output: 0.125, 0.5, 2 or 5 W (user selectable)
Pulse length: 4 ms
Pulse repetition: 2 pulse/s, 1 pulse/s or 1 pulse/2 s (user selectable)
Operating depth: 1,000 m

Contractor
Benthos Inc, North Falmouth, Massachusetts.

VERIFIED



ALP-365 Flexi-Pinger™ (RJE International Inc) 0077538

DRI-267

Type
Diver operated transponder interrogator.

Description
This is a seven-channel acoustic transponder interrogator which features a backlit LCD display showing range to the transponder, as well as bearing (derived using phase-comparison technology) information to the transponder. An optional surface conversion kit (ACU-266) allows the user to turn the unit into a surface unit. It is designed for use with the UAT-376, UAT-387 and UAT-387E acoustic transponders. The system can interrogate and track seven different transponders, each operating on a different frequency. It can be factory-programmed to be compatible with customers' existing acoustic transponders.

Transducers

Model	Applications					Frequency Range		Beam Pattern (deg)	
	Echo Sounder	Transponder	Side Scan	Hydrophone	Omni Projector	Low kHz	High kHz	Horizontal Wide	Vertical Narrow
147	Yes	-	-	-	-	24-50	-	17-23	-
152	Yes	-	-	-	-	24-38	-	14-23	9-15
142	Yes	-	-	-	-	-	160-600	-	5-12
T18	Yes	-	-	-	-	-	120	16.5	10.5
T37/T28	Yes	-	-	-	-	-	200	6.0	3.1
T27	Yes	-	-	-	-	12	-	33	33
76	Yes	-	-	-	-	24-38	160-600	14-23	5-12
T22	Yes	Yes	-	-	Yes	2	-	omni	-
T36/T61	-	-	Yes	-	-	100	500	1 and 0.3	40
T62/3/4	-	-	Yes	-	-	100	500	1 and 0.3	40
T30	-	Yes	-	-	Yes	50-60	-	omni	180
T43	-	Yes	-	-	Yes	45-61	-	omni	180
T54	-	Yes	-	-	Yes	8-16	-	omni	180
B1/200	-	-	-	Yes	-	-	0.1-150	omni	omni
D/11	-	Yes	-	Yes	Yes	0.1-20	-	omni	omni
D/17P	-	Yes	-	Yes	Yes	0.1-30	-	omni	omni
D/26P	-	Yes	-	Yes	Yes	0.1-45	-	omni	omni
D/70	-	-	-	Yes	Yes	0.1-100	-	omni	omni
D/140	-	-	-	Yes	Yes	-	0.1-200	omni	omni
D/300	-	-	-	Yes	-	-	0.1-500	omni	omni

The unit is suitable for use where an underwater acoustic transponder needs to be located, tracked or homed in on by a diver and is useful for underwater tracking and navigation where stealth is a key concern.

The system includes a compass and rechargeable battery pack with charger.

Specifications

Length: 32 cm
Diameter: 11.4 cm
Weight: 3.35 kg
Transmitter: 26 kHz
Receiver: 25, 27 to 32 kHz
Acoustic source level: 184 dB/l μPa/m
Transmit repetition rate: 1.2 s
Transmit pulse length: 5.0 ms
Sensitivity: −190 dB/1 μPa/m
Beam width: ±15°
Operating depth: 200 m

Contractor

Benthos Inc, North Falmouth, Massachusetts. ***VERIFIED***

DRT

Type

Double Resonant Transducer (DRT).

Description

With the current emphasis on broadband sonar signal processing, new classes of transducer are under development at the NUWC. One of these is the DRT. The DRT is a mechanical series arrangement of two piezoelectric ceramic stacks with a centre mass between them plus a tail and head mass at opposite ends. This arrangement creates a double-resonant transducer, in which a shorter piezoelectric section controls the upper resonance and a longer piezoelectric section controls the lower resonance. The configuration of the transducer under study uses 26 ceramic rings on the longer stack and three ceramic rings on the short stack. The transducer features a 363 cm^2 radiating face (piston), with a length of 40.6 cm and weight of 23 kg without the underwater housing. The transducer is capable of producing high acoustic output power levels over two octaves.

Operational status

Under development.

Contractor

Naval Underwater Warfare Center, Newport Division, Newport, Rhode Island.
NEW ENTRY

ELP-362D

Type

Emergency locator beacon.

Description

The ELP-362-D is designed for applications where size and reliability in severe environmental conditions are critical. It can be used to mark aircraft or aircraft voice and data recorders for recovery in case of loss over water and for marking mines, torpedoes and 'black boxes'.

Contractor

Benthos Inc, North Falmouth, Massachusetts. ***VERIFIED***

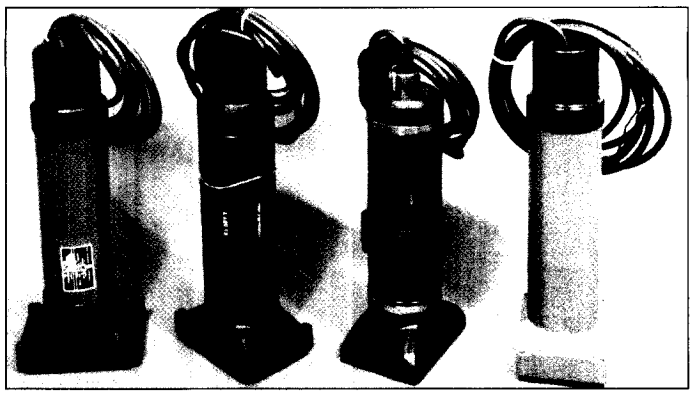
Flextensional transducers

Type

Flextensional transducers for ASW.

Description

A variety of transducers are available with design frequencies from below 200 Hz to units with a resonant frequency in the range of 3 kHz. These transducers produce



Range of Raytheon transducers (Raytheon) 0131458

sound pressure levels up to 217 dB from each transducer. The flextensional transducers are ideally suited for LF active towed arrays.

Cylindrical transducers are also manufactured which have been demonstrated to provide the greatest power per unit volume/weight compared to many other transducers. These are sufficiently lightweight but robust in nature to be suitable for use in sonobuoys and expendable systems.

LF magnetostrictive transducers have also been produced that operate at frequencies down to 1 kHz.

Operational status

In service.

Contractor

Raytheon Electronic Systems, Portsmouth, Rhode Island.

VERIFIED

Low-frequency Transmit Subsystem (LTS)

Type

Flextensional transducer acoustic source array.

Description

The LTS is a large, hydrodynamically stabilised array of low-frequency, active, high-powered projectors with associated power amplifiers, handling equipment, software, data processing and a unique transmit control beamformer.

The LTS is claimed to be the largest flextensional system ever built. LTS forms part of the US Navy's SURTASS system, the total system including a towed hydrophone array, processing and display equipment, communications and navigation segments and a shore facility (see entry on SURTASS).

Operational status

Two LTS sets were built under a contract issued in October 1990: one set for technical evaluation and the other for operational evaluation. Hardware endurance testing commenced in May 1991 and was completed in the summer of 1991. The first production module was delivered early in July 1991 and delivery has been completed.

Contractor

BAE Systems North America, Information & Electronic Warfare Systems, Nashua, New Hampshire.

VERIFIED

Model 30

Type

High-powered projector.

Description

The Model 30 is a high-powered, low-frequency, broadband, flextensional transducer with an uncompensated operating pressure of 300 psi. The transducer weighs 96 lb in air with the coil, and has a minimum efficiency rating of 80 per cent.

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit juws.janes.com

Operational status
The Model 30 has been used by the US Navy in a variety of exercises and operational tests.

Contractor
BAE Systems North America, Information & Electronic Warfare Systems, Nashua, New Hampshire.

VERIFIED

Model 40

Type
Flextensional transducer.

Description
The Model 40 flextensional transducer is a high-power, low-frequency, broadband flextensional transducer. It has an uncompensated operating pressure of 300 psi, weighs 84 kg in air with its coil and has a minimum efficiency rating of 80 per cent.

Operational status
The Model 40 has been used by the US Navy in a variety of exercises and operational tests.

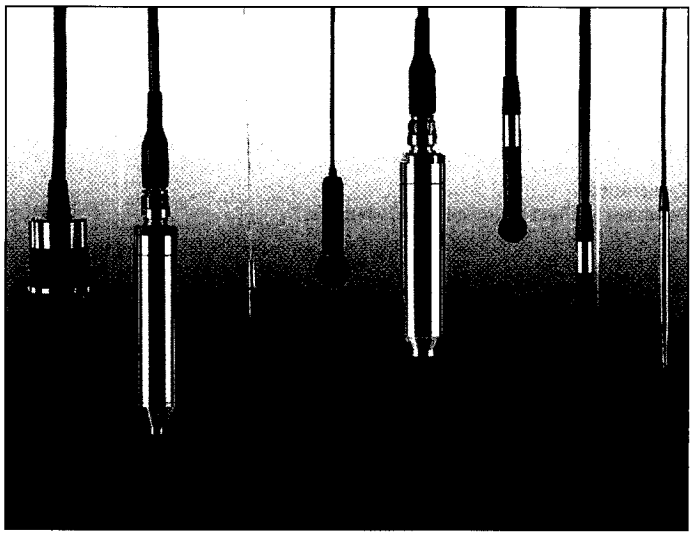
Contractor
BAE Systems North America, Information & Electronic Warfare Systems, Nashua, New Hampshire.

VERIFIED

RESON transducers and hydrophones

Type
Acoustic transducers and reference hydrophones.

Description
RESON manufactures transducers and hydrophones for a wide range of underwater measuring systems and industrial products. The equipments are available for systems and products such as echo-sounders, flow-, level- and velocity meters, side scan systems and sonar arrays.



RESON standard hydrophones 0009871

RESON transducers and hydrophones

Model	Description	Resonant Frequency (Usable Bandwidth)	Vertical Directivity Pattern	Horizontal Directivity Pattern	Transmitting Sensitivity (+/– 3dB)	Receiving Sensitivity (+/–3dB)	Maximum Power	Depth (Survival)	Weight in air with cable
TC 1010	Telephone/ Distress Pinger	12 kHz (7-16)	200°	Omni	+ 129 dB	– 185 dB	300 W	800 m	3.2 kg
TC 1032	Telephone Transducer	8 kHz (6-15)	80°	Conical	+ 139 dB	– 162 dB	400 W	800 m	5.8 kg
TC 1035	Communication Transducer	9.5 kHz (8-11)	70°	Omni	+ 148 dB	– 184 dB	1,000 W	3,000 m	9.6 kg
TC 1037	Telephone Transducer	8 kHz (6-16)	80°	Conical	+ 145 dB	– 171 dB	400 W	800 m	
TC 2016	Survey Transducer Echo-sounder	200 kHz +/–10	9°	Conical	+ 173 dB	– 187 dB	300 W	30 m	1.8 kg
TC 2024	Survey Transducer Echo-sounder	200 kHz +/–10	9°	Conical	+ 173 dB	– 187 dB	300 W	30 m	2.3 kg
TC 2032	Side-scan Transducer	60 kHz +/–6	53°	1.8°	+ 175 dB	– 179 dB	1,000 W	600 m	9.6 kg
TC 2046	Echo-sounder Transducer	200 kHz	18°	Conical	+ 160 dB	– 192 dB	50 W	30 m	0.5 kg
TC 2053	Triple Beam Width	100 kHz +/–5 kHz		Conical				50 m	10 kg
A	Transducer for Survey		30°		+ 162 dB	– 192 dB	200 W		
B1	Purposes w/Adaptable		10°		+ 171 dB	– 183 dB	500 W		
B2	Footprint		5.5°		+ 176 dB	– 178 dB	1,500 W		
TC 2078	Directional Transducer for Echo-sounder	300 kHz +/–15	2.6°	Conical	+ 179 dB	– 184 dB	1,000 W	400 m	7.8 kg
TC 2080	Echo-sounder Transducer	30 kHz (27-35)	45°	Conical	+ 161 dB	– 182 dB	300 W	250 m	3.6 kg
TC 2084	Echo-sounder Transducer	33 kHz (28-34)	21°	Conical	+ 166 dB	– 178 dB	1,000 W	30 m	5 kg
TC 2088	Side scan Transducer	100 kHz +/–20	30-35°	1.9°				600 m	
TC 2105	Positioning/ Navigation Echo-sounding	430 kHz +/–20 (430-500 kHz)	50°	Conical	+ 166 dB	– 178 dB	10 W	50 m	
TC 2111	Compact Echo-sounder Transducer	200 kHz +/–10	18.3°	Conical	+ 163 dB	– 189 dB	50 W	30 m	0.4 kg
TC 2115	Broad-band Transducer for Echo-sound	30 kHz (28-34)	23°	Conical	+ 168 dB	– 178 dB	1,000 W	50 m	5 kg
TC 2116	Broad-band Transducer for Echo-sound	50 kHz (40-110)	13.5°	Conical	+ 172 dB	– 177 dB	1,000 W	40 m	5 kg
TC 2122	Dual Frequency Survey Transducer	33 kHz 200 kHz	20° ,9°	Conical, Conical	+ 167 dB + 170 dB	– 178 dB – 187 dB	1,000 W, 450 W	50 m	5 kg

RESON transducers and hydrophones continued

Model	Description	Resonant Frequency (Usable Bandwidth)	Vertical Directivity Pattern	Horizontal Directivity Pattern	Transmitting Sensitivity (+/– 3dB)	Receiving Sensitivity (+/–3dB)	Maximum Power	Depth (Survival)	Weight in air with cable
TC 2127	Narrow Beam Survey Transducer	600 kHz +/–10	3.2°	Conical	+ 173 dB	– 187 dB	450 W	50 m	2.3 kg
TC 2130	'BASS' Broad-band Transducer	100 kHz, 150 kHz, 200 kHz	16.4°, 12.4°, 8.1°	Conical, Conical, Conical	+ 160 dB + 158.4 dB + 155.5 dB	– 177 dB – 180 dB – 185 dB			2.3 kg
TC 3012	Transducer for Sound Velocity Equip	1 MHz +/–50 kHz	5.8°	Conical	+ 173 dB	– 202 dB	10 W	500 m	0.075 kg
TC 3017	2 MHz Narrow Beam-width Transducer	2 MHz	2.2°	Conical					0.075 kg
TC 3019	Air Transducer for Pulse-Echo	2 MHz +/–100 k	5°	Conical	upon request	request	5 W	N/A	0.010 kg
TC 3021	Transducer for Sound Velocity Equip	2 MHz +/–150 k	2°	Conical	+ 186 dB	– 205 dB	5 W	700 m	0.035 kg
TC 3022	Universal Transducer in CuNi10-Alloy	1 MHz +/–50 kH	5.8°	Conical	+ 174 dB	– 202 dB	10 W	1,000 m	0.1 kg
TC 3027	Transducer for Sound Velocity Equip	1 MHz +/–100 k	5.8°	Conical	+ 170 dB	– 200 dB	10 W	500 m	0.04 kg
TC 3029	Universal Transducer	500 kHz	11°	Conical	+ 165 dB	– 192 dB	5 W	500 m	0.04 kg
TC 4003	Pinger Location Hydrophone w/Line Driver w/Preamp, box	37 kHz, 45 kHz, 70 kHz +/–10 k	84.1°, 86.3° 48.3°	34.7° 28.4° 16.1°	N/A, N/A, N/A	–157 dB, –158 dB, –144 dB		900 m	2 kg
TC 4004	Explosion tested Submarine Hydrophone	1 - 11 kHz (17)	Omni	Omni	+ 107 dB	–197 dB	–	800 m	0.35 kg
TC 4013	Miniature Reference Hydrophone	120 kHz (1 Hz-170 kHz)	270° (Omni)	Omni	+ 133 dB (80- 130 dB)	– 210 dB	–	900 m	0.075 kg
TC 4014	Broad-band Spherical HY w/26dB Preamp	15 Hz - 480 kHz	270° (Omni)	Omni	N/A	– 187 dB (Linear)	<50 mA (12 - 24 V)	1,000 m	0.65 kg
TC 4023	Robust Reference Hydrophone	100 kHz (10- 200 kHz)	270° (Omni)	Omni	149.5 dB (100- 30 dB)	– 200 dB (–207 dB)	–	800 m	1.5 kg
TC 4027	General Purpose HY w/20dB Preamp	10 Hz - 10 kHz	Omni	Omni	N/A	– 180 dB	60 mic amp (steady st.)	300 m	0.133 kg
TC 4032	Low Noise / High Sensitivity HY w/ 10dB Preamplifier	5 Hz - 120 kHz (flat 1 - 80 kHz)	270° (Omni)	Omni	N/A	– 170 dB	<40 mA (12 - 24 V)	900 m	0.825 kg
TC 4033	Robust, Spherical Reference Hydrophone	100 kHz (1 Hz - 160 kHz)	270° (Omni)	Omni	+ 149 dB (96- 136 dB)	–203 dB	–	900 m	1.5 kg
TC 4034	Ultra Broad-band Spherical Reference HY	300 kHz (1 Hz - 430 kHz)	270° (Omni)	Omni	+ 145 dB (75- 135 dB)	– 218 dB (Linear)	–	800 m	1.6 kg
TC 4035	Miniature Probe HY w/10dB preamp, 4mm tip, High Freq	50 - 900kHz	270° (Omni)	Omni	N/A	– 214 dB (Linear)	<15 mA (10 - 18 V)	200 m	0.7 kg
TC 4037	Spherical Ref, HY, Low Frequencies, High Pressure	1 Hz - 100 kHz	270° (Omni)	Omni	–	– 195 dB		2,000 m	
TC 4038	Miniature Reference Hydrophone - 4mm (TC 4035 w/o preamp)	10 - 800 kHz (linear 100-500 kHz)	270° (Omni)	Omni	–	– 227 dB @100 kHz		20 m	0.023 kg
TC 4050	Mini Flush-mounted HY 10mm tip	1 Hz-120 kHz	>180 (Omni)	Omni	N/A	– 216 dB		400 m	0.7 kg

A continuing programme of research and development ensures that equipments are available to meet the most demanding customer requirements as well as for simple transmit/receive operations. The product line encompasses both omnidirectional and directional transducers in a wide frequency range covering 3 kHz to 2 MHz.

The TC 1010 is a universal underwater telephone or distress pinger transducer, hemispherical in shape and oil filled. This unit is fully shock tested for submarine applications.

The TC 1032 is a universal broadband underwater telephone transducer that is designed to fit into existing housings either directly or with the use of a special adapter. The unit is fully shock tested for submarine applications.

The TC 4004 is a high-performance hydrophone developed specifically for use in submarine sonar arrays. Its frequency range, together with its physical dimensions make it a suitable substitute for existing stave hydrophones. The unit is shock tested to standard submarine shock specifications. A unique feature is the special water blocked cable termination, which enables a new cable to be connected if the existing one becomes damaged.

Contractors

RESON Inc, Goleta, California.
RESON A/S, Slangerup, Denmark.
RESON Offshore Ltd, UK.

VERIFIED

Transducers

Model number	Frequency	Beamwidth	Depth*	Comment
TR-109	3.5 kHz	**	10,000 m	4 kHz CHIRP; arrays replaces TR 75A
TC-4NB	4 kHz	60°	5,000 m	CHIRP
TC-2040	7 kHz	65°***	10,000 m	8 kHz CHIRP; arrays
TC-12NB	12 kHz	18°	10,000 m	CHIRP
TC-12/34	12/34 kHz	30/10°	6,000 m	CHIRP; replaces AN/UQN-1
TC-24	24 kHz	22°	2,000 m	
7426C	24 kHz	22°	2,000 m	Through hull mount
TC-33	33 kHz	21°	1,400 m	
7510	40 kHz	20°	1,000 m	
2572	40 kHz	43°	1,000 m	
7511	100 kHz	9°	500 m	
7245A	208 kHz	3°	350 m	
200T5H	200 kHz	10°	250 m	

Note: * System depth performance is a function of frequency, power level, transducer beamwidth, efficiency, transducer mounting depth and ship specific acoustic environment

** TR-109 transducers are designed to be mounted in arrays having the following beamwidths: array of 4/53°; array of 7/43°; array of 9/35°; array of 12/30°; array of 16/26°

*** An array of 6 TC 2040 transducers has a beamwidth of 28°

Transducers

Type
Bathymetric and hydrographic survey echo-sounder transducers.

Description
Ocean Data Equipment Corporation offers a complete line of acoustic transducers for shallow and deep water bathymetric and hydrographic surveying and for sub-bottom profiling. Transducers are available in the following frequencies in narrow and wide beamwidths: 3.5, 7, 12, 24, 33, 40, 100 and 200 kHz. Single transducers and arrays of transducers for sea chest or towfish installation can be provided. Wide frequency bandwidth transducers for CHIRP sub-bottom profiling are standard.

Contractor
Ocean Data Equipment Corporation, E Walpole, Massachusetts.

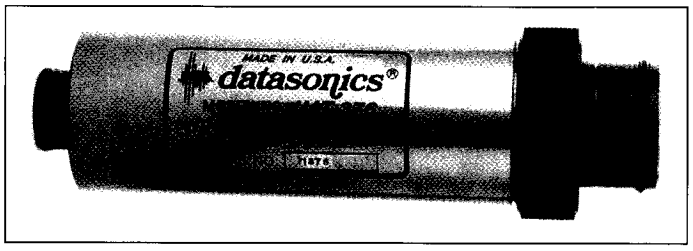
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UAT-376

Type
Underwater acoustic transponder.

Description
The general purpose unit is designed for use with a variety of diver and ship installed acoustic interrogators and is compatible with the Trackpoint II and TLX navigation systems. The unit operates in the mid-range frequency band of 20 to 35 kHz and is powered by two 9 V alkaline or lithium transistor type batteries and can be deployed in depths up to 1,000 m.

The unit, in its aluminium housing, is suitable for marking, relocating and tracking objects, equipment or sites, for measuring distance to an object or divers underwater and for marking underwater sites or objects where stealth and secrecy are necessary.



UAT-376 pinger (RJE International) 0105321

Specifications
Frequency
receive: 26 kHz
transmit: 25, 27 to 32 kHz
Output: 180 dB/l µPa/1 m

Contractor
Benthos Inc, North Falmouth, Massachusetts.

VERIFIED

MISCELLANEOUS EQUIPMENT

Australia

ISCS

Type
Integrated Ship Communications System (ISCS).

Description
The ISCS, manufactured by CEA Technologies is in service on the Huon class minehunters. The system provides a highly integrated internal and external communications capability. The core of the system is a set of digital communications buses that perform all switching control functions and routing of all secure and non-secure voice and data information. A common bus structure is used to carry voice and data communications traffic, and to control information between system components. Three interconnected bus subsystems connect all external communications equipment, secure equipment and secure voice terminals and an internal communications bus to connect the ship's non-secure voice terminals.

The system integrates:
- GMDSS
- Secure voice and data
- Tactical voice and data
- Telephone services
- Entertainment radio
- Computer LANs
- Voice recording of selected communications
- Message handling
- Communications management functions, and
- Internal communications such as broadcast, point-to-point, network calls, alarms and check fire.

The antenna system is optimised for use on small to medium vessels where space is at a premium, or larger vessels where complex communications requirements require a reduction in the number of antennas mounted. The system includes:
- broadband and wide dynamic range LF/MF/HF active dipole antennas
- a combination vertical antenna providing separate VHF
- UHF, SATCOM and GPS output for distribution via VHF and UHF multicouplers, and
- VHF/UHF transmit antenna

The VHF and UHF antenna are passive transmit and receive units. HF whips, INMARSAT B and INMARSAT C antennas are also available. Radios may be sourced from a variety of manufacturers to allow optimal choice, commonality with other equipment in service or availability of support, and to ensure flexibility for future growth and to meet changing requirements through-life.

The internal communications system provides access to external radios, intercom, main broadcast, alarm control, audio entertainment and tactical voice, and to a PABX for connection to public telephone servers via a local exchange when in port, within cellular coverage areas or via INMARSAT.

The external communications outfit may comprise various combinations of transmitters, receivers or transceivers operating in the MF/HF, VHF and UHF bands. Facilities to receive and display Link 11 are available. Other systems include integrated DGPS and weather fax.

Control of communications is exercised through a communications management terminal and switching systems managed by a single operator. Once a communications plan has been entered the communications room can be unstaffed for normal operations, making the system ideal for minimum crewed vessels. The message distribution system includes cryptographic equipment, a message handling unit and secure voice facilities.

Internal communications are managed using a dedicated internal communications bus which interconnects a number of general purpose voice terminals located at various points throughout the ship. The voice terminals provide an intuitive menu-based user structure and have adjustable brilliance controls to protect night vision.

The ISCS provides a total communications package for vessels that have complex communications requirements with limited deck space and minimum staffing levels.

Operational status
In service aboard Huon class minehunters. Under contract for the Armidale class patrol boats.

Contractor
CEA Technologies Pty Ltd, Fyshwick ACT.

UPDATED

Canada

CTASP

Type
Commercial-off-the-shelf (COTS) Towed Array Signal Processor.

Description
CTASP is an advanced signal processing and display system used to detect, localise and track surface and subsurface targets. It interfaces with the command and control system in order to provide fire-control solutions. The system uses commercial high-speed DSPs within a VME chassis. CTASP uses an open system architecture and can be made to integrate with most passive towed arrays. It can be supplied either as a complete end-to-end solution, including handling systems and towed arrays, or be integrated into an existing towed array as a system upgrade. CTASP can also be offered with a Low-Frequency Active Sonar (LFAS) solution, either as original fit or as a future enhancement.

Operational status
Commercially available.

Contractor
Array Systems Computing Inc, Toronto, Ontario.

VERIFIED

Reconfigurable, Scalable Multiprocessor (RSM)

Type
Embedded signal processor.

Description
The RSM is a modular, fault tolerant, reconfigurable integrated data acquisition and processing system, intended for use as an embedded signal processor in a variety of sonar applications including partial digitisation and signal processing on existing sonar systems or as the basis for the new sonar systems. The RSM consists of a reconfigurable parallel array of Processing Elements (PEs), all of which are connected across several databusses. Interprocessor data communication is achieved through time-division multiplexing on a proprietary bus. System control communications are performed over a VMEbus. The scalable PE array can be arbitrarily configured to any parallel and/or series topology suitable for a given application. Both online system health monitoring and detailed offline diagnostics are available. In the event of a recoverable error, the RSM will restore its original configuration through the dynamic reallocation of system resources.

Specifications
Input: analogue channels up to 80
Dynamic range: (total) >100 dB/channel
Output: analogue channels up to 80
Bandwidth: 500 Hz to 10.8 kHz
Processing: computational capacity 3.6 Gflops (peak)
Integer and/or IEEE 32 bit floating point
Host Interface: Ethernet (802.3) and TCP/IP >500 kbytes/s

Contractor
Northrop Grumman - Canada, Burlington, Ontario.

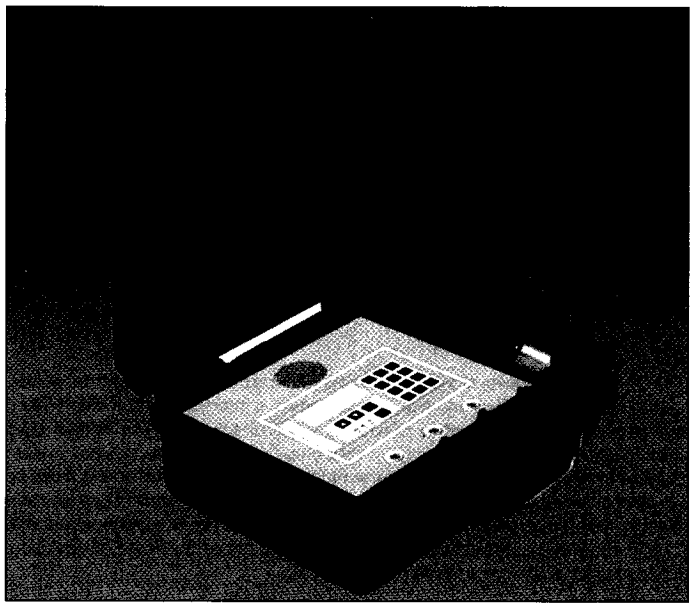
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France

LORES

Type
LOcalisation and REcovery System (LORES).

Description
The LORES localisation and recovery system for sunk targets can be deployed from all types of surface platform. The device has an effective range of 4,000 m and



Surface control unit of LORES (Thales Safare) 0538183

an operating depth of up to 3,000 m and can be used to locate lost vehicles such as VDS, ROV, AUV and to search for lost divers. The surface equipment comprises an immersed acoustic section and a watertight case. The MMI displays the distance and bearing in real time on an LCD screen. An optional GPS system can provide precise geographical localisation data. The orientation is relative or absolute with the optional external GPS system.

The beacon is powered by a lithium ion battery, and the surface equipment by a reloadable lead battery.

Specifications

Height (beacon): 160 mm
Diameter (beacon): 100 mm
Weight (beacon): 2.7 kg in air
Frequency: 9 to 12 kHz
Operating range: ≤4,000 m
Operating depth: ≤3,000 m
Data precision: distance 5 m, 1% of the distance
Bearing: 7°

Contractor

Thales Safare, Sophia Antipolis. ***UPDATED***

Germany

MSC (Mine warfare Support Centre)

Type

Land-based data evaluation centre for mine warfare data.

Description

The MSC is a land-based data evaluation facility based on commercial-off-the-shelf (COTS) workstation hardware and peripherals with the following main characteristics: a central database for underwater objects; the merging and evaluation of underwater data from different sources (minehunting sonars, side scan sonars, manual inputs, and so on); and the preparation of mine warfare missions.

The MSC is fitted with the electronic sea chart capability (ECDIS). This feature allows display overlay of geographical and mine warfare data and thus easy correlation for evaluation, planning and storage. Search area and track planning for minehunting and minesweeping missions can be centralised with the aid of the MSC. Underwater information and results from previous missions can be merged with mission planning data and stored on a portable data media for use on board MCMVs to improve their MCM capability.

The flexible database organisation gives a high-storage capacity and enables the adaptation to various input sources and sensors. Likewise the output format and media for use on board MCMVs or other evaluation centres is characterised by a high degree of flexibility.

The STN ATLAS MSC allows for bi-directional data exchange with the integrated minehunting weapons system MWS 80/MWS 90/MCM 2000 and other data sources and users.

Operational status

In operational service.

Contractor

ATLAS Elektronik GmbH, Bremen. ***VERIFIED***

Shore-Based Information Centre

Type

Analysis system for hydroacoustic noise and signals, and for the creation and maintenance of databases.

Description

The Shore-Based Information Centre (SOBIC) has been developed and manufactured by STN ATLAS to enable naval forces to get maximum use from the passive sonar sensors installed in surface ships, submarines, ASW aircraft, helicopters, shore-based underwater surveillance and harbour protection facilities.

Intercepted hydroacoustic noise and signals of target vessels not only reveal the bearing but also carry numerous items of information regarding the source of the sound. This information can be extracted and understood only when it has been processed, evaluated and classified. To perform this, SOBIC acts in a central role:

- raw acoustic recordings from all available hydroacoustic sensors are transferred to the SOBIC, accompanied by detailed descriptions of the classified source of noise if possible
- the analysis personnel of SOBIC evaluate the recordings with all different kinds of signals processing available, such as Lofar (with different algorithms of pre- and post-FFT processing), Demon, spectrum analysis, audio analysis, transient analysis and sonar signal analysis. The optimum output is the identification after correlation of the classified signals with information from other sources
- SOBIC establishes and updates an acoustic database of all sources possible in the operational area
- SOBIC distributes user-adapted databases to all vessels, shore stations and training centres equipped with passive acoustic sensors
- feedback reports and recordings are used to provide continuous updating of the SOBIC-controlled database.

Operational status

In service.

Contractor

ATLAS Elektronik GmbH, Bremen. ***VERIFIED***

Italy

ORACOM 2000

Type

Operational research tool for anti-torpedo countermeasures.

Description

ORACOM (Operational Research for Acoustic Countermeasures) 2000, is a software simulation system that allows the definition, optimisation and assessment of torpedo countermeasures systems; it is a comprehensive, multi-application simulation tool for analysts involved in one-shot and statistical evaluations of torpedo defence systems based on acoustical soft-kill and hard-kill countermeasures.

ORACOM 2000 may simulate any engagement involving an attacking platform which fires up to four torpedoes, and a target platform which may become alerted and attempt to evade by iterative countermanoeuvres and the deployment of acoustic countermeasures.

The simulator has been conceived to characterise parametrically (approximately 600 parameters) the various components of the simulated scenario. This feature allows the operator to:

- Define the behaviour of new systems (both countermeasures and torpedoes) and optimise their performance
- Assess the performance of existing systems, representing, if possible, the present performance by means of the proper selection of inputs.

ORACOM 2000 allows the following basic studies to be performed:

- Type of anti-torpedo effectors to be used
- The evading counter-manoeuvres of the attacked target
- Release tactics of countermeasures

ORACOM 2000 represents the evolution of the already existing ORACOM system, developed during the early 90s. The new version includes:

- Parametric models of lightweight and heavyweight torpedoes
- Torpedo types: wire-guided, acoustic homing, straight runner, wake homer
- Up to four different kinds of sonar available on board targets (hull mounted, VDS, towed array, interceptor)
- Torpedo on top launch capability
- Definition of different counter manoeuvres and countermeasures systems for different angular sectors
- Advanced graphic presentation: 2-D/3-D view, zoom, panning, playback, history
- Audio channel

The simulator works on an Intel Pentium IV workstation equipped with Microsoft Windows NT 4.0/2000/XP operating system. The high level programming languages are: C++, ANSI C and FORTRAN 77.

Contractor

Whitehead Alenia Sistemi Subacquei SpA, Livorno. ***VERIFIED***

Norway

MFPS

Type
Minefield planning, evaluation and realisation description tool.

Description
The MineField Planning System (MFPS) is a tool designed to assist the process of planning a controllable minefield. The system can be used in the various stages of planning, to create the most cost-effective minefield. When planning has been completed, the system produces complete lists of all the items needed to realise the field.

MFPS is a Commercial-Off-The-Shelf (COTS) based system running on a standard workstation.

The system uses a very high-resolution three-dimensional bottom terrain model and a set of automatic and manual functions to assist the minefield designer in the task of designing an effective minefield. Additional visual aids are provided to assess the actual placement of equipment on the seabed.

A set of system-defined parameters, affecting minefield content and behaviour, may be altered by the minefield designer when specific details need to be studied.

MFPS allows a set of different threat scenarios to be created for simulation purposes. Using these scenarios, the system may be used to perform simulated target runs through a designed minefield. A simulation run includes target engagement, mine detonation and damage evaluation. The simulation produces data on inflicted target losses and overall mine usage and this is used by the minefield designer to evaluate the behaviour and performance of the minefield.

When a minefield layout has been completed, the system computes the cost of the complete minefield. All equipment used in the field will be included in this analysis, and any additional operator-defined overhead costs (rates for ships, man-hours and so on) not directly related to the equipment can be taken into account if required.

A complete description of the minefield may then be produced on paper. This includes a complete inventory of all the equipment with sub-parts in the minefield, and a colour map of the minefield area. An additional equipment list featuring the planned co-ordinates of all the equipment in the field can be produced on paper and/or on a data cassette tape for data transfer to the minelaying vessel (KNM *Tyr* of the Royal Norwegian Navy). The system is also used in conjunction with the IDA system (see IDA entry).

Operational status
In service at KNM *Tordenskjold*.

Contractor
Kongsberg Defence & Aerospace AS, Kongsberg.

VERIFIED



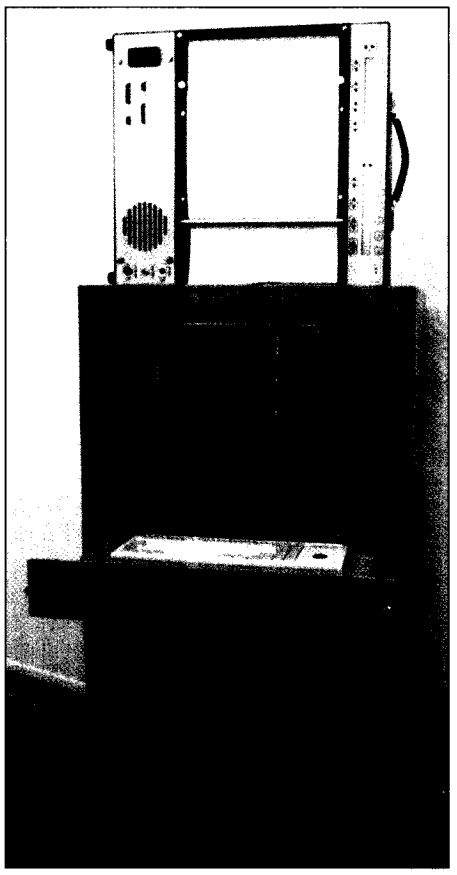
MFPS system equipment

Spain

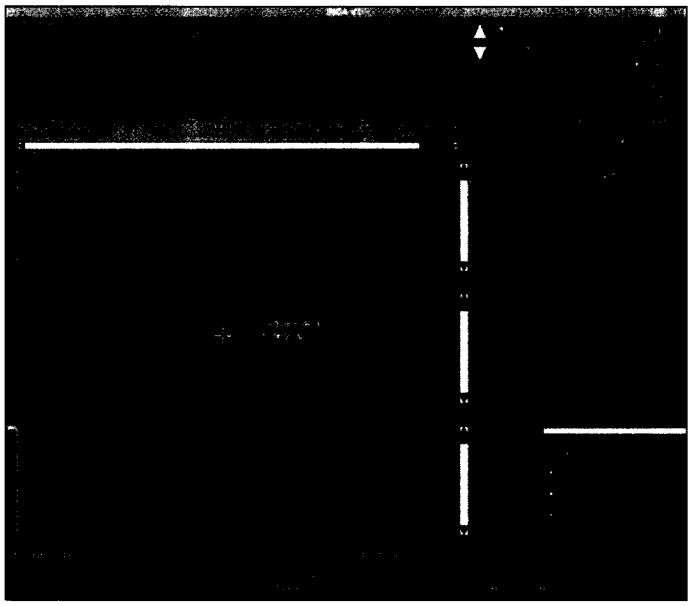
SICLA

Type
Acoustic classification system.

Description
SICLA is a powerful computer-aided acoustic classification system fitted on board submarines and surface ships. It is directly connected to any acoustic sensor output (sonar, sonobuoy, recorder and so on) and provides simultaneous and interactive analysis, graphic tools and target database.



Sicla console (Courtesy SAES) 0043252



Sicla display (Courtesy SAES) 0043251

The frequency band covers 0 to 8 kHz, processing simultaneously in real time more than 10 Lofar, Demon, Vernier, Ali, transients analysis as well as a high-fidelity audio signal.

SICLA allows the digital recording of acquired signal and onboard or onshore quick post-analysis at up to 20 times the real time.

The modular design of SICLA allows configurations in a reduced volume and weight.

The operational use is greatly simplified by the extensive use of the latest technologies in man/machine interface and database management, allowing powerful computer-aided hypothesis generation and verification.

Operational status
In production and in service.

Specifications
Weight: 54 kg
Dimensions:
(rack) 60 × 60 × 50 cm
(monitor) 50 × 45 × 60 cm
Power: 0.4 kVA (115 V/60 Hz)

Contractor
SAES, Cartagena.

VERIFIED

Sweden

Safe Barrier System

Type
Intruder security system.

Description
Developed in co-operation with the Swedish Navy, the Safe Barrier System is a strong physical shield in combination with sophisticated alarm and surveillance techniques. It is designed to protect vital and vulnerable coastal installations against surface and subsurface intrusion. The system can be adapted to suit the anticipated type of intruder whether divers, torpedoes, mini-submarines, ROVs or surface vessels.

The system consists of: the alarm net system; the alarm; the gate; buoyancy units; anchoring devices; surface and subsurface surveillance; and the command centre.

Each net section is manufactured using automated construction techniques. The net mesh consists of a double insulated galvanised wire 4 to 8 mm in diameter and coated with polyethylene for electrical integrity and with an outer durable polyurethane jacket for additional protection. The knots are made of SS-reinforced solid polyurethane.

The Safe Barrier System allows authorised vessels to pass through vertically controlled gates. The gate is an alarm net section connected to the net system at the sides and the anchoring devices. At the surface the net is connected to inflatable twin hoses, stretching over the entire gate's width. When closed, the hoses are filled with compressed air. When opening the gate, remotely controlled discharge valves evacuate the air, which causes the net to sink.

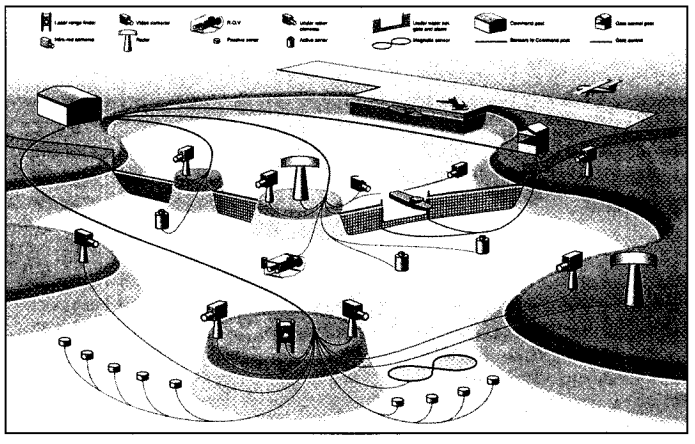
The monitoring and alarm system covers all components of the alarm net system. These include the net panels, anchors, interconnections, buoyancy units and access gates. The alarm system consists of both a sabotage/intrusion alarm and a service guard.

Cutting, short circuiting or bypassing the net system(s) activates the sabotage alarm system in the command centre. The service guard ensures that the complete system can be maintained in a timely manner.

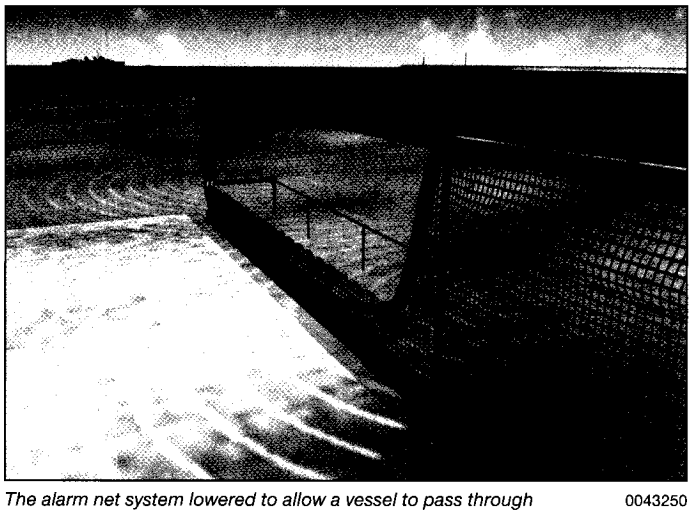
The surface surveillance and sub-surface surveillance includes acoustic, IR, radar, camera and magnetic, state-of-the-art technology.

The command centre collects and registers data for analysis from all the different sensor systems and alarm systems in the protected area. Sophisticated software integrates the different systems and presents relevant information in a logical and user-friendly format as a support for decision making and for active countermeasures.

Operational status
More than 40 installations operational worldwide.



Safe Barrier System 0043248



The alarm net system lowered to allow a vessel to pass through 0043250

Contractor
Safe Barrier Systems Sweden AB, Askim.

UPDATED

United Kingdom

ATAHS

Type
Towed array heading reference sensor.

Description
ATAHS was specifically targeted to meet the requirements for high performance, ruggedised and compact sensor for the UK and European sonar 'Towed Array' programmes. The sensor which is based upon 3-axis fluxgate and 3-axis accelerometer technology, is now fully developed and is in full production.

ATAHS is designed and tested to achieve full performance throughout a wide spectrum of environmental requirements. The sensor has been completely qualified by the manufacturer and its customers against the effects from such parameters as shock from underwater explosion, EMC and thermal shock. ATAHS has been operationally proven on a number of towed array programmes and has been approved for use by the QinetiQ Test and Evaluation authority.

The ATAHS solid-state package is housed in a titanium pressure vessel and provides 3-axis acceleration and heading data via a serial datalink. All processing is carried out within the sensor using high performance microcontrollers to convert the sensor data into heading with respect to magnetic north. It features a digital output with 16 bit resolution and has an accuracy better than 0.5 per cent. The sensor is 25 mm diameter by 130 mm long and is suitable for immersion in kerosene filled arrays at pressure up to 350 bar.

Operational status
In production. Selected for the UK and European programmes.

Contractor
Ultra Electronics, PMES Hednesford, Cannock, Staffordshire.

UPDATED

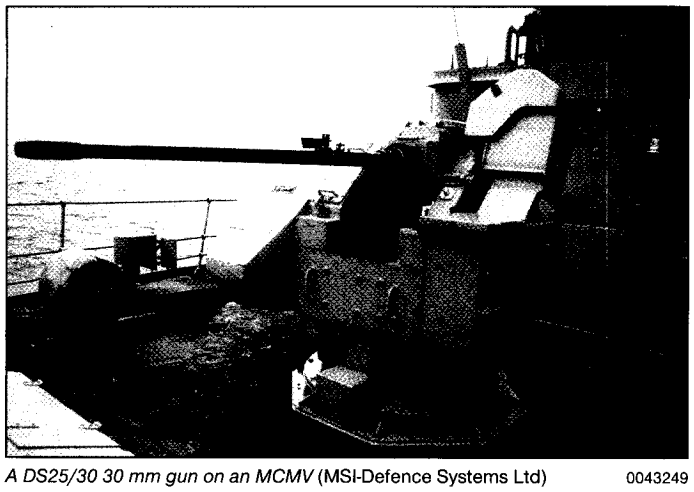
DS25/30 naval gun

Type
Small calibre gun for close-range air and surface defence.

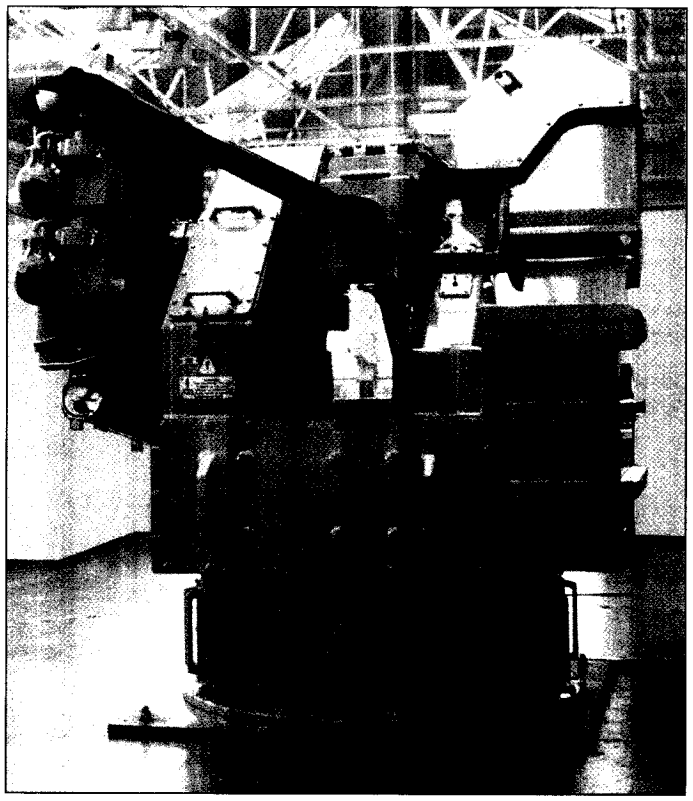
Description
The DS25/30 series of naval guns, which is used as a primary armament for patrol craft and MCMVs and as secondary armament on frigates, is stabilised and completely self-contained and requires no deck penetration. The configurations within the DS25/30 family provide a high degree of flexibility in terms of weapon system and method of control. They feature low-magnetic, radar and IR signatures, utilising advanced materials and control techniques.

LOCSIG is locally controlled by a seated operator and is fully stabilised, utilising rate integrating gyros to aid tracking. REMSIG is remotely controlled via the ships fire-control system, with reversionary local control. AUTSIG provides an autonomous tracking capability with a remote below-deck console.

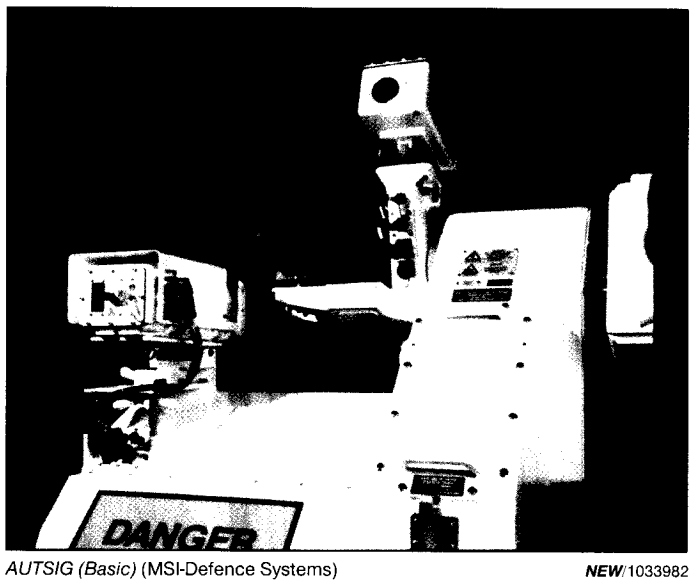
There is a choice of 25 or 30 mm cannon, for example Oerlikon KCB for the Type DS30B, the M242 (25 mm) or Bushmaster II (30 mm) for the Type DS25/30M, and



A DS25/30 30 mm gun on an MCMV (MSI-Defence Systems Ltd) 0043249



SIGMA with a 30 mm cannon and Mistral missiles (MSI-Defence Systems)
NEW/1033984



AUTSIG (Basic) (MSI-Defence Systems) ***NEW***/1033982

the Mauser 173 for the Type DS30F. SIGMA (Stabilised Integrated Gun Missile Array) is a dual layer extended range weapon system combining surface-to-air missiles and 25 or 30 mm cannon from a common mounting.

With various sight options there is a day/night capability.

Operational status
To date, approximately 70 type DS30B naval guns have been supplied to the Royal Navy where it is the standard fit on the Hunt and Sandown classes and has been selected for the T45 programme. More than 20 are in service with several other navies, including the Australian Huon class MCMVs.

Specifications
Operational elevation arc: –25 to +70°
Operational training arc: –175 to +175°
Velocity (training and elevation): 55°/s
Acceleration (training and elevation): 80°/s²
Swept radius: 2.365 m
Ready use ammunition: 160 rds

Oerlikon KCB 30 mm
Rate of fire: 650 rpm (max)
Muzzle velocity: 1,080 m/s
Recoil force: 1,400 kg (max)

Contractor
MSI-Defence Systems Ltd, Norwich, Norfolk.

UPDATED

EFS 1

Type
Single-axis underwater electric field sensor.

Description
Ultra Electronics electric field sensors are used to measure electric fields in seawater with high precision. The technology utilises specially designed Silver/Silver Chloride sensor elements and extremely low noise preamplifiers to achieve detection in the nV/m range. The very high performance is achieved due to the exceptionally low noise of the electrodes and pre-amplifiers.

The three pairs of electrodes together with matching pre-amplifiers and filters are normally used together to form a 3-axis measurement sensor. This configuration is typical of a simple sensor arrangement suitable for OEM integration. Alternatively, Ultra are able to offer complete stand alone electric field sensor solutions and multi-influence sensor solutions that can measure magnetic, electric, acoustic and pressure influences.

Applications include: geophysical measurements and prospecting, oceanographic studies, long-range detection and surveillance and ship signature ranging and management.

Examples of resolution for differing baselines include:

1m I/P noise = 0.5 nV Hz -½ = 0.5 nV Hz -½ m-1
5m I/P noise = 0.5 nV Hz -½ = 0.1 nV Hz -½ m-1
10 m I/P noise = 0.5 nV Hz -½ = 0.05 nV Hz -½ m-1

Operational status
Electric sensing elements together with matching pre-amplifiers, in service.

Contractor
Ultra Electronics, PMES, Hednesford, Cannock, Staffordshire.

NEW ENTRY

EFS 3

Type
3-axis underwater electric field sensor.

Description
Ultra Electronics 3-axis electric field sensors are used to measure electric fields in seawater with high precision. The technology utilises specially designed Silver/Silver Chloride sensor elements and extremely low noise pre-amplifiers to achieve detection in the nV/m range. The very high performance is achieved due to the exceptionally low noise of the electrodes and pre-amplifiers.

The sensor has a spherical top that contains three pairs of low-noise silver/silver chloride electrodes. The electrodes are arranged to measure the electric field in the two mutually orthogonal horizontal planes and the vertical. These measurements are directly related to longitudinal, athwart ships and vertical fields. Physical separation of the sensors is 500 mm, giving an effective separation between each electrode pair of 750 mm due to shape gain provided by the spherical sensor design.

Applications include: ship signature ranging and management, long-range detection and surveillance, geophysical measurements and prospecting, and oceanographic studies.

Ultra also offer (as an option) 3-axis magnetometer, 3-axis accelerometers, pressure sensor and interface electronics. These reside within the pressure housing and are aligned with the electric field sensors. The accelerometers are used to determine roll, pitch and yaw. The magnetometer can provide accurate magnetic static and alternating magnetic measurements in addition to providing the heading reference of the sensor, which is calculated using the information from the magnetic sensor and accelerometers.

Operational status
Electric sensing elements together with matching pre-amplifiers/with 250 mm base line sensor, are in service.

Contractor
Ultra Electronics, PMES, Hednesford, Cannock, Staffordshire.

NEW ENTRY

Magnetic Gradient Sensors

Type
Gradiometers.

Description
The GS2, GS3 and 9 Term Gradiometers enable the highly accurate measurement of the vectors of magnetic fields. The gradient measures the change of magnetic field with distance away from the magnetic source (spatial derivative).

The GS2 gradiometer has a separate fluxgate probe assembly and control electronics connected by a cable. The outputs are analogue voltages proportional to field strength. The unit measures the vector components of the incident magnetic field, together with the longitudinal axis spatial derivative (gradient). The analogue outputs are scaled for nominal values of 10 microTelsa/V and 10 (microTelsa/m)/V with full-scale output of 100 microTesla and 100 microTesla/m.

The GS3 gradiometer is similar to the GS2 with the control electronics combined within the fluxgate probe assembly. The analogue outputs are scaled for nominal values of 10 microTelsa/V with a full-scale output of 100 microTesla.

The 9 Term gradiometer is a more sophisticated sensor that measures the triaxial spatial derivative. It comprises four fluxgate assemblies and associated electronics packaged in an underwater housing.

Operational status
All sensors are in production.

Contractor
Ultra Electronics, PMESHednesford, Cannock, Staffordshire.

UPDATED

Marine Sound Signal Mk 8

Type
Surface-to-submarine signalling device.

Description
The Marine Sound Signal Mk 8 was developed for the Royal Navy as a hand-launched signalling device for exercise and communication purposes. The device is supplied ready for use and requires no services or preparation. To operate, the device is opened by pulling on a ring on the lid to tear it off. The safety clip is removed by pulling a lanyard. The device is then ready for deployment.

All three safety mechanisms — hand operated safety clip, hydrostatic pressure switch and magnesium silver seawater electrolytic bridge — must operate before detonation can occur. If conditions prevent detonation, the device will fail-safe after five minutes immersion, when a soluble pellet dissolves to create an open circuit to the detonator.

The device is powered by an integral 1.5 V LR6 AA alkaline battery. The device can be dropped from helicopters up to an altitude of 150 m above sea level and the sound source has a maximum range of 1.8 km in still water.

Operational status
In service with the UK Royal Navy and navies world-wide.

Specifications
Length: 152 mm
Diameter: 67 mm
Weight: 0.8 kg
Charge: 28 g A5 composition
Operating depth: 10.7 m (±1.5 m)

Contractor
Flight Refuelling Ltd, Wallop Defence Systems Division, Middle Wallop, Hampshire.

VERIFIED

MTSS

Type
Mine warfare Tactical Support System.

Description
MTSS is an autonomous stand-alone (or integrated) series of mine warfare tasking, planning and evaluation systems. It has flexibility to be deployed in the following variants:

- in a standard ISO container fitted as a command HQ for the MCM Commander
- as an office system version for training or shore command HQ usage
- as a portable version in a series of ruggedised boxes for deployment on any COOP or integrated into standard racking in any MCMV or warship.

The equipment comprises commercial-off-the-shelf (COTS) hardware and software where appropriate and is the result of many years of successful MCM operations by the Royal Navy and Mod UK/Computing Devices Company expertise in aviation electronics, software development and integration. The MTSS is a multiseat system with the information presented to the operator on high-resolution colour computer screens using the industry standard X-Windows/Motif Graphical User Interface. MTSS enables the operator to perform the required functions through the various stages of MCM route generation, planning, tasking and evaluation. MTSS communicates with the MCMVs (and other units/authorities), through its comprehensive signals package. This facility enables the transfer of formatted, structured and free text signals and utilises specialised MCMV combat system data.

Additionally, bulk route survey data can be downloaded or passed to the appropriate tactical display to ensure the integrity and completeness of the underwater picture. MTSS also displays and updates numerous totes, including mine, equipment, operation defects and ship planning. The system is UNIX-based, currently using SPARC servers and can be operated using any ship or shore supply.

Operational status
The MTSS has been in service with the Royal Navy since October 1994. Since that date it has been operated successfully on joint United States Navy exercises off the USA coast and with NATO and own national forces. The MTSS has been purchased by Middle East and Asian navies with a similar requirement and other NATO countries have registered their interest. Selected modules from the MTSS are planned to be incorporated into other command system support programmes.

Contractor
General Dynamics United Kingdom Ltd, St Leonards-on-Sea, East Sussex.

VERIFIED

MTSS(R)

Type
Mine Warfare Tactical Support System.

Development
The MTSS(R) is being developed by Drumgrange in the UK, in partnership with the Australian software company Solutions from Silicon, for the UK Royal Navy as a replacement for the existing MTSS.

Description
The MTSS(R) will incorporate functions developed by Solutions from Silicon for the Australian MINTACS system (see entry on MINTACS). Among the specific features to be provided will be mission planning for all aspects of MCM operations including minehunting, minesweeping and clearance diving, MCM force assessment, threat assessment and force scheduling. Under the planning provision clearance levels and time taken for a particular operation are calculated and for force assessment the system calculates the combined clearance for a total MCM force, and displays this on the tactical display. Threat assessment calculates the remaining threat to vessels after clearance has taken place and force schedule provides views of tasks by date, asset, and Q-route segment. The tactical display presents the operator with situation display showing cleared channels, suspected minefields, and detected mines. As the mission progresses the clearance levels are displayed and colour coded. Raster and vector charts are imported to provide background data. These can be overlaid with detailed environment and sidescan sonar data. Additional tools provide data acquisition (including sonar imagery), detection probability, classification probability and position accuracy (both static and dynamic).

The system provides tools for data exchange with mine warfare data centres (including the RN route survey database), combat management systems (all NAUTIS variants) and the EDS Defence RN command support system as well as individual message handling systems.

The MINTACS software will run on Server 2000 hardware under Windows XP and continued development may offer commonality of function between the RN and RAN systems.

The standard system will comprise a PC server with three PC workstations, a projector and printer. Each workstation incorporates two flat-panel screens with facilities for the operator to input data on one while viewing the tactical display on the other. The workstations are based on Dell computer systems with Blazpoint ruggedized deployable PC hardware for use onboard MCMVs.

A total of eight systems are on order, three being for shorebased use and five for deployment aboard MCMVs.

Operational status
July 2004 – The first of eight MTSS(R) systems enters service.

Contractor
Drumgrange Ltd, Chertsey, Surrey.

NEW ENTRY

SPUD

Type
Spectral multichannel analytical system.

Description
The SPUD analysis equipment has been developed, using the Thales Underwater Systems Series 5 technology, for detailed spectral analysis of data in the field or laboratory. The system features 24 inputs with 40 independent processing channels with spectrum or modulation processing selectable on each channel with up to 15,360 Hz bandwidth per channel. The man/machine interface is an easy-to-

use menu system presented on a high-definition colour VDU which controls the processing carried out by an array of digital signal processors. The system architecture allows the efficient incorporation of the user's specialist algorithms and requirements. A built-in 105 Mbyte hard-disk stores output data for rapid redisplay of sections of interest. A removable hard-disk recorder can be included for archive and reference purposes. Two linescan printers can be controlled by the system for continuous hard-copy output.

Operational status
In service with the Royal Navy and fitted on board the NATO trials ship *Alliance*.

Contractor
Thales Underwater Systems, Cheadle Heath, Greater Manchester.

UPDATED

SUA

Type
Underwater signalling device.

Description
The SUA (Signal Underwater Acoustic) has been developed as an HE version of the DRS (Diver Recall Signal) as an alternative to the Marine Sound Signal.

The unit is operated by hydrostatic pressure, the depth being preset. The body is made of corrosion-free plastic or treated aluminium.

The device incorporates a number of safety features including an end cap that ensures that the mechanism is locked in the safe position with the piston sealed against external pressure. To operate, the end cap is removed and the device thrown or launched into the sea. If the device fails to reach its operating depth, it is deactivated by a potassium bromide pellet that dissolves and floods the unit.

The device creates a single, high-intensity acoustic sound with a range of 500 m in still water.

Operational status
Available for production.

Specifications
Length: 270 mm
Diameter: 42 mm
Weight: 500 g
Charge: 28 g HE
Operating depth: 9-12 m (or according to customer specification)

Contractor
Flight Refuelling Ltd, Wallop Defence Systems Division, Middle Wallop, Hampshire.

VERIFIED

Submarine Signals

Type
Various types of submarine signalling store.

Description
These range of submerged signalling devices are designed to identify the position or existence of a submerged submarine to surface ships, to send messages in a passive mode or to signal or represent torpedo firing during exercises.

The signals are launched form within the submarine through the pressure hull via the submerged submarine ejectors (SSE) Mk 2m Mods OB, 3 and 3V, Mk 5 Mods 01 and 2, Mk 6 and Mk 8.

On ejection the end plate beneath the hydrostatic mechanism is removed and remains in the launcher. The water pressure acting on a flexible diaphragm in the base of the mechanism holds two cocked strikers in the safe position until the float reaches a depth of approximately 10 m. At this depth the hydrostatic pressure allows the striker to move forward to stab initiated igniferous detonators. Flame from the detonators ignites a 10 second nominal pyrotechnic delay train which in turn transfers flame to the main filling to provide the desired affect.

The various types of signal include:

- Candle smoke white Mk N.6 Mod 4 which produces white smoke with a lambent orange flame for about 5 minutes
- Candle smoke yellow Mk N.7 Mod 4 which produces dense yellow smoke for a minimum of 2½ minutes
- Fluorescent Box Mk N.4 which produces a green slick on the surface for between 10 and 15 minutes
- Message carrier Mk N.4 a paper message carrier
- Float signal submerged (grenade) Mk N.3 Mod 4
- Float signal submerged fluorescent Mk 4 Mod 4, which produces a green slick on the sea surface for between 10 and 15 minutes.
- Grenade signal No 65, Mk N.3 red which produces a red signal star for 10 seconds at an altitude of 150 ft
- Grenade signal No 65, Mk N.3 green which produces a green signal star for 10 seconds and which is designed for use with the float signal submerged (grenade).

Contractor
Flight Refuelling Ltd, Wallop Defence Systems Division, Middle Wallop, Hampshire.

VERIFIED

Type 7986

Type
Lightweight acoustic release transponder.

Description
The Type 7986 lightweight release transponder is a small, low-cost unit that can be deployed on the seabed and activated by an acoustic signal to release moored loads up to 125 kg. An innovative screw-off release mechanism ensures a positive action unaffected by marine growth. Options include a canister of rope that is paid out as the unit returns to the surface from where the line can be used to recover any equipment to which it is attached.

The Type 7986 has the ability to both receive and transmit acoustic signals. This provides the operator with confirmation that the release mechanism has been activated. It also allows slant ranges to be measured for accurate positioning purposes and for relocating it prior to activation of the release mechanism.

The unit can also be used in conjunction with Sonardyne's range and direction guidance systems, ROV-Homer and Homer-Pro. These systems enable a diver or ROV pilot to return to targets marked with a transponder quickly and easily, months or even years after it has been deployed. The transponder's exact seabed co-ordinates can be quickly and easily determined using the ROV-Trak system.

The transponder is depth-rated to 500 m, at which slant ranges of 750 m are typical, making it suitable for use in most continental shelf waters.

The device is constructed from high strength plastics that offer excellent corrosion resistance. The transponder has a long operational life. Field replaceable alkaline or lithium battery packs give the device a listening life of 18 months or 4½ years respectively.

The surface control system consists of a portable deck unit and a dunking transducer that is supplied with 10 m of cable. The deck unit is used to program the transponder with its unique, high security acoustic identity, which can be chosen from one of hundreds available. It also serves to test the unit's release mechanism prior to deployment and can be controlled via RS-232 which enables raw image data to be logged onto a PC.

Operational status
The Type 7986 has been purchased by QinetiQ for seabed deployment and the recovery of underwater equipment and targets for use in mine warfare research trials.

Specifications
Frequency: 35-50 kHz
Transmit source level: 185 dB re 1µPa@ 1 m
Receive sensitivity: <110 dB re 1 µPa
No of unique identities: 3,600 field programable
Operational depth: 500 m
Safe payload: 125 kg

Contractor
Sonardyne International Ltd, Yately, Hampshire.

VERIFIED

VMAG

Type
3-Axis magnetic sensor.

Description
The Ultra Electronics VMAG sensor is the latest development in a series of versatile high performance magnetometers, specifically designed for a wide range of surveillance and measurements applications. A number of VMAG sensors can be configured to allow surveillance of a considerable area, via a RS422/485 serial digital data interface.

This high reliability sensor is a two-part design with two cylindrical titanium pressure housings intended for immersion in non conduction fluid to 100 m depth (10 bar). Alternatively, Ultra is able to offer a range of pressure vessel enclosures into which the VMAG sensors can be easily incorporated.

The sensors feature high accuracy and resolution combined with very low noise and low power consumption.

Operational status
In service.

Contractor
Ultra Electronics, PMES, Hendesford, Cannock, Staffordshire.

NEW ENTRY

Wideline 200 series

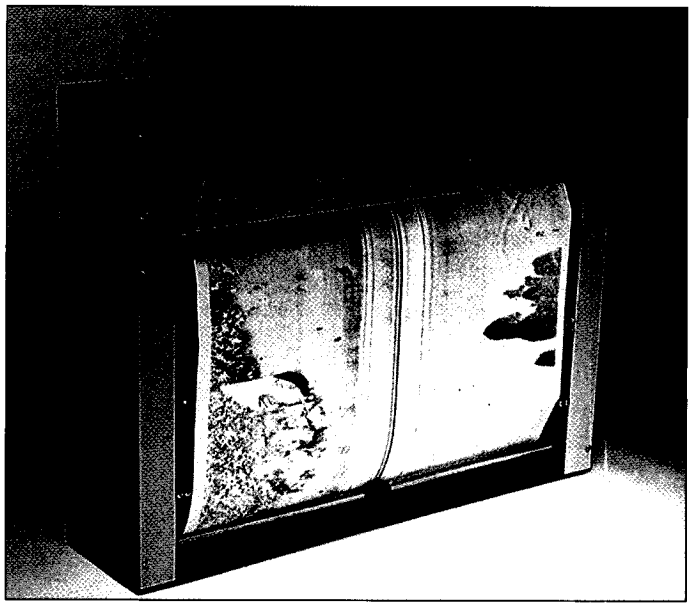
Type
Three-channel analogue and digital recorder.

Description
The Wideline 200 Series three-channel recorder provides 20 in, near photographic quality images using a direct thermal print process with 256 pixels/in with up to 256 shades of grey and 64 lines per second print speed. The machine is controlled via a 48-character alphanumeric LCD for all status and error messages, and push-button selection of range, sweep speed, trig level, delay, print direction and grey scale thresholds. Dynamic range on paper is 19 dB. The use of thermal film increases the dynamic range to 23 dB. The unit provides a display of any one, two or all three analogue channels with independent selection of operating functions.

Operational status
Over 500 systems have been sold worldwide and are in service with a number of navies including the Royal Navy (where it is linked with the Type 2031 system), Royal Air Force, French Navy (Fast Time Analysis Programme – FTAS), Italian Navy (FTAS), Royal Netherlands Navy (FTAS), US Navy (FTAS), and US Navy Surface Ship Analysis Centers (SSAC).

Contractor
Ultra Electronics Ocean Systems, Weymouth, Dorset.

UPDATED



Wideline 200 digital recorder 0009869

RESEARCH AND DEVELOPMENT

Introduction

This section seeks to present within the constraints of space available, a resume of the capabilities and background of some of the research and development organisations around the world involved in various aspects of underwater warfare.

This section will continue to expand as more information becomes available.

VERIFIED

Australia

Defence Science and Technology Organisation (DSTO)

Type

Scientific and technological research organisation.

Background

The Defence Science and Technology Organisation (DSTO) in Australia is part of the Department of Defence with expertise in such disparate areas as acoustics, advanced sensors, C^3I, communication networks, electronic warfare, operations and exercise analysis, human factors, platform survivability, information technology and security, modelling and simulation, radar, signal processing, sonar, surveillance, systems integration and weapons systems including explosives ordnance.

The primary role of DSTO is to provide professional, impartial, timely, innovative and informed advice on science and technology that is best suited to Australia's defence and security needs. DSTOs activities focus on satisfying requirements for new and enhanced defence capabilities, and on ways of making the best use of existing assets. Australian Defence Force (ADF) capabilities are enhanced through systems studies and tactical and operational analyses of individual platforms and weapons, as well as joint, multiplatform theatre operations. DSTO has significantly reduced the cost of ownership of ADF assets by developing smart maintenance and life extension programmes.

DSTO employs about 2,100 staff, predominantly scientists, engineers, IT specialists and technicians. The organisation comprises a corporate office at Defence headquarters in Canberra and major research laboratories headquartered in Melbourne and Edinburgh near Adelaide. DSTO also maintains research facilities in Canberra, Sydney, HMAS Stirling at Rockingham (near Perth), Scottsdale in Tasmania and Innisfail in northern Queensland.

DSTO supports Australia's defence by:

- Investigating future technologies for defence applications
- Ensuring Australia is a smart buyer of defence equipment
- Developing new defence capabilities
- Enhancing existing capabilities by increasing operational effectiveness, improving safety, maximising availability and reducing cost of ownership.

Description

Undersea Warfare R&D in DSTO is focused on technologies and capabilities that are crucial to safe and successful operations in the maritime environment, and include maritime operations research, ship and submarine combat and sensor systems, sonar technology and processing, mine warfare and mine and torpedo countermeasures.

To support its functions DSTO comprises 10 scientific divisions organised into two major research laboratories, the Aeronautical & Maritime Research Laboratory and the Electronics & Surveillance Research Laboratory.

The main divisions of the Aeronautical & Maritime Research Laboratory are: the Maritime Operations Division and the Combat Systems Research Centre (CSRC).

To support its leading edge, maritime technology research, DSTO operates a comprehensive range of capabilities and research tools, including a Combat Systems Research Centre (CSRC), a portable magnetic range, a Sonar Research Projector, an Acoustic Calibration Tank facility and a sonobuoy test range.

To assist the ADF in maintaining a technology edge, DSTO is a major player in a programme of Capability and Technology Demonstrators (CTDs) that allow rapid translation of evolving technologies into defence capabilities. Current CTDs that are relevant to undersea warfare are:

- a Bistatic Barra sonobuoy system to provide the ADFs airborne ASW assets (AP-3C Orion maritime patrol aircraft and Seahawk helicopters) with a potent area search and initial detection capability against modern conventional submarines;
- advanced mine warfare sonar systems that will quantitatively assess the ability of advanced mine hunting sonars, such as synthetic aperture sonars and parametric sonar techniques, to detect and classify low target strength mines and mines buried in seabed mud;
- seabed array systems to extend maritime tactical surveillance capability through rapidly deployable systems and/or deep-water installations for strategic surveillance;
- the use of fibre-optic technology and optical processing to develop new acoustic sensors and processing techniques.

Some of DSTOs current research activities in undersea warfare are described under the following headings.

Command and Control

To achieve the necessary improvements in the effectiveness of combat systems in naval platforms, quite different architectures than are presently found in most combat systems are required. These new architectures need to be designed to take account of COTS equipment as well as handling much larger data rates across their prime databuses. DSTO, through its CSRC, is creating the research environment for DSTO, the Royal Australian Navy (RAN) and industry to rapidly prototype new concepts and demonstrate the operational advantages and technical and system risks.

The RAN is also concerned about the proliferation of different types of combat systems throughout the fleet and the drain upon resources that result from supporting such diversity. The CSRC is developing combat system architectures that should allow for greater commonality and thereby reduce the number of combat system architectures, with the objective of determining whether a generic combat system architecture could be used on both surface ships and submarines. The applications that run on this architecture will be however, still tailored for the operational requirements of the platform. If this can be achieved, very significant resource savings should result in many areas, including training.

Simulation and Emulation of Maritime Systems

The CSRC, in its support to the Collins class, has developed a virtual submarine that emulates and simulates the function of a submarine. Emulation of the submarine combat data system has been achieved by hosting the actual submarine software on COTS hardware that faithfully replicates the function and form of the submarine's multifunction common consoles. Time series sonar data, either recorded or simulated, can be processed within the virtual submarine thereby supporting a research programme into new combat data system architectures and operational concepts. In this way, new concepts can be rapidly prototyped and tested. Furthermore new software and hardware that might be used on the Collins class can be tested using the virtual submarine and integration aspects addressed before installation on operational submarines. Such an approach allows operator assessment at the outset, reduces technical risk and saves time in that significantly less testing at sea is required.

The Virtual Submarine uses a mix of sonar system simulators, acoustic emulators and non-acoustic system simulators. The sonar system simulator, supplied by the US Navy, provides passive and active sensor performance prediction algorithms and scenario generation capability, providing the Virtual Submarine with a synthetic environment in which simulations can take place.

DSTO has also developed a virtual minehunter for operator-in-the-loop simulation to demonstrate enhancements to the RAN Huon class minehunter coastal vessels' tactical data system. Enhancements, including command decision aids and high level operator aids such as computer processing of screen displays, detection probability estimation and improved human-computer interaction, assist in optimising the vessels' effectiveness and safety. The virtual minehunter provides a COTS version of the Huon class Nautis II-M tactical data system.

Development of a virtual ship has also commenced in the CSRC. The objective of this work is to introduce High Level Architecture (HLA) techniques into Australia in a fully supported manner. This is already well advanced and it will allow the RAN, DSTO and industry to explore together new system configurations for the surface fleet. This work is also laying the foundations for simulation-based acquisition.

Surveillance

DSTO has developed a testbed for real-time at-sea evaluation of sonar processing concepts (CIRCE), that is helping to define an upgrade path encompassing COTS-based processors and new processing algorithms for the Scylla sonar suite in the RANs Collins class submarines. DSTO has also developed a multistatic sonobuoy programme (RAPTOR) that is designed to enhance the surveillance and detection capabilities of the RAAFs upgraded AP-3C Orion maritime patrol aircraft. It is also playing a significant role in evaluation of equipment, systems and architectures for a proposed LF active/passive sonar system for the RAN.

A LF airborne electromagnetic technique is also being developed which involves remote sensing of the seabed and the geological structure beneath the seabed from an airborne platform, which has potential for future use in amphibious operations, hydrographic reconnaissance and mine warfare. The technique can also be used to measure ice thickness.

Sonar Technology and Processing

Fibre optic hydrophones and thereby acoustic sensors employing such devices offer the prospect of significant operational gains. Arrays made of fibre optic acoustic sensors can be much lighter than those using ceramic or poly (vinylidene fluoride) hydrophones, and the electrical power requirements are much lower. This allows large aperture arrays to be constructed that are much lighter and easier to handle. There are also other advantages such as the very high dynamic range that can be realised with fibre optic hydrophones. This can allow weak targets to be detected in the presence of strong target noise sources.

DSTO has developed directional hydrophones that can overcome the left-right ambiguity of conventional towed arrays. This work has been complemented by sonar processing techniques that allow target tracks to be maintained during a

change in direction of the array. The operational gains in terms of target motion analysis are significant for submarines and in particular surface ships. DSTO is also developing new sonar signal processing techniques to support research programmes in acoustic daylight and in the use of stochastic resonance to both active and passive sonar systems. The objective of this research is to introduce new operational techniques that will significantly enhance sonar performance and achieve greater flexibility in the use of sonar sensors, particularly where information is available on the ambient conditions that determine sonar performance.

The Maritime Operations Division also operates a Sonar Research Projector (SRP). This is a towed underwater acoustic projector operating in the 50 Hz to 10 kHz band for studying various factors that affect sonar detection performance such as:

- environment effects
- factors and phenomena affecting sound propagation
- signal processing software and hardware
- detection software and hardware

The projector can be deployed from a variety of platforms at depths to 300 m at speeds up to 4 kt and Sea State 3. It provides a maximum sound pressure level of up to 210 dB.

Signature Management

The ability to measure submarine-radiated noise levels, including the directivity of the radiated noise, offers considerable operational tactical advantages. DSTO is currently investigating options to determine submarine-radiated noise signature, including accelerometer arrays to measure hull and machinery vibration, and acoustic holography as a static calibration method. Research is also being conducted into suitable displays for tactical acoustic information as well as tactical interpretation of the radiated noise signature. Currently under development is a closed loop degaussing system for the Collins class submarines. This system is designed to counter the effects of stress magnetisation changes in the pressure hull.

DSTO is also currently developing a 3-D computational technique to reduce the magnetic signature of naval platforms. This generates an exact model of the vessel geometry including the magnetic characteristics of the steels used and the shape of the degaussing coils, their locations and the current they normally carry. The technique allows accurate observation of how the degaussing coils affect the steel throughout the vessel using computational analysis rather than time consuming and tedious measurements.

Operations and Exercise Analysis

DSTO has developed a Maritime Exercise Analysis System (MEXANS) as a rapid, in-depth analysis system for sea trials and exercises. It alleviates the problem of handling a wide variety of recording systems, and has been adopted by the RAN Submarine Operational Analysis Group as its main analysis tool, and will be the standard analysis system for all ADF maritime platforms. Typical data include navigational tracks, sonar and radar contacts, combat system information and sequences of tactically significant events, which can be analysed using a Geographical Information System to display event reconstructions in order to provide measures of effectiveness and performance for each platform in an exercise.

DSTO Interaction with Australian and Overseas Organisations

To assist the ADF achieve greater self-reliance in defence, DSTO works closely with Australian defence industry, both informally and through formal alliances, so that industry is better able to produce and develop high technology equipment to support the ADF. Examples include an innovative ultra-sonic acoustic mine imaging sonar for which Thomson Marconi Sonar Pty Ltd was awarded a full-scale engineering development contract, and an Australian minesweeping and support system marketed by ADI Limited.

DSTO also has extensive formal and informal links with Australian and overseas academic and research institutions and overseas military organisations, and participates in a number of international defence science agreements and bilateral research arrangements, which enable DSTO to contribute to and keep abreast of new developments in military R&D.

Contractor

The Defence Science and Technology Organisation, Canberra, ACT.

UPDATED

Canada

Defence Research and Development Canada

Type

Scientific and technological research agency.

Background

The Defence Research and Development Canada (DRDC) in Canada is a special operating agency within the Department of National Defence (DND) designated to provide science and technology leadership in support of Canada's defence capabilities.

The primary role of the organisation is to facilitate and support the Department of National Defence's (DND) ability to arrive at informed decisions regarding future defence policy, force development and equipment procurement. It also supports military operations by engaging in R&D activities that provide improved support, knowledge, protection and response to potential threats. By its assessment of technological trends, threats and opportunities it enhances the preparedness of the Canadian Forces. Further benefits are gained through its exploitation of emerging technologies. Finally it supports the Government through its contribution and maintenance of a national defence, science and technology industrial capability that is internationally competitive.

Description

The primary objective of DRDC is to ensure that Canada is technologically prepared and relevant in the future security and defence environment. The underpinning of this role is the agency's technology investment strategy setting out 21 R&D activities that DRDC is pursuing in support of Canada's defence. These include interoperability, decision-making capabilities and asymmetric threats.

Major coalition operations of the last decade have aptly illustrated the need for allied interoperability. A key thrust of DRDCs strategy in this area involves joint allied research through forums such as the technical co-operation programme where Canada, together with member nations Australia, New Zealand, UK and US conduct collaborative defence research.

A critical part of deriving what research advancements offer, is to trial them. Through the technology demonstration programme, DRDC provides such a forum for researchers to evaluate new technology before proceeding to development. For Canadian industry and other partners the technology demonstration programme is a setting to display new technologies and explore options for inserting them into operational systems.

The DRDC has organised its science and technology expertise into three main areas: sensors and information technology, combat systems and human systems. The DRDC carries out its work at five main sites: the Defence Research Establishment Atlantic (DREA), Defence Research Establishment Valcartier (DREV), Defence Research Establishment Ottawa (DREO), Defence and Civil Institute of Environmental Medicine (DCIEM) and Defence Research Establishment Suffield (DRES).

In the field of undersea warfare, the DRDB focuses on technologies and capabilities that ensure that Canadian Forces are equipped with the most up-to-date sensor and weapon systems enabling them to effectively carry out ASW and mine warfare operations. To this end R&D activity is carried out by DREA and centres on three major areas – sonar sensors and undersea environmental acoustics, naval and airborne sonar technologies and electromagnetics.

Sonar Sensors and Acoustics

The primary aim of R&D in this field is to gain in-depth knowledge of the characteristics of the underwater acoustical environment that is applicable and appropriate to sonars used by the Canadian Forces. To achieve this, DREA develops techniques for measuring and modelling those characteristics and develops sensors which exploit those properties. Currently, efforts are being devoted to understanding and building up knowledge of the littoral and shallow water environment. Research includes an Arctic acoustics programme investigating the possibility of using underwater acoustic surveillance systems in Canadian Arctic waters.

DREA, in co-operation with industry, is involved in projects such as, an improved LF sonobuoy, microbuoys and so on; the Theseus AUV designed to lay cables in a hostile environment such as the Arctic; ultra-sensitive low-noise sensors; high efficiency underwater sound transmitters such as the Barrel Stave projector; mathematical models of sound propagation in shallow water at low frequency; LF underwater reverberation and so on.

To assist the DREA in its work it has access to the vessel *Quest* for sea trials and data gathering. The DREA has acquired a considerable level of expertise in the Arctic environment.

Sonar Technology

In this area DREA provides expert advice to Canadian Forces on naval and airborne sonar technology with particular reference to transmitter and receiver arrays, signal/data processing and MMI. DREA is primarily engaged in concept studies, development and concept demonstration models of sonar systems. Much of this work is carried out under contract to industry, although in-house research is carried out to formulate and evaluate initial concepts and provide independent assessment. Projects in which DREA has been involved include the Canadian CANTASS towed array sonar and the SQS-510 MF active sonar. Some of the projects currently under study include: the Concept of an Airborne Sonar Demonstrator (CASD) sonar processor which is under consideration for updating the Aurora; active sonar emulation for the SQS-510 as a means of possibly improving its detection performance against torpedoes and mines; torpedo countermeasures; upgrading of sonobuoys including the fitting of GPS; and experimental work on LF active sonar concepts for the Towed Integrated Active Passive Sonar (TIAPS) project which is aimed at the CPF update.

To assist DREA in its work it uses a combat system evaluation and analysis laboratory (TTCP-CSEAL) for testing sonar processing and information management algorithms.

Electromagnetics

This work covers three main areas – airborne Magnetic Anomaly Detection (MAD); underwater electromagnetic detection of ships and submarines; and MCM systems.

In-house work is kept to a minimum in order to be able to maintain access to foreign defence information and to advise Canadian Forces of developments in other countries.

Some of the areas of activity in which DREA is involved include: ambient LF EM background and detection of dc and LF ac magnetic and electric field emissions of submarines and surface vessels; processing of electric and magnetic signals and development of suitable sensors to detect such emissions; maintenance of a database of EM signatures, MCM systems and route surveying; sonar image processing for mine detection and classification; ROV and AUV platforms for MCM; and gathering of environmental data together with the use of navigation and side and sector-scan sonar systems for MCM. To assist DREA in this work it

operates both Dolphin and Phantom ROVs and is able to use the instrumented underwater test ranges at Nanaimo and Halifax.

Mine Countermeasures

One of the areas in which the DCIEM has been involved with the Experimental Diving Unit has been the development of specialised military diving equipment. Of particular importance has been the development of diving sets used by the Canadian Navy (SIVA 55 and SIVA +). These suits (referred to in the Canadian Navy as CCDA and CUMA), are now in service with the navies of Belgium, Netherlands, New Zealand, Norway and South Africa, and have been evaluated by about 10 other countries. The suits are acoustically and magnetically invisible to mines, but are of simple design which reduces the need for extensive training, ensures simplicity of operation under difficult conditions and eases maintenance.

Interaction with other organisations

DREA shares its development efforts with allied defence departments and has access to allied navies classified information that is made available to it under MoUs. Other work involves the organisation sharing data with other governmental departments such as the Geological Survey of Canada, and the Institute of Aerospace Research. A lot of the work carried out by DREA is highly classified and requires government-to-government exchange of information.

Contractor

Defence Research & Development Canada, Ottawa.

VERIFIED

Netherlands

TNO Physics and Electronics Laboratory

Type

Scientific research institute.

Background

TNO's vision for the future has embraced the concept of continuing to develop itself as a user-oriented laboratory, concentrating on the entire information chain. This means the gathering, processing, transport, security and management of information and the making of decisions based on it. It has the capability to carry out in-depth studies and system development at the highest level, both on individual aspects, as well as the entire information chain.

To carry out its work effectively, TNO has been organised into six main operational divisions covering Programme and Communications, Operational Research and Business Management, Command and Control and Simulation, Electronics and Electronics Warfare, Observation Systems, and Telecommunications and Security.

In its Strategic Plan for 1999-2002, TNO has identified 14 core areas in which it will concentrate in the coming years covering a wide range of disciplines, one of which is defence. The strategic plan has set targets for market-generated revenue in these core areas and has identified areas where the Dutch government anticipates support from TNO – one of these being defence. It has been assumed that Government funding for specific research projects will remain constant over the next few years, but contract research will provide alternative funding and is expected to increase, leading to a fall in government funding. How this will affect the defence sector remains to be seen. Nevertheless, defence remains the third highest revenue earner behind nutrition and transport.

Description

The defence area experienced strong growth during 1998 and, together with the Dutch MoD, TNO is working towards achieving greater participation in international defence projects, working with both Dutch, German and Canadian partners.

In the area of underwater warfare the Observation Systems Division is responsible for carrying out research into radar, IR, electro-optics and acoustics. In this latter area work is undertaken by the Underwater Acoustics Group. The Group's mission is to maintain and expand the national technology base in the disciplines of the underwater natural environment, array technologies, sonar systems and underwater weapons in particular in support of the Royal Netherlands Navy. In pursuance of this mission, the Group is well versed in the fields of environmental modelling and simulation, sonar array technology, the estimation of the behaviour of towed arrays and acoustic signal processing.

Its three main areas of technological development are the underwater environment; new array technologies; and sonar systems and underwater weapons.

Underwater Environment

Within this discipline, the Group has acquired considerable knowledge regarding the physical processes and attributes which affect the underwater natural environment and how these characteristics affect the behaviour of acoustic signals, and the physical parameters of those characteristics.

In 1996 the Group, in partnership with Thales Underwater Systems (formerly Thomson Marconi Sonar) (France), SACLANT Undersea Research Centre (Italy), Heriot-Watt University (Scotland) and the University of Wales (Wales), embarked on the PROSIM (Propagation channel simulator) project. The objective of this project was to develop a software package designed to simulate the effect of a shallow water propagation channel (water depth 50 to 300 m) on a broadband (0.1 to 10 kHz) acoustic signal.

Other projects in this discipline include the ALMOST 2000. This is an operational model for propagation and range prediction which offers users a powerful tactical decision aid for both LF and HF variable depth sonars. The other project is ROBLINKS – a collaborative enterprise with Thales Underwater Systems (formerly Thomson Marconi Sonar) (France) and the Ruhr University (Germany), designed to develop new techniques for underwater acoustic communication based on continuous parallel identification of the channel response. Experimental measurements were carried out in the North Sea in May 1999 using the Netherlands survey vessel *Tydeman*.

New Array Technologies

In 1998 the first phase of the New Array Technology (NAT) project was successfully completed. Working in co-operation with Thales Underwater Systems of France, the Underwater Acoustics Group developed new technologies for an LF active towed array sonar for use in shallow waters. Under this project the two organisations developed data acquisition hardware and software, and implemented signal processing techniques for the new generation hydrophone array. This cardioid array comprises three acoustic receiver arrays housed in a single sonar array. Using this technology enabled the problem of left-right ambiguity to be overcome. Data from this project has been incorporated in the Thales CAPTAS sonar system. Following on from this work the Netherlands Navy's interest in shallow water sonar operations has led to the NAT II project. This is a 2-year programme under which the active transmission aspect of the sonar will be studied. As part of this investigation new pulse shapes will be investigated and tested as well as techniques for determining both the range and speed of a target using a single ping. Among other projects the Euclid RTP10.13 is an internationally Government-supported programme (involving the Ministries of Defence of the Netherlands, Germany and the UK) involving Ultra Electronics Ocean Systems (UK) and LITEF GmbH (Germany). The objective of this part of the Euclid Programme is to provide the three countries with technological expertise to develop and build accurate heading sensors suitable for inclusion in small diameter towed arrays. Trials with the Euclid heading sensor in a towed array were held in late 1999.

Sonar Systems and Underwater Weapons

Among projects currently in train in this discipline is the ALF (Active Low Frequency) sonar with which numerous at-sea trials have been conducted. Other ATAS systems are also under study and in the Autumn of 1998 two different prototype ATAS systems underwent shallow water evaluation trials. These trials were carried out in support of the Royal Netherlands Navy's aim to procure an ATAS system for the M class frigates.

Currently the Group is carrying out research into various areas related to torpedoes and torpedo defence. The main focus is on developing technology to detect the radiated noise from torpedoes and the impact this has on torpedo defence systems. The main objective is to achieve timely detection of a torpedo, conduct localisation and classification operations and to develop soft-kill systems. The work is being carried out in close collaboration with the development of the torpedo defence testbed at TNO-FEL. Within this project the ALMOST 2000 is of considerable assistance.

The latest development is Socrates (sound calibration and testing) a multipurpose towed acoustic source, which can be made available for underwater acoustic research trials. It will be used for surface ship and submarine exercises and evaluation studies relating to active sonar systems. Socrates can serve as an artificial target or as an acoustic beacon (see separate entry).

Mine Warfare

Within this field TNO has carried out work with regard to the problem of buried mines. Two major questions have been addressed:

- Where and in which areas and under what conditions does burial occur? and
- How can buried objects be detected?

TNO has undertaken a joint research effort with the navies of France, Germany, Netherlands, United Kingdom and USA together with SACLANTCEN to fuse all available knowledge on the subject, combined models on mine burial processes and evaluated the models in a series of sea trials. Detection of buried mines has concentrated on parametric detection techniques and synthetic aperture techniques.

Other studies into mine warfare have resulted in the development of a MCM-risk plan PC-based software application program which allows an MCM officer to:

- Plan an operation based on maximum reduction of the remaining risk to shipping within the time available;
- Plan a non-uniform coverage MCM operation based on a probability density function of the across channel position of shipping;
- Re-plan an ongoing MCM operation taking into account the effectiveness of the effort already expended;
- Plan an MCM operation taking into account MCM operations already carried out in the area.

The program also allows the MCM officer to manually plan an operation and carry out 'what if' assessments.

This program is available to all NATO countries.

TNO has also developed the HORSE (Hunt Or Sweep Evaluation) system to help the Netherlands Navy to decide where and when to deploy either the new Troika influence sweep system or the upgraded hunting system in the upgraded Alkmaar class MCMVs. HORSE is a mathematical algorithm which will assist the tasking authority in creating the most effective way of assigning tasks to various units, which unit is to perform the task, and where and when. TNO is also carrying out research into, and evaluating the feasibility of, mine jamming. Mine jamming involves influencing the signature of target ships in such a way that they are not recognised by the mine as valid targets.

Interaction

The Acoustics Group is involved in many international projects and co-operates with many different universities around the world. It is also involved with industries and research establishments in Canada (DREA), France (DGA, GESMA, Thales

Underwater Systems), Germany (ATLAS Elektronik, LITEF), Italy (Alenia), Norway (Norwegian Defence Research Establishment), Sweden (Defence Research Establishment), United Kingdom (QinetiQ, Ultra Electronics and Ocean Systems) and United States of America (SACLANT Undersea Research Centre).

Operational status
TNO is currently examining future ASW capability requirements for the Netherlands Navy. This work involves research into LFAS technologies; sensor performance in adverse littoral environments; acoustic signature assessment; and sensor impact studies. The work also involves study into new signal processing techniques and acoustic communication technologies for use in a multistatic sonar environment. The research will be incorporated into the planned ASW upgrade of the Netherlands Navy's 'Karel Doorman class frigates, which will include installation of an LFAS capability. Central to the research will be the Socrates (Sonar CalibRAtion and TESting) high power broadband (950 Hz to 2.1 kHz) towed acoustic source.

Contractor
TNO-FEL, The Hague.

UPDATED

Norway

FFI (Norwegian Defence Research Establishment)

Type
Technological research and development establishment.

Background
The Norwegian Forsvarets Forskningsinstitutt (FFI) Government agency was established at Kjeller in 1946 to conduct R&D related to Norwegian defence requirements, and also to contribute to industrial and technological development within Norway. The FFI is responsible to the Norwegian MoD.

Description
The FFI is organised into five divisions covering – electronics, environmental toxicology, weapons and equipment, underwater defence and systems analysis.

The main tasks of the FFI are to conduct research and development for the Norwegian armed forces and to keep the political and military informed as to current development in technology that would have a bearing on defence and national security. For long-term defence planning the FFI provides analytical support and assists the armed forces in making decisions regarding procurement of defence materiel and possible areas for future development. In this, emphasis is placed on the development of new concepts that will meet military requirements, but remain within cost constraints.

In pursuance of these aims some 60 per cent of FFIs activities are devoted to concept studies, development and testing of prototypes. Projects that are considered suitable for future development are pursued in co-operation with one or a number of commercial enterprises.

Typical of such enterprises is UNISON 2005 (Underwater Information and Sonar technology) that is aimed at supporting the development of the next generation of combat system for underwater warfare. In this study the main objective is to develop and demonstrate new solutions that combine sensor and external data using modern information and communication technology that will be suitable for operations in the littoral. The programme involves two major commercial Norwegian companies – Kongsberg Defence and Aerospace, and SIMRAD – together with FFI: additional input is being provided by the Royal Norwegian Navy. The principal areas of technology being addressed by the joint group are:

- computers and software for C³I
- fire-control system
- underwater technology and sonar systems.

Future Norwegian programmes that will draw on the results of UNISON 2005 are:

- new class of frigates
- new class of submarine
- Ula class submarines mid-life update
- Oksøy and Alta class MCMV mid-life update
- Ula class submarine Lofar system.

The aim of UNISON 2005 is to develop an affordable technology for a future combat system that will offer more effective detection and classification of targets leading to more successful engagements at longer range with a reduced manning requirement.

As part of the ongoing requirement to keep procurement within budget constraints the group will examine the possibilities for common components applicable to a number of tasks such as:

- sonar performance prediction in the Norwegian littoral using parametric sonar and hydrographic, oceanographic, meteorological and geographical information
- HCI (Human Computer Interface) for tactical overview of situations where large amounts of data are to be presented
- operator support for planning and optimal use of sonars
- reducing false alarm rates in the littoral by improving target classification using, for example broadband signals and processing
- an architectural framework that can encapsulate functionality and incrementally develop reliable software components to enable the development and use of automated tactical planning.

The commercial companies, the Norwegian Industrial and Regional Development Fund and the Norwegian MoD, are funding the UNISON 2005 Programme.

FFI, in conjunction with Kongsberg Simrad and the Norwegian Navy, is preparing prototype Hugin AUVs to enable the Norwegian Navy to establish a forward-deployed MCM rapid environmental assessment capability for the Norwegian mine warfare flotilla. Some test and evaluation trials have already been carried out and a Hugin vehicle is expected to be subject to operational evaluation by the Norwegian Navy early in 2005.

Contractor
Forsvarets Forskningsinstitutt, Kjeller.

UPDATED

Singapore

DSTA

Type
Defence Science and Technology Agency (DSTA).

Background
Formed on 29 March 2000 from the Defence Technology Group (DTG), which it replaced, the DSTA is responsible for the acquisition, development and upgrading of platforms and weapons systems for the Singapore Armed Forces. As part of its remit, therefore, it has responsibility for managing the country's defence-related research and development activities. It also advises MINDEF on science and technology developments that might have particular relevance to defence.

In addition, DSTA oversees the development and maintenance of the military infrastructure of the country and the provision of engineering services, in particular computer programming and the development and upgrading of software.

Description
The DSTA is organised around various types of military programme in order to gain optimum integration of effort to provide the customers with the best solution to their problem. To achieve this the DSTA is organised into nine main Programme Management Teams, some of which were previously controlled by the DTG and the Defence Administration Group of MINDEF. These Teams include:

- Aeronautical Systems
- Land Systems
- Naval Systems
- Armament Systems
- Guided Systems
- Sensor Systems
- R & D
- Information Technology
- Building and Infrastructure

Each Team provides its customers (MINDEF, and the Singapore Armed Forces) with the necessary technology and systems to enable them to effectively carry out their tasks. The Programme Management Teams are also fed by and feed into three Development Units (Information Technology Laboratories, the Defence Medical Research Institute and DSO National Laboratories). In addition, the DTSA involves a number of partners in its various activities including industrial partners, Universities and R & D Institutions.

The Naval Systems Team, in collaboration with other Teams and Development Units, is able to harness current and emerging technologies involving a wide variety of disciplines, and by collaboration with national and international partners, to provide the Singapore Navy with innovative and customised solutions. Typical of these solutions has been the introduction into the Navy of the new Landing Ship Tank and the development of the submarine arm, with the acquisition of the ex-Swedish submarines, a project in which it has been closely involved.

Under the DSTA the department which has most relevance to underwater warfare is the DSO. DSO was itself re-organised in 1997 aimed at providing greater flexibility in management, recruitment and other areas. The DSO manages a Centre for Underwater Systems, which carries out R & D in surface and sub-surface platforms, sensors and weapon systems associated with underwater warfare.

It is involved in two main programmes, one of which is intimately associated with underwater warfare. This is the Underwater Programme in which ASW and MCM acoustic technologies, underwater EW and underwater communications form a major function. Part of the work involves developing innovative sonar signal processing to enhance sonar functions and performances deployed in littoral waters. In addition, the Centre is well equipped to carry out studies into new developments associated with EW and then to undertake demonstrations of new concepts.

Much work is involved with underwater acoustics and the way the environment affects sound propagation. This involves the development of sophisticated simulation models for propagation, noise, reverberation, sonar performance and target scattering simulations.

Magnetic and electric field analysis in naval applications also forms part of the DSOs work.

The Marine Systems Programme is involved in the study of hull design and hydrodynamic performance of both surface and sub-surface platforms. Included in these studies are the effects of underwater explosions on various structures and underwater stealth.

To carry out its function the DSO is organised into 13 Centres of Excellence:

- Advanced Systems
- Communication Systems
- EW
- Radar Systems
- Systems Engineering
- Underwater Systems
- Unmanned Systems
- Physical Sciences
- Information Systems Security
- Electromagnetics
- Decision Support
- Chemical Defence
- Advanced Electronics and Signal Processing

Contractor

DSTA, Science Park Drive or Depot Road, Singapore.

VERIFIED

Sweden

FOI

Background

FOI is a government agency under the Swedish Ministry of Defence and the main resource in applied research for defence and security purposes in Sweden. The agency was formed in 2001 as a merger between the earlier agencies the Swedish Defence Research Establishment (FOA) and The Aeronautical Research Institute of Sweden (FFA). The agency is divided into seven research divisions, one administrative division and the Air Force Air Combat Simulation Centre. The research divisions are oriented towards different areas of expertise and named accordingly: Defence analysis, Systems Technology, Weapons and Protection, Sensor Technology, C2 Systems, NBC-Defence and Aeronautics.

FOI has about 1,280 employees, of whom around 900 are researchers with an academic or post-graduate degree. The annual turnover in 2002 was around 1.2 billion Swedish kronor (€130 million).

Description

Overview of underwater research

The aim of the underwater research carried out by FOI is to create, evaluate and communicate knowledge and new technology in support of the Swedish Armed Forces. The Agency also supports the armed forces with training and education, often using modelling and simulation. An important part of the work is done in support of the Swedish Defence Materiel Administration (FMV) on the specification and development of new systems such as the next generation of submarines and the Visby class corvette. A large part of the groups research is focussed on the special problems associated with the littorals and especially the Baltic.

Underwater research is spread over several research divisions, the main part of which is conducted within the division of Systems Technology where investigations into underwater acoustics and underwater electromagnetics are carried out. The work consists of almost all aspects of these areas including the development of sensors and wave propagation and signatures from various objects. Research is also conducted into underwater communication and mine countermeasures.

At the Sensor Systems division research is conducted into optical systems and lasers for underwater applications. There are both sensor and communication applications for optical systems under water. This research is performed in close co-operation with the work at Systems Technology, and often in common research projects.

Underwater explosives and the effect of underwater explosions are research topics investigated at the Weapons and Protection division. This is done both theoretically and experimentally, for example as explosive tests against decommissioned naval vessels. The division also investigates problems related to flow-induced noise using Computer Fluid Dynamics (CFD).

Naval and underwater operations research is managed by the Defence Analysis division in close co-operation with the Navy. OR personnel are placed with the navy carrying out research and development into tactics and exercise evaluations. There are also OR personnel supporting the Navy in studies and long term planning.

Two of the most important experimental resources for underwater research at FOI are the indoor tank laboratory in Ursvik, Stockholm and the outdoor research facility at Djupviken in the southern part of the Stockholm archipelago. The tank measures approximately 7 × 3.7 × 3.7 m and holds brackish water with a salinity equal to that of the Baltic outside Stockholm. The tank is used for measurements and sensor calibration and is currently undergoing an upgrade program to be able to handle both acoustic and electromagnetic sensors.

The outdoor facility at Djupviken consists of a small laboratory on land and a pontoon building, which gives the opportunity to conduct outdoor experiments in a sheltered environment. There is also a small boat called *Decibella* available and a ROV called Plums. Djupviken is used for low frequency calibration and field trials. Both Djupviken and the tank are managed by the of Systems Technology division.

The extreme littorals

The classic operational environments for the Swedish Navy are the Baltic and North Sea. In some respects the whole of the Baltic can be classified as littoral. The average depth is about 57 m. It is probably hard to find any part of the Baltic where one is more than 200 km from any coastline.

The water is brackish. In the north of the Gulf of Bothnia the salinity is about 0.1 per cent. In the south of the Baltic we have a salinity of about 0.8 per cent close to the surface and 1.2 per cent near the seabed and on the west coast of Sweden the salinity is more commonly 3.5 per cent. This has implications for sonars. The bottom of the Baltic is hard, which leads to high levels of reverberation for low frequencies (<10 kHz). As a result Swedish sonars tend to work at about 20 kHz. But, in the salt water the 20 kHz frequency is quickly attenuated. The sound velocity profile is season-dependent. This is not unique for the Baltic, but the absence of tides leads to situations where there is no mixing of upper and lower layers of water, and hence the effect of the layered water is very prominent.

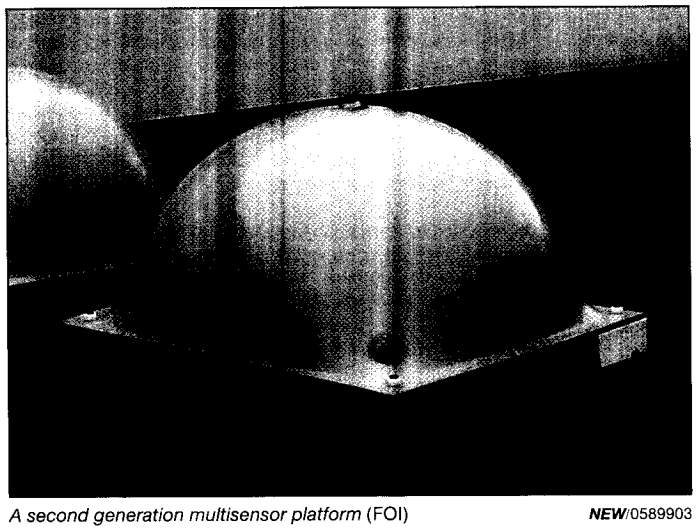
The conductivity, measured in Siemens per meter (S/m), varies from almost zero in the north to about 4 S/m on the west coast. This has implications for electric sensors, but not magnetic ones, as the detection distances fall as the conductivity goes up. As a further complication, there is 2,700 km of coastline and archipelagos with hundreds of islands to guard and defend. The whole Baltic is a littoral zone and is sometimes referred to as 'the extreme littorals'. This is to emphasise that what Sweden faces in the Baltic, is not only a coastal zone but also a very difficult one.

Anti-Submarine Warfare in the archipelago

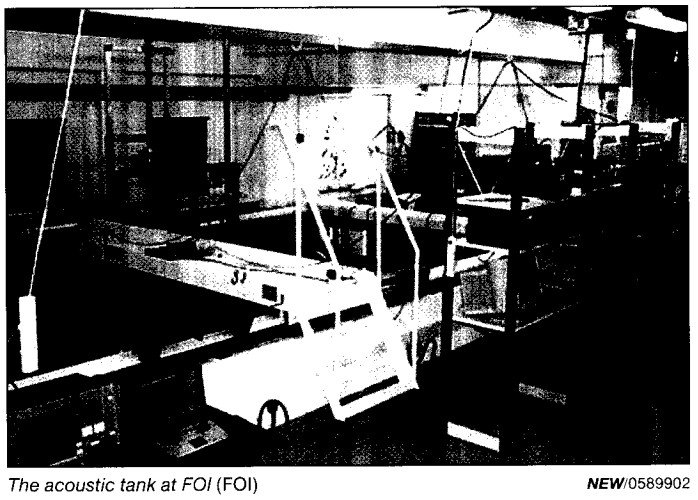
The extreme littorals are the most challenging environments for ASW. During and after the ASW-operations in the 1980s when Swedish borders were regularly violated by foreign submarines, the FOI (then FOA) was commissioned to undertake a large number of research projects with the specific aim of enhancing Swedish ASW capability. Those projects ranged from exercise evaluation tools and tactical trainers to new types of underwater sensors and weapons. The heritage from this research in the late 1980s and early 90s has been well looked after and FOI today is a world leading research institute in some areas of underwater research.

Technology for Network Enabled Underwater Warfare

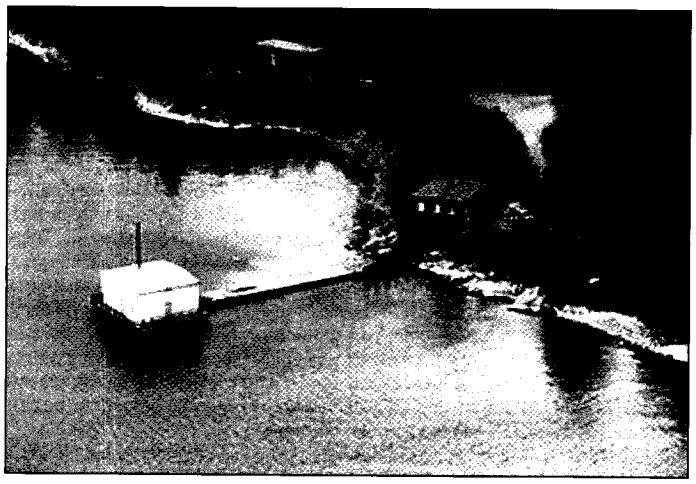
The Swedish Armed Forces has begun a transformation process towards a Network Based Defence. This applies to all systems, above and under water. The network of underwater systems is a part of a larger network and the true network-enabled capabilities will emerge only when above and under water systems begin to merge into the same network, and not into two or more different networks. Network Enabled Capabilities may very well be the answer to the question of how ASW can be handled in the littorals. A systematic networking and various systems and services, combined with knowledge of the operational area will be the factor that will give Sweden the edge, the situation awareness of the underwater battlespace.



A second generation multisensor platform (FOI) ***NEW***/0589903



The acoustic tank at FOI (FOI) ***NEW***/0589902



The FOI research site at Djupviken south of Stockholm (FOI) ***NEW***/0589904

FOI-research in support of the Netcentric approach
FOI is deeply involved in research to support the Swedish Armed Forces transition from a traditional force into a networked force. In the area of underwater warfare this research is done at all different levels. Below is a short list of systems and topics studied and developed by the FOI.

Oceanography
Knowledge of how the water behaves and an ability to predict the underwater environment is essential to a surface ship or a submarine that wants to know what is happening but not to be seen. This knowledge is put in to a model called COMBIS (COmbined Maritime Background Information System). The aim of the tool is to visually present the amalgamated maritime background with one single tool. It has two purposes: first of all it is a research tool that can be used to predict such factors as detection range and environmental parameters prior to experiment. It could also be used to try different algorithms.

Secondly it is a training tool that can be used with navy personnel when varying effects need to be visualised, for example the electric field and its propagation in the water versus the seafloor.

Sensors
The carbon fibre electrode is an electric field sensor that is used to measure the electric potential in the water. The background to this is that the vast majority of ships and submarines generate an Underwater Electric Potential, (UEP) due to the fact that a steel hull holds a turning bronze propeller. This electric field can be detected and a typical sensor system is a three-axis one that holds a sum of six electrodes.

The carbon fibre electrode has been developed by FOI/FOA and who hold a patent that has been licensed to a Swedish firm that manufacture them. One of the advantages of the fibre electrode is the large total area that is exposed to the water. The area is in the order of 4 m^2. The electrode is sensitive to electric fields with frequencies from about 0.1 Hz up to a few kHz. The applications are, among others, surveillance systems, buoy sensors or mine fuses.

FOI also carries out a lot of work on acoustic sensors, both active and passive. As a rule, the Agency doesn't develop hydrophones or transducers. Their work is instead focused on waveforms and signal processing with the aim to get as much as possible out of the system. FOI is among other things working on Synthetic Aperture Sonar (SAS), multistatic sonars and parametric sonars. For a multistatic system to work properly, the receiver must know where and when a signal was transmitted. Over land or on the surface this can be achieved by radio or by cable/fibre. If a submarine is a part of the system this is not possible. To address this problem FOI has developed a GPS-based clock that is very accurate. It can be used by the transmitting and receiving platforms in the multistatic mode.

FOI has also developed a highly successful multisensor platform that consists of electric, magnetic, acoustic and pressure sensors. The platform holds, in addition to the sensors, a small computer and can be deployed in a small network to cover an area such as a harbour.

Communication
Communication is one of the most important parts of a network-centric approach to underwater warfare. FOI is currently investigating different techniques for underwater communications such as electromagnetic, acoustic and optic. The ability to detect a transmission in an environment with multipath propagation where symbols tend to mix with each other has resulted in a lot of research into signal processing.

Weapons
FOI has traditionally been involved in the development of underwater weapons such as heavyweight torpedoes and ASW-grenades. Today the pace of development of new systems is a lot slower than 15 years ago. FOI is involved in a few weapons projects and tries to uphold the competence as a support to the Navy.

Underwater explosives
In all underwater warfare systems a warhead is needed. FOI are currently developing underwater explosives with increased bubble energy. This new generation of underwater explosives is based on the new oxidizer AND (Ammoniumdiniteramide).

Autonomous Underwater Vehicles (AUVs)
FOI is currently involved in a number of projects concerning autonomous vehicles. The systems range from navigation and design of the control system to concepts of underwater vehicles with associated sensor suites.

Modelling and simulation
The importance of modelling and simulation is growing in almost all areas concerning underwater warfare. FOI uses modelling and simulation for research, acquisition, training, decision and analysis. The Agency has developed and maintains a number of models on various levels of complexity. For example there are models for wave propagation, electric conductivity, for countermeasures and mine warfare. There are also models for determining the effect of underwater explosions on ships and models for analytical and mission planning purposes for example in ASW training and evaluation and sonobuoy deployment.

Contractor
FOI, Systems Technology Division, Stockholm.

UPDATED

United Kingdom

QinetiQ

Type
Scientific research and support organisation.

Description
QinetiQ is one of Europe's largest science and technology solutions companies, employing nearly 10,000 staff, including many of the UK's leading scientists and internationally acclaimed experts. Formerly known as the Defence Evaluation and Research Agency (DERA), QinetiQ was founded from the laboratories of the UK MoD. Today it operates in markets as diverse as marine, energy, telecommunications, automotive, rail, electronics, defence, space, health, oil and gas, aerospace and information technology. QinetiQ's facilities include indoor and outdoor ranges, wind tunnels, marine testing facilities, automotive test tracks and climatic testing laboratories.

QinetiQ's heritage covers the pioneering research and development of many household technologies such as liquid crystal displays (LCDs), carbon fibre, the technology for flat panel speakers, infrared sensors, and microwave radar, a life saving foetal heart monitoring system, plus other significant advancements in healthcare and passenger security and transport.

The Carlyle Group, one of he world's leading private equity firms, was selected by the MoD in 2002 as a strategic partner to invest in QinetiQ as a stepping stone to eventual flotation. The transaction that allowed the firm to acquire a 33.8 per cent stake in QinetiQ was completed at the end of February 2003. A further 3.7 per cent of shares were made available to QinetiQ staff, with MoD retaining a 62.5 per cent stake. Carlyle will bring QinetiQ access to further capital, global expertise and cross industry contacts. QinetiQ is now well placed for its transition from European to global leader.

Among the underwater warfare areas of expertise and technology in which QinetiQ is involved are:
- R&D in submarine design
- sonar systems
- countermeasures
- oceanography
- mine warfare
- signature management

As part of its work, QinetiQ examines and advises customers on the most suitable areas for R&D in terms of time, money and human resources. For example in the area of submarine design QinetiQ can examine requirements and assess potential designs, reporting on physical disciplines such as hydrodynamics, signature management, manning requirements and so on. To further consolidate its capabilities in this area, QinetiQ opened a new Centre for Submarine Technology at Winfrith Technology Centre, Winfrith, Dorset on 26 July 2001. The new Centre will allow the UK MoD and commercial customers to access submarine expertise at QinetiQ.

Similarly with combat systems QinetiQ can formulate and design such systems.

In the field of environmental science QinetiQ provides expertise in diving and submarine escape and rescue systems, MCM diving equipment such as underwater communications, self-contained breathing apparatus and other essential systems.

QinetiQ has also been involved in the field of platform systems integration — the integration of all the major elements in a warship to produce an efficient weapons platform. This involves such multidisciplines as machinery, and platform control; sensors; signature management; the deployment of AUVs; weapons handling, discharge and control and so on.

In the field of communications QinetiQ is typically involved in areas such as low-level digital signal processing, optical processing, maritime communications and systems integration, all vitally important to the conduct of underwater warfare.

Research and consultancy work covers requirements analysis, architecture performance, systems integration, radio spectrum management, system interoperability, equipment evaluation and technical support to aid in procurement.

The company has previously been deeply involved in sensor technology and development in particular sonar systems for ASW and MCM, torpedo defence, countermeasures, buried mine detection and so on.

To assist in its work, QinetiQ operates a scale replica model of the 'Trafalgar' class submarine. QinetiQ also operates the world's first trimaran warship, the RV *Triton*, which will be used to evaluate this hull form for future warship design, together with new equipment that could form the basis for a Future Surface Combatant (FSC) for the Royal Navy.

Contractor
QinetiQ, Farnborough, Hampshire.

UPDATED

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INDEXES

Manufacturers' Index

A

Aanderaa Instruments
CMB 3280 Coastal Monitoring Buoy 579
DCM 12 Doppler Current Meter 579
RCM 9 recording current meter 580
Series 7 oceanographic instruments for data collection . 581

ABE Elettronica SpA
Thetis BLD-727 ESM system 244
ULR-741 ESM/ELINT system 244

AB Precision (Poole) Ltd
ABLO36 underwater telephone 265
Limpet Mine Disposal Equipment (LMDE) 508
Type 778 echo-sounders 644
Type 780/786/787 echo-sounders 645
Type 2073 underwater telephone 80

Abeking & Rasmussen
'Aydin' class minehunter 397
Ensdorf/Kulmbach class minesweepers 398
MJ 2000 minehunting system 400
Type 332 Frankenthal class minehunter 399

ACSA Underwater GPS
GIB-ROV tracking system 493
GIB-DPS 520
GIB-FT 554

ADI Ltd
AMAS minesweeping system 501
Huon class minehunter 392
MCS minesweeping control system 641
Safety Flare 76
Visem MCM training aid 613

Admiralty Yard, St Petersburg
Amur class submarine 56
Kilo class submarine design 54
Lada class submarine 56

Aeromaritime Systembau
ICS integrated communications system 253

African Defence Systems
MTDS minehunting data system 429

Akhtuba, Volgograd
Fixed sonar systems 219

Allen Osborne Associates
AN/UQN-5 SANS swimmer area navigation system 543
V-COM 260

AMS (Alenia Marconi Systems)
Astute Combat Management System (ACMS) 115
Command console 653
Distress submarine location equipment (Type 639) 80
KAFS submarine combat information and fire-control system 115
Manta data handling system 116
NAUTIS-M system 430
NECTA environmental tactical aid 587
SAWCS acoustic warfare system 182
SMBPS 256
SMCS-NG submarine command system 117
SMCS submarine command system 116
Sea Piper diver communication system 539
Submarine platform control system 96
UwEM monitoring system 589

AMS Simulation and Training
Astute class training service 617
Hunt class trainer 614
Machinery simulators 617
Merlin Acoustic Trainer 621
MPAST sonar training systems 621
Periscope simulator 618
Sandown class trainer 614
SCTT submarine command team trainer 609
Sea King ASW sonar trainers 621
SMCS operator trainer 610
Sonar principles trainer 628
Submarine team trainers 610

Anteon Corporation
AN/37U-1 mechanical sweep system (AN/SLQ-53) 510
SEA SHADOW diver propulsion vehicle 72

Applied Microsystems Ltd
CTD-12 Plus miniature conductivity, temperature, depth probe 578

Applied Physics Laboratory, Univ of Washington
LIMIS diver sonar 544

Arbeitsgemeinschaft
MJ 2000 minehunting system 400

Array Systems Computing
AN/FQR-503 towed array mission simulator 623
CANTASS PAS analysis system 134
CTASP signal processor 667

Atkins, WS
NSRS rescue vehicle 76

Atlas Elektronik GmbH *see* **STN Atlas Elektronik GmbH**

Australian Submarine Corporation
Collins class submarine design 58

Avondale Industries
Osprey class MCMV 416

B

BAE Systems, Australia
Launcher Control System (LCS) 103

BAE Systems Avionics
AA34030 sonobuoy command transmitter 209

BAE Systems, Hampshire, UK
AMNS 511

BAE Systems Marine
'Astute' class nuclear-powered submarine 62

BAE Systems North America
AN/ARR-78(V) sonobuoy receiving system 212
AN/BRD-7 DF system 248
AN/BRT-6 communications system 267
ATD-III LIDAR system 455
ES and ADF 250
Low-frequency Transmit Subsystem (LTS) 663
Model 30 high-powered projector 663
Model 40 flextensional transducer 664
T-1630/SRT SEPIRB 81

BAE Systems, Plymouth, UK
SAMHADS message processing system 255

BAE Systems Underwater Systems
Acoustic support function 586
ATAS V1/V2/V3 sonar 151
BARS Bearing Ambiguity Resolution Sonar 152
Combined Influence Sweep (CIS) 507
DEBRA beach reconnaissance aid 534
Flextensional transducers 661
LESCUT torpedo decoy 228
Limpet mines and timers 360
MERS signature measurement 566
Mk 11 depth charge 371
MSSA Mk 1 minesweeping system 508
OSDI interface system 116
SAP mine disposal system 499
Sea Sting mine disposal system 500
SEPADS Type 2068 system 588
Versatile Exercise Mine Systems (VEMS) 359
Wire sweep Mk 8 509
Wire sweep Mk 9 509
Wire sweep Mk 105 509
Wire sweep monitoring equipment 510

BAE Systems Underwater Weapons
Archerfish self-propelled MCM munition 480
Bathyscan depth sounder 599
Marlin AUV 481
Shaped charge mine disposal system, Sea Sting 500
Spearfish torpedo 327
Sting Ray torpedo 328
Stonefish mines 361, 362
Tigerfish Mod 2 torpedo 330
Torpedo launchers 330

Ballard Power Cells
Fuel cell 85

Beaufort Air-Sea Equipment Ltd
SEIE Mk 10 escape unit 77

Beliard Polyship
Tripartite minehunter 400

Benthos
ALP-365 Flexi-Pinger 662
COBRA-TAC 543
DHS-100 sonar 543
DPL-275A pinger/receiver 544
DRI-267 transponder interrogator 662
ELP-362D emergency locator beacon 663
Mark-Trak navigational system 545
Sub-Monitor tracking system 546
Super SeaROVER ROV 491
UAT-376 acoustic transponder 666

Bharat Electronics
Toted torpedo decoy 227

Bluefin Robotics
BPAUV 485

BMT Defence Services Ltd
SSGT 65

Boeing Company
LMRS mine reconnaissance vehicle AN/BLQ-11 483
UGM-84 Sub Harpoon anti-ship missile 306

Bridport Aviation Products
Torpedo recovery system 330

BrodoSplit
R-1 Swimmer Delivery Vehicle (SDV) 57
R-2 two-man Swimmer Delivery Vehicle 38
Velebit midget submarine 38

Bulgarian Academy of Sciences' Institute of Metal Science
PDM-2H anti-invasion mine 345

C

CAE Electronics Ltd
ACTS 'Astute' class training service 617
AN/ASQ-504(V) AIMS system 285
Control & instrumentation ('Astute' class) 85

Calzoni SpA
Gas exhaust valves 92
LARSC Launch and Recovery Smart Crane 497
MHAP-20 minehunting autopilot 426
MIN Mk 2 ROV mine disposal system 475
Non-penetrating masts 92
Steering system 93
Universal Modular Mast 278

Cammell Laird (VSEL)
Upholder class submarine 65
Victoria class submarine 65

Cardoen Industrias Ltda
AS-228 depth charge 365

Carleton Life Support Technologies, Fullerton Sherwood Division
SIVA diver rebreather apparatus 516
SIVA S-10 oxygen rebreather apparatus 516

Carleton Technologies Inc
UBA Mk 16 545

CEA Pty Ltd
CSDS coastal surveillance display system 218
ISCS integrated ship communication system 667

CETUS Systems AB
BBT500 transducer 660
BBT900 transducer 660
Pressure sweep 507

Charles Stark Draper Laboratories
UUV 485

Chelsea Technologies, West Molesey
Aquashuttle Mk III 598
SEASOAR data acquisition vehicle 599
SSMS 599
TEDAS 600

China Aerospace Industry Corporation
CSS-NX-5 (JL-2) ballistic missile 290

China National Electronics Import and Export Corporation
921-A ESM equipment 241

China Precision Machinery Import and Export Corporation
CSS-N-4 Sardine (YJ-1/C-801) 302
CY-1 ASW surface-launched missile system 302

China Shipbuilding Trading Company
Type 312 'Futi' class minesweeper 394

Chinese State Factories
CSS-N-4 Sardine (YJ-1/C-801) 302

Claverham Ltd, Industrial Activation Division
Torpedo steering actuation systems 331

Cogent Defence Systems, Newport
Type 2019 intercept sonar 182

Columbia Research Organisation
SDV-X and Piranha 71

Computing Devices Canada Ltd *see* **General Dynamics Canada**

Constructions Industrielles de la Méditerranée (CNIM)
Calas ASW training target vehicle 633

Corda Ltd, Farnborough, Hampshire
DINAMO 586
INSIGHT 586

Cosmos SpA
Chariot CE2F/X100 small chariot 49
MG 120/ER Shallow Water Attack Submarine (SWATS) 50
Mk 31 underwater charge 347
Mk 41 underwater charge 347
Mk 414/430 limpet mines 348
X 201 SWATS midget submarine 51

C-TEC, New Delhi
Limpet mine 347

C-Tech Ltd
CMAS-36/39 mine detection and avoidance sonar 437
CSAS-80 sonar 217
CSDS-85 sonar 217
CTS-24 ASW OMNI sonar 135
CTS-36/39 OMNI sonar 135

CTM, Gliwice
Toczek countermining charge 498

D

Dalian Warship Institute
EM 52/55 rising mine 346

Danyard A/S
Flyvefisken class MCMV 394
MSF class mine countermeasures drone 395
SAV class minehunter drone 396

DARPA, Arlington, Virginia
UUV 485
EMTC 575

Datamat
MACTIS MM/SSN-714(V)2 426
Mine Data Centre 427
Mine warfare testing range 560
SACTIS MM/BSN-716 110
Submarine attack team trainer 607

DCN International
Agosta class submarine design 39
AP4 acoustic minesweep 504
ASRC sonobuoy remote control 208
ATS series torpedo control systems 108
Barracuda 40
DUBV 43B/C sonar 141
E14 acoustic torpedo 312
E15 acoustic torpedo 312
ERATO torpedo recovery vehicle 467
F17 wire-guided torpedo 312
Impact MU90 torpedo 318
L3 torpedo 313
L5 torpedo 313
MESMA closed Rankine-cycle engine 87
Minetac MCM command & control system 423
Neptune software 585
Pneumatic ram discharge device 314
SAT combat system 104
Scorpene design of submarines 47
Sea Keeper stand-off MCM system 439
SET combat system 104
SLAT anti-torpedo warfare system 228
STS series control systems 109
Tripartite minehunter 400

Deep Ocean Engineering
Phantom ROV 489

Defence Evaluation & Research Agency (DERA) *see* **QinetiQ**

Defence Procurement Agency
FASM future attack submarine 62
Maritime Underwater Future Capability (MUFC) 64

Defence Research and Development Branch, Ottawa
Scientific and technological research 676

Defence Research and Development Laboratories
Sagarika cruise missile 292

Defense Material Administration
Pressure sweep 507

Denel (Naschem)
Samcon 600 multi-influence mine 356

DGA, Paris
Barracuda attack submarine 40

Digital Systems and Design Ltd
Sonar procedures trainer 628

Direction des Constructions Navales *see* **DCN**

Divex, Aberdeen
Mk 5 enclosed mine lift bag 361
Oxymax 3 diving set 537
SAR drysuit 539
Shadow excursion 540
Stealth Combat/Stealth EOD rebreathers 540

DRS Technologies
AN/SQQ-T1 sonar training set 629
AN/SQR-17A signal processor 157
AN/UYQ-65 integrated processor/display set 653
AN/UYQ-70 ADS 654
MDE Military Display Equipment 654
OPUS console 653
Sea Sentry coastal and harbour surveillance system 221

DRS Precision Echo Inc
AN/AQH-4(V)2 system 192
AN/AQH-9 system 192
AN/AQH-11 system 193

Drumgrange
MTSS ® 672
SPIRE III data telemetry and analysis 211

DSND Consub SA
MCF-100 moored contact mine 344
MCT limpet mine 344
MFI influence mine 345

DDSTA, Singapore
Defence research 678

DSTO Defence Science & Technology Organisation, Canberra
Scientific and technological research 675
Wayamba MCM vehicle 462

Dvigatel Zavod
65-73/-76 ASV torpedos 321
MDM/UDM series mines 354
SMDM self-propelled mines 355
Test-71 series ASW torpedo 322
Type 53 series heavyweight torpedoes 322
VA-111 Shkval torpedo 324
UMGT-1 ASW torpedo 323

E

EADS Deutschland GmbH
FL 1800 U submarine ESM/DF system 242
MJ 2000 minehunting system 400
Seicam 1001 audio distribution system 253
USK 800 series direction-finding systems 242

EADS Launch Vehicles
M-4 ballistic missile 290
M-51 ballistic missile 291

ECA
DUBM 42 (IBIS 42) sonar 439
K-ster mine destructor vehicle 468
Mine disposal vehicles training simulator 613
OLISTER subsea mine warfare system 468
PAP Mark 5 ROV mine disposal system 469
PAP Plus remotely controlled vehicle 470
PAPSIM ROV simulator 613
RECA mine disposal charge 494
STAR submarine target 633
SYVA frigate ASW system 106
TOSCA towed subsea carrier 471

EDO Corporation, Electro-Ceramic Products
HSCP-600 current profiler 581
Model 505 emergency underwater telephone 265
Model 3040 Doppler velocity log 646
Model 4240 Doppler sonar velocity log 646
Model 5400 underwater telephone 266

EDO Corporation, Combat Systems Division
AN/SQR-18A(V) TACTAS sonar 157
AN/SQS-35 sonar 158
AN/UQN-4 sonar sounding set 601
AR-700(S)5 249
AR-900 249
CS-3701 250
FFISTS II tactical decision aid 121
MFS-7000 sonar 146
Model 610 sonar 163
Model 700 series sonar 163
Model 780 series sonar 164
Model 980 series sonar 164
Model 997 series sonar 165
Model 1110 sonar 187
Model 1120 sonar 187
Model 1525 CTFM sonar 188
Model 9057 sonar sounding set 601

EDO Corporation
AN/ALQ-219 SWIMS minesweep system 511
Mk 105 airborne minesweeping system 512
MOLS open-loop sweep 513
OASIS minesweep system (AN/ALQ-220) 511

Eiva A/S
MCM command & control system 422
Navigation data management 641

Elbit Ltd
Timnex II ESM/ELINT system 243

Elesco Oy
FDS 700 degaussing system 569
Magnetic Sweep 502
MAINS system 503
MGS-900 signature measurement range 557

Emirates Marine Technologies
Class 4/5 SDVs 62

EMS Development Corporation
Device 14G1 sonar trainer 629

Enersys Ltd
Lead/acid batteries 96

ESCO Electronics Corp
Mobile multifunction countermeasures device 237

Etienne Lacroix Défense
LAT anti-torpedo jammer 227

Eurotorp
A244/S torpedo 317
ATS series torpedo control systems 108
B515 torpedo launch system 318
Impact MU 90 torpedo 318
SPS115 109
STS series control systems 109

F

FAST Consortium
ACTS Astute class training service 617

Feedback Instruments Ltd
AST Acoustic Systems Trainer 626

FFI, Horten
Acoustic antenna 505
Herdla 564

FFI, Oslo
LUNDAR sensor platform 563

FIAT Componenti e Implanti per l'Energia e l'Industria SpA
FCS Mk 3 submarine command and control systems 110

Fincantieri
Type 212A patrol submarine 44

Flagship Training Ltd
ACTS Astute class training service 617

Flight Refuelling Ltd
Barracuda 233
DRS diver recall signal 535
Marine sound signal Mk 8 672
SUA underwater signalling device 673
Submarine signals 673

Florida Atlantic University
Morpheus AUV 487

FOI, Systems Technology Division
Research and Development 679

Forsvarets Forskningsinstitutt, Norway
Research & Development Agency 678

G

Galileo Avionica
MM/BPS-704 radar 649
MM/BPS-804 radar 650
OTS-90 avionic sonic system 191

Gaymarine
Gigas ROV mine disposal vehicle 474
Pluto Plus ROV mine disposal vehicle 477
Pluto ROV mine disposal vehicle 476

Gdynia Shipyard
Krogulec class minehunter/sweeper 407

Gearing & Watson Electronics Ltd
Subtrack target training systems 637
Transducers 662

GESMA
LUNDAR sensor platform 563

GETEN (Hellenic Navy Research and Development Centre)
Kanaris submarine fire-control system 108

General Dynamics Advanced Technology Systems
Sea Sentinel Undersea Coastal Surveillance System (UCSS) 221
SOSUS fixed sound surveillance system 222

General Dynamics Canada
AN/SQR-501 CANTASS 134
AN/SQS-510(V)sonar system 134
AN/UYQ-501(V) Shinpads display 653
AN/UYS-504 sonobuoy processor 207
AQQ-T501 tactical aircrew trainer 623
AQQ-T502 training system 624
ETAS analysis system 207
HI-TASS training system 624
Hydra MSS sonar 136
MVASP acoustic processor 207

General Dynamics Communications
Extremely Low-Frequency (ELF) communications programme 258
SUBTACS submarine tactical communications system 260

General Dynamics Defense Systems
Mk 98 strategic missile fire-control system 122

General Dynamics Electric Boat Division
Cutthroat LSV-2 69
Dry Deck Shelter for SDV 69
Los Angeles class nuclear submarine 69
Ohio class SSGN 71
Seawolf class nuclear submarine 72
SLWM missile 306
Virginia class nuclear submarine 74

General Dynamics Information Systems
AN/WLQ-4(V)1 SIGINT system 248
AN/WLR-8 EW receiver system 248

General Dynamics United Kingdom
MTSS 672
MWCSS 426

GESMA
LUNDAR sensor platform 563

Gidropribor
TEST-96 dual-role torpedo 322
USET-95 torpedo 323

Giessen de Noord, van der
Tripartite minehunter 400

Global Marine Systems
Sea Sentinel Undersea Coastal Surveillance System (UCSS) 221

Gorki
Kilo class submarine design 54

H

Hagen Division, EXIDE Nordic
CSM battery cell 89

Halifax Shipyard Ltd
Kingston class MCMV 393

Harris Acoustic Products
AN/PQS-2A sonar 542
AN/WQC-2A communication set 257

Haux-Life-Support GmbH
Flying Bell 521
Haux-Deepstar 80/C diving system 521
Haux-Medistar 1250/5.5 522
Haux-Profi-Medicom recompression chamber 522
Haux-Spacestar 1300/5.5 Dome 523
Haux-Starcom recompression chambers 523
Haux-Super-Transstar recompression chamber 524
Hydra 2000 diving simulator 524
MEDUSA diving simulator 524

Hawker Chloride Industrial Batteries *see* **Enersys Ltd**

HDW, Kiel
Circe anti-torpedo countermeasures 228
Dolphin class submarine design 41
PEM AIP fuel cell 90
TCM 2000 submarine countermeasure system 227
Type 209 submarine design 42
Type 212A design 44
Type 214 patrol submarine 46

Hermes Electronics *see* **Ultra Electronics, Canada**

Hitachi
OQS-3A/-8 sonar 147
Sugashima class minehunter/sweeper 403
Uwajima class minehunter/sweeper 403
Yaeyama class minehunter/sweeper 403

Honeywell Training & Control Systems
RUR-5A ASROC 305

Huludao Shipyard
Type 093 submarine 38

Hydrovision Ltd
Hyball remotely operated underwater vehicle 480

I

Indal Technologies
Model 15-750 variable depth sonar 137
Sonar handling equipment 137

Innova
TASSEN tactical sensor unit 506

Institute Dr Förster
Land range 557
Mobile overrun range 558
Open range 559
Stationary range 559

Institute for Maritime Technology (IMT)
Samcon 600 multi-influence mine 356

Interfloor Ltd, Hunter Division
Pro-Am/Pro-HD dry diving suits 539
PRO-CBX 450 drysuit 539
PRO-HRM 1200 rubber suit 539
PRO-VSN 1100 drysuit 539

Intermarine, Savannah
Osprey class MCMV 416

Intermarine SpA
Gaeta class minehunter 401
Huon class minehunter 392
Lat Ya class minehunter 402

International Submarine Engineering (ISE)
Aurora towfish 462
Dolphin semi-submersible 464
Dorado semi-submersible 465
HYSUB ATP25/40/150/250 ROV 465, 466
Theseus AUV 466
Trailblazer 25 ROV 467

Interspiro
Buddyphone communication system 533
DCSC diving system 533
Divator Mk II 535
Oxydive breathing apparatus 537

Iran Electronics Industries
HOD HOD 1 communication system 525
HOD HOD 2 communication system 525

Izar, Cartagena
Scorpene design of submarines 47
Segura class minehunter 409
SMYC combat control system 429

J

Jet Propulsion Laboratory
MUDSS survey system 514

Jeumont-Schneider
Electric propulsion motor 86

J & S Marine
SCTAS 182
STLS shipborne torpedo launch system 329

K

Kaman Electro-Optics Division
Magic Lantern minehunting system 456

Kangnam Corporation
Swallow class MCMV 404
Yang Yang class minehunter 405

Karachi Shipyard
MG 110 midget submarine 54

Kawasaki
Harushio class submarine design 52
Oyashio class patrol submarine 52

KBM, Kolomna
SS-N-19 Shipwreck (P-500 Granit) 294

Kelvin Hughes Ltd
CSR submarine radar 649
Electronic Chart display unit (ECDIS) 643
INTPS Integrated Navigation and Plotting System 643
Master Yeoman chart table 644
TRAC & CHART systems 644
Type 162M sonar 446
Type 1007 radar 651

Khabarovsk Yard
'Natya' class minehunter/sweeper 408

Klein Associates Inc
Series 5000 sonar imaging system 453, 500, 602
System 3000 side scan sonar 603

Kockums, Malmo
Challenger class submarine 57
Collins class submarine design 58
Gotland class submarine design 59
S-SRV rescue vehicle 77
Stirling AIP engine 94
URF rescue vehicle 77
Vastergotland A-17 class submarine design 61
Viking class submarine design 49

Kockums Naval Systems, Karlskrona
Landsort class MCMV 410
SAM remote-control minesweeping drone 411
Styrsö class MCMV 412

Kollmorgen Corporation
AN/BVS-1 electro-optic mast 281
Model 76 periscope 281
Model 86 electro-optic mast series 282
Model 90 electro-optic periscope system 282
STVTS periscope training system 620
Universal Modular Mast 278

Kolpino Yard, St Petersburg
'Lida' class minehunter 407
'Natya' class minesweeper/hunter 408

Komsomolsk
Kilo class submarine design 54

Kongsberg Gruppen ASA
Agate acoustic sweep 505
IDA command & control system 427
MASTT (MPS Action Speed Tactical Trainer) 608
MASWT (MPS Anti-Submarine Warfare Trainer) 608
MFPS minefield planning system 669
MICOS minehunting command system 428
MMSS (MPS Multibeam Sonar Simulator) 625
MSI-90U command & weapons control system 112
MSI-90U Mk 2 command & weapons control system .. 113
MSI FC tactical picture compilation and weapon designation system 113
Satyr minefield control system 429
Submarine tactical trainer 609
Terne III rocket-propelled depth charge 368

Kongsberg Simrad AS, Horten
EM 120 multibeam sonar 597
EM 121A multibeam sonar 597
Hugin 3000 AUV 477
Minesniper destructor vehicle 478
SA 950 sonar 444
SS 2450 anti-submarine warfare sonar 148

SS 9500 mine detection and avoidance sonar 445
ST 240 Toadfish sonar 149
ST 2400 anti-submarine warfare sonar 149
WINSON sonar operator unit 149, 445

Kongsberg Maritime Inc
EM 121A mapping sonar 597
SH 100 minehunting sonar 454

Kongsberg Simrad Ltd, Aberdeen
OE 0285 submarine ice operation camera 280
OE 1324 ROV camera 499
OE 2700 ROV cameras 499
OE 9020 Seahawk diver TV system 536
SRS INTO 79
SSE-launched Transponder 80
Type 2059 acoustic tracking system 431

Kongsberg Simrad Mesotech Ltd, Canada
MS 900/900D ROV sonar 591
MS 1000 ROV sonar 591
SM 2000 ROV/surveillance sonar 592

Krasnoje
Kilo class submarine design 54

Krögerwerft
Ensdorf/Kulmbach class (Type 352/333) minesweepers 398
Type 332 Frankenthal class minehunter 399

KVH Industries Inc
C-100 sensor 645
GyroTrac digital compass 646

L

L-3 Communications, East
IRR radio room 259

L-3 Communications ELAC Nautik GmbH
DSE 1 diver sonar camera 520
KE 8 hydrophone 659
KE 9 hydrophone 660
Lopas passive sonar 176
LSE 800 sonar transducer 660
Scout sonar 177
Subtas target simulator 634
UT 2000 underwater communication 254
Vanguard sonar 145
VE 5900 naval echo-sounder 642

L-3 Communications, Link Simulation & Training
Airborne ASW trainers 621
Device 14A12 ASW team tactical trainer 611
Device 14E35 acoustic operator trainer 629
Device 21A42 Trident command team trainer 611
Tactics trainer 611

L3 Communications, Ocean Systems, California
AN/AQS-13 helicopter sonar 193
AN/AQS-18 helicopter sonar 194
AN/AQS-18A helicopter sonar 194
ASLS sonar 451
EMD mine destructor 486
Helras long-range dipping sonar 195
LFATS sonar 163
TB-23 towed array 188
TSUNAMI sonar 166

Laingsdale Engineering
Samcon 600 356

Litton Marine
AN/BPS-15 submarine radar 652
VMS-ECDIS electronic chart system 647

Litton Systems Inc, Amecon Division
AN/BLD-1 DF system 247

Lockheed Martin
RO-308/SSQ-36 data recorder 582

Lockheed Martin Federal Systems, Manassas/Owego
AN/BQQ-6 sonar 185
AN/BSY-1(V) submarine combat system 118
CCSM submarine combat system 120

Lockheed Martin Laboratories, Camden
SOAS (Submarine Operational Automation System) command support software 122

Lockheed Martin Missiles & Space
ATMS track management system 589
DSRV1/2 rescue vehicles 80
UGM-96 Trident C-4 ballistic missile 297
UGM-133 Trident D-5 ballistic missile 299

Lockheed Martin Naval Electronics & Surveillance
ADS advanced deployable system 220
Air training systems 622
AN/AQS-232 (AMNS) 511
AN/BLQ-10 ESM system 247
AN/BQQ-5 sonar 185
AN/BQQ-10 ARCI system 186
AN/BSY-1(V) submarine combat system 118
AN/BSY-2 submarine combat system 119
AN/SQQ-14 sonar 450
AN/SQQ-89 surface ship ASW combat system 119
AN/SQR-19 TACTAS sonar 158
AN/SQS-53 sonar 158
AN/WLD-1 remote minehunting vehicle 484
HAS-2154 LF sonar 162
International air training systems 622
LBVDS sonar 162
Mk 6 dead reckoning tracer 646
Mk 116 ASW control system 122
MRUUV 488
Pathmaker mine warfare system 451
RUM-139A VL-ASROC 305
Sea Sentinel Undersea Coastal Surveillance System (UCSS) 221
Speed log system 647
SUBICS 900 submarine combat control system 123
TB-16 towed array 188
TB-29A towed array 188
UQQ-2 SURTASS surveillance system 167
USFCS submarine combat information and fire-control system 125

Lockheed Martin, Perry Technologies
CETUS II AUV 485
MUST Lab 488

Lockheed Martin, Tactical Defense Systems
AN/UYQ-70 ADS 654
Kanaris submarine fire-control system 108
MMC Modular Multifunction Console 654
MRCS console system 655

Lucent Technologies
AN/BQR-15 sonar 186
AN/BQR-15 9080 thin-line sonar 186
MESA Multiplexed Extended Sensor Array 576
SURTASS RDA towed array 166

Lürssen Werft
Aydin class minehunter 397
Ensdorf/Kulmbach class minesweepers 398
MJ 2000 minehunting system 400
Troika minesweeping systems 396
Type 332 Frankenthal class minehunter 399
Type M48 Bang Rachan class MCMV 398

M

Magnavox
AN/SSN-2(V) PINS integrated navigation system 431

Makeyev Design Bureau
SS-N-8 Sawfly ballistic missile 293
SS-N-18 Stingray (RSM-50 Volna) 294
SS-N-20 Sturgeon (RSM-52) 295
SS-N-23 'Skiff' (RSM-54 Sineva) ballistic missile 295
SS-NX-30 Bulava 297

MAN B & W Diesel Ltd
Valenta diesel engine 97

MARCOM Defence
Buddy through-water communicator 533
G 732 Mk II underwater telephone 265
G 733 SLUTT target 637
G 738 decoy 234
G 750 sonar 153
Sea Siren decoy system 233
Type 182/G 738 decoy 234
Type 184M/P sonar 153
Type 185/G732 Mk II throughwater communication system 265
Type 2007 sonar 182

Marine Air Systems
MAS exercise limpet mine 351

Marinette Marine Corp
Avenger class MCMV 415

Mazagon Dockyard Ltd
ATV nuclear-powered attack submarine 47

MBDA Missile Systems
Milas missile system 303
SM 39 Exocet missile 302

Mécanique Creusot-Loire
Mk 54 anti-submarine rocket 365

Military Equipment & Technologies Research
STAT-100 torpedo decoy 232

Ministry of Aerospace Industries
CSS-NX-5 (JL-2) ballistic missile 290

Mitsubishi Heavy Industries
Harushio class submarine design 52
OQS-4A hull-mounted sonar 147
Oyashio class patrol submarine 52
Type 73 lightweight torpedo 321
Type 89 torpedo 321

Monfalcone, Italy
Sauro class submarine design 51

Morfizpribor, St Petersburg
Arktika (MG-100) Arktika-M (MG-200) 181
Fixed sonar systems 219
Platina (MG-335) active/passive sonar 151
Rubikon (MGK-400) 181
Shelon dipping sonar 151

MSI-Defence Systems
AZL submarine mast 651
BASAR breathing apparatus 532
BIBS (SUBS) BU breathing unit 532
Compression chambers 533
DS25/30 naval gun system 670
FEMS minelaying system 614

MTU
396 series turbocharged diesel engine 89

N

Nautronix Helle Ltd
Model 353X communications system 535
Model 2433A beacon 661
Model 3220C two-diver telephone 535
Model 3342C diver speech unscrambler 536
Model 6280 diver-held pinger receiver 536
Model 6281 surface and diver pinger receiver 536
Pinger locating devices 661

Nautronix Ltd, North Fremantle
ATS Acoustic tracking system 422
RS5D acoustic positioning system 553
RS 910 series acoustic positioning system 553
SARA noise range 553

Naval Coastal Systems Station
Littoral mine 362

Naval Undersea Warfare Center
21UUV 482
Double Resonant Transducer (DRT) 663
LBVDS sonar 162
LDUUV 486
Manta test vehicle 487

NEC Corporation
OQR-1 towed array sonar 147
OQS series hull-mounted sonar 147
OQS-101/102 hull-mounted sonar 147

Netzler and Dahlgren
NDC 1000 machinery control 94

Newport News Shipbuilding
Cutthroat submarine test vehicle 69
Dry Deck Shelter for SDV 69
Los Angeles class nuclear submarine 69
Virginia class nuclear submarine 74

Nordic Defence Industries A/S
DAMDIC Mk 1 mine disposal charge 493

Northbend Instrumentation (Pty) Ltd
Matrix modular mines 356

Northrop Grumman Canada
AN/SQQ-504 towing condition monitor 133
OH-5001/SQS-505(V)6 simulator stimulator 624
RSM Reconfigurable Scalable Multiprocessor 667

Northrop Grumman Electronic Systems
AN/BPS-16 submarine radar 652

Northrop Grumman, Oceanic & Naval Systems
21 HS series COTS sonar 156
AN/AES-1 ALMDS 455
AN/AQS-14A, AN/AQS-14(V1) minehunting sonar 449
AN/SLX-1 MSTRAP 156, 236
AN/SQQ-28 sonar signal processing 156
AN/SQS-53 sonar 158
AN/WLR-9A acoustic intercept 187
AN/WLY-1 acoustic intercept 236
ASDS advanced SEAL delivery system 68
CCSM submarine combat system 120
Mk 50 lightweight torpedo 335
NMRS mine reconnaissance vehicle 489

SAWCS acoustic warfare system 182
SM 2000 imaging sensor 457
SPAT acoustic target 639

Novator NPO
SS-N-15 'Starfish' ASW missile 304
SS-N-16 'Stallion' ASW missile 304
SS-N-21 'Sampson' (RK-55) cruise missile 293
SS-N-27 Klub S 3M-54E cruise missile 292

NPO Mashinostroenia, Moscow
PJ-10 anti-ship missile 292
SS-NX-26 Yakhont 296

NPO Strela
PJ-10 anti-ship missile 292

O

Ocean Data Equipment Corporation
Bathy 500 recording echo-sounder 602
Bathy 2000/2000P signal processing 602
DSN-450/DSL-250 sonar speed log 645
Echo-sounder transducers 666
Neptune RSVP/CTD-1020 sound velocimeter 582

Odense Staalskipsvaerft A/S
Viking class submarine design 49

Oki Corporation
OQR-2 sonar 147

Oki Electric Industry Ltd, Tokyo
ZQQ series submarine sonars 178

Opgal Optronic Industries
Nite Eye thermal imager 278

Optech Inc
Hawk Eye LIDAR mine detection system 455
SHOALS-Hawkeye airborne lidar bathymeter 591

Orca Instrumentation
GIB-FT tracking range 554

Orcatron Communications Ltd
Scubaphone 515
Scubaphone Vox 515
Special Diver Unit (SDU) 518
Subphone 518
Subphone Model 2190 518

P

PAG Automasjon A/S
MoDive dive monitoring system 526

Patria Finavitec Oy
Sonac AMS acoustic mine sweep 503
Sonac PFA Passive Fixed Array sonar system 217
Sonac PTA Passive Towed Array system 137
TSS towed sound source 633

Pendik Naval Shipyard
Aydin class minehunter 397

Pennsylvania State University
Seahorse AUV 491

Perry Slingsby Systems
EL050(2056), EL057, EL067 series deep-phone underwater telephones 541
LR 5 rescue vehicle 78

Peterson Builders Inc
Avenger class MCMV 415

Petrozavodsk Shipyard
Sonya class coastal minesweeper 409

Polatomic
Helium magnetometer 286

Q

QinetiQ
Mermaid Marine Environmental Model and Integrated Database 587
NASP non-acoustic sensor platform 482
OCIDAS-1 Ocean Intervention and Data Assimilation System, Phase 1 588
Research and development 680
SCTAS 182

R

Rafael
Adaptive noise cancellation 573
ATC-1 torpedo decoy 229
ATC-2 torpedo decoy 230
ATDS torpedo defence system 230
CORIS-TAS towed array sonar 146
C-Pearl-S ESM/ELINT system 243
DIVEGUARD Mk 2 526
LESCUT torpedo decoy 228
Scutter expendable torpedo decoy 230
SUBSCUT torpedo decoy 229

Raytheon Company, Naval & Maritime Systems
AN/SQQ-89(V) trainer 628
CCS Mk 2 submarine integrated weapon control system 121
DS1200 series trainers 629
LS-4096 laser imaging system 456
Mk 30 Mod 2 ASW training target 638
TSMT FES shore-based trainer 631

Raytheon Systems Company
ALISS sweep system 510
AMNS 511
AN/AQS-20 side-scan sonar 449
AN/AQS-20/X side-scan sonar 450
AN/AQS-22 ALFS Airborne Low-Frequency Sonar 190
AN/ASQ-81(V) ASW magnetometer 285
AN/ASQ-208(V) MAD system 286
AN/BQQ-5 sonar 185
AN/BQS-13 (BQR-24) sonar 186
AN/SLQ-48 MNS mine disposal system 483
AN/SQQ-32 sonar system 443
AN/SQS-56/DE 1160 sonar 159
Combat Control System Mark 2 (CCS Mk 2) 121
CCSM submarine combat system 120
DE 1160(I) sonar 160
DE 1164 sonar 160
DE 1167 sonar 161
DE 1191 sonar modernisation 161
DMSS2000 LF sonar system 146
FACDAR degaussing/acoustic range 563
Flextensional transducers 663
Helium-3 ASW magnetometer 286
HOTTorp training torpedo 333
ISCWS integrated system 121
Kingfisher sonar 162
LSM Littoral sea mine 362
Mk 37 Mods 1 and 2 torpedoes 333
Mk 46 lightweight torpedo 333
Mk 48 ADCAP torpedo 334
Mk 50 lightweight torpedo 335
Mk 54 Lightweight Hybrid Torpedo (LHT) 336
MSMS magnetic signature measurement system 560
NT 37 C/F torpedo 336
NT 37G Seahuntor torpedo 337
RAMICS mine clearance system 514
Sea Sentinel Undersea Coastal Surveillance System (UCSS) 221
Solid-State Transmitter (SST) 166
UGM-109 Tomahawk cruise missile 297

Raytheon Systems Training Division
MWSIM mine warfare simulator 615

RDM Submarines
Walrus class submarine 53

Reson Inc
SeaBat 6012 ROV sonar 437
SeaBat 8100 mine avoidance sonar 437
SeaBat 8101 echo-sounder 592
SeaBat 8111 echo-sounder 593
SeaBat 9001 echo-sounder 593
SeaBat 9002 echo-sounder 593
SeaBat 9003 echo-sounder 594
Transducers & hydrophones 664

Reson Offshore Ltd
SeaBat 6012 ROV sonar 437
SeaBat 8100 mine avoidance sonar 437
SeaBat 8101 echo-sounder 592
SeaBat 8111 echo-sounder 593
SeaBat 9001 echo-sounder 593
SeaBat 9002 echo-sounder 593
SeaBat 9003 echo-sounder 594
Transducers & hydrophones 664

Reson Systems A/S
SeaBat 6012 ROV sonar 437
SeaBat 8100 mine avoidance sonar 437
SeaBat 8101 echo-sounder 592
SeaBat 8111 echo-sounder 593
SeaBat 9001 echo-sounder 593
SeaBat 9002 echo-sounder 593
SeaBat 9003 echo-sounder 594
Transducers & hydrophones 664

Rheinmetall De Tec
265 R exercise fuze 494
DM 19 A3 explosive minesweeping cutter 504
DM 59/DM 69 Remote-Controlled Explosive Cutter (RCEC) 494
DM 119/DM 129 Remote-Controlled Explosive Cutter (RCEC) 494
DM 211 and 221 charges 366
DM 1002-3009 A2-A3 remote-controlled fuze 495
E 67/E 67 Mod 1 firing transmitter 495
MCOT 613
ROV simulator 614

Romtehnica
ASW rocket 368
GIS-1 grenade 368
MAD-1 anti-invasion mine 351
MMA influence mine 351
MMMCA contact mine 352
MP-2 limpet mine 352

Rosboronexport
MSHM continental-shelf mine 354
PMK-1 rocket-powered torpedo 355

Rubin
Kristall 93

RUMIC Ltd
LR 5 DSRV 78
Scorpio 45 rescue vehicle 79

S

Saab Bofors Dynamics AB
Alecto ASW system 369
ASW-601 system 370
BDC 103 underwater charge 370
BGM 100 Rockan mine 357
BGM 600 mine 358
BGM 601 Bunny mine 358
BMM 80 mine 359
BMP 200 data acquisition platform 564
BMP 201 measuring platforms 565
BMP 202 data acquisition platform 565
Double Eagle mine disposal ROV Mk II 479
Double Eagle mine disposal ROV Mk III 479
IBIS VII PVDS sonar system 473
MDC 605 mine disposal charge 498
MS 106 mechanical sweep 507
SCC-200/ISCMMS steering/management systems 94
Terfenol-D transducer 660
T Mk 9 Mod explosive cutter 507
Torpedo propulsion system 324
Tp 45 (43X2) torpedo 324
Tp 46 Grampus torpedo 325
Tp 62/Torpedo 2000 326
Tp 617 torpedo 326
Type 375 rocket system 370
UDAS data acquisition 566

Saab Tech Systems AB
9 MJ 400 minehunting system 429
Mine Warfare Command Support System (MWCSS) ... 425
NEDPS (NIBS) submarine action information and fire-control system 113
Sesub 940A submarine combat system 114

SAES, Cartagena
Mila-6B limpet mine 356
MO-90 moored mine 357
SICLA acoustic system 669
Solarsub towed array sonar 182
STTS simulator 609
SVB 93

Safare Crouzet SA *see* **Thales Safare**

Safe Barrier System AB
Safe Barrier intruder security system 670

SAFT
Primary batteries 314

SAGEM
Attack Periscope (APS) 274
CSR submarine radar 649
Infra-red Mast (IMS) 274
Minicin inertial navigation system 641
Optoradar Mast (OMS) 274
PL 13 control console 88
Submarine non-penetrating mast (SMS) 275
Search electro-optic Periscope (SPS) 275
SIGMA 40 XP 641
SS Mk 1 control console 88
ST 5 attack periscope 276
Type J periscope 276

SAIC (Science Applications International Corporation)
CSDS coastal surveillance display system 218
Swimmer detection sonar 222
Underwater Sentry 223

Saiv AS
SD204 STD/CTD 580

SAM Marine Electronics GmbH
Alpha Doppler log 642
Component Range 557
DEG-CAD modelling system 558
Deg Comp Mod 1 degaussing system 569
DESO 14/25 echo-sounders 595
Fansweep 20 596
Hydromap software system 596
Hydromap Susy software system 596
Hydrosweep DS-2 sonar 596
Hydrosweep MD-2 sonar 597
Mora Sym ranging system 558
Parasound survey system 597

SEA Hydro Products
Hydrocom diver speech processor 544

SEI SpA
CM101-CAP countermining charge 495
CM102-ECP explosive cutter 496
CM104-CAP countermining charge 496
CM106-ECMO countermining charge 497
DC 101 anti-submarine charge 366
DC 103 anti-intruder defence 367
Exercise mines 350
MN 102 Murena seabed mine 348
MN 103 Manta mine 349
MN 105 Seppia mine 350
MP-80 sea mine 350
MR-80 sea mine 350
MWS minefield planning support system 427
SLD 302-Airone anti-intruder defence 367
Target detection device 347

SEMT-Pielstick
12 PA4 series diesel engine 85

Sensytech Inc
AN/SLQ-25A 236
Mk 62, 63, 64 and 65 Quickstrike series mines 363

SFB Informatica
KAFS submarine combat information and fire-control system 115

Ship Analytics
ASTT Action Speed Tactical Trainer 610
Passive acoustic analysis trainers 630
Sonar simulator 630

Siemens AG
ELMA magnetic sweep 505
Nautos platform management system 91
PEM AIP fuel cell 90
Permasyn electric motor 91

Signature Industries Ltd
SARBE 10 personal locator beacon 79

Sippican Inc
Mk 39 EMATT target 639
SSXBT/SSXSV Bathythermograph 582
SSXCTD submarine-launched probe 582
Type 2090/IBIS Integrated Bathy Information System 585
XBT/XSV Bathythermograph system 583
XCP profiler 583
XCTD expendable conductivity, temperature and depth profiling system 584

Sippican Inc, Spears Communications Group
BWA Buoyant Wire Antenna 257
HF communications antenna 258
Mast antenna 259
MFM antenna 259
Towed communications buoys 269
VLF/LF antennas 260

Smolensk Aircraft Plant
SS-N-14 'Silex' ASW torpedo 304

Solutions from Silicon Pty
MINTACS software 422

Sonardyne Ltd
DME acoustic depth measuring 498
ROV/Diver Trak 499
ROV-Homer 499
ROV-TRAK 499
Type 7986 transponder 673
UHDLS Under Hull Diver Location System 542

Southern Oceanics (Pty) Ltd
600 series divers' heaters 527
BH series carbon dioxide scrubbers 527
LG 360 wet bell diving system 527
LM series recompression chambers 528
LS 370 wet bell dive system 528
Offshore series recompression chambers 529
RD 2300 hyperbaric chamber complexes 530
SM-5 containerised dive system 530
SM-5 D12 escape & rescue system 76
TC 1000 transport chamber 531
TC 1150 transport chamber 531

Southwest Research Institute
AU-506 ESM antenna 249

Space and Naval Warfare Systems Center
Marine Mammal System (MMS) 513

Sparton Corporation, Electronics Division
AN/SSQ-36B bathythermograph 578
AN/SSQ-41B sonobuoy 204
AN/SSQ-41N sonobuoy 204
AN/SSQ-53E sonobuoy 198
AN/SSQ-53F sonobuoy 198
AN/SSQ-57B sonobuoy 204
AN/SSQ-57M sonobuoy 204
AN/SSQ-57SPC sonobuoy 205
AN/SSQ-58B sonobuoy 205
AN/SSQ-62 series DICASS sonobuoy 199
AN/SSQ-77C (VLAD) sonobuoy 200
AN/SSQ-86(XN-1) downlink communication sonobuoy 268
SUS Mk 84 communications device 268

Spears Communications Group *see* **Sippican Inc**

Spirotechnique I C, La
DC 55 breathing apparatus 519

SSPA Maritime Consulting AB
SonTak tactical decision aid 586

State Scientific and Production Enterprise
S-3V depth charge 369

Stelkon
Samcon 600 356

Stenmar SonaVision Ltd
AS360 ROV sonar 445

STN ATLAS Elektronik GmbH
AGUS ASW trainer 605
AIS 11 sonar 442
AMNS 511
ASA 92 series towed array sonar 144
ASO 83-86 series sonars 145
ASO 90 series sonar systems 144
AWU 206A SCTT attack trainer 605
CIC simulator 606
CSU 3-4 sonar 175
CSU 83 sonar system 175
CSU 90 sonar system 175
DM 51 anti-invasion mine 346
DM 61 influence mine 346
DSQS-11 M sonar 442
DSQS-21 (ASO 83-86) series sonars 145
FAS 3-1 sonar 176
HNSAS simulator 606
Hydroacoustic coastal range 218
ISUS 90 integrated combat system 107
MAS mine avoidance sonar 442
MCM 2000 mine countermeasures weapon system 424
MJ 2000 minehunting system 400
MSC Mine warfare Support Centre 668
MWS 80 minehunting weapons system 425
NATAT team trainer 606
NVC (Navigation and Vessel Control) equipment 424
Permanent Magnet Motor 314
Pinguin B3 ROV mine disposal system 471
PRS 3-15 sonar 177
PSU 83 sonar 177
SCOTT submarine combat trainer 606
SCS 617
SCTT submarine command team trainer 607
Seafox mine disposal vehicles 472
Seapike anti submarine weapon 314
Security Eye sonar system 178
Seehecht (DM2A3/4) torpedo 315
Shore-Based Information Centre 668
SST 4 torpedo 316
Submarine control simulator 617
SUT torpedo 316
TAS 90 towed array sonar 145, 178
TCCR command and control system 424
TCD Tactical Command and Documentation equipment 424
Troika minesweeping systems 396

Stocznia Marynarki Wojennej
Project 257 minesweeper (Kormoran) 407

Strachan & Henshaw Ltd
COMTASS towed array system (handling system) 152
SCTAS 182
Submarine signal and decoy ejectors 234
Weapon handling and launch system 332

Sudomekh
Kilo class submarine design 54

Sunlight Company, Athens
Batteries 92

Systems Engineering
DIPS information & positioning system 534

T

Taganrog
Platina (MG-335) active/passive sonar 151

Technicatome-Jeumont SA, Nantes
Electric motor 86
Magtronic electric motor 86

Techtest Ltd
15-300 series submarine HF system 254

Telephonics
AN/URR-76 VLF receiver 257

Terma Elektronik A/S
Scanter navigation radars 649
TACTICS combat information systems 103

Texas University
AN/WQX-2 sonar 220

Thales Airborne Systems
DR 2000 U ESM receiver 241
DR 3000 U ESM system 241
DR 4000 U ESM system 241

Thales Avionics
MAD Mk III detector 285

Thales Communications Ltd
RICE 10 internal communications 255

Thales Nederland
PHS-32 sonar 148
PHS-36 sonar 148
SEWACO VIII weapon control system 111
SIASS-1 and -2 sonars 179
SINBADS submarine integrated battle and data system 112
ZW07 submarine radar 650

Thales Optronics
190 mm electronic periscopes (CK038/CH093) 279
254 mm electro-optic periscopes (CK043/CH093) 279
CM010 series periscopes 280
Compact periscopes 279

Thales Safare
ERUS MIL.COM underwater communications 519
ESAX-2A sonar locator beacon 659
LORES 667
QSUA-4A acoustic noise monitoring system 573
SNM 40/120 monitoring system 573
TULIP Net communication system 253
TUUM-4 underwater multifrequency telephone 263
TUUM-5 underwater emergency telephone 264
Velox M7 sonar intercept receiver 174
Velox M8 sonar intercept receiver 174

Thales Sensors Ltd
Manta ESM system 244
Porpoise ESM equipment 245
Sealion ESM system 245
UAP family of ESM systems 246

Thales Special Products
PRS-02/Pathfinder 585

Thales Training & Simulation
Machinery Control Trainer (MCT) 617
Submarine Command Team Trainer (SCTT) 610
Submarine Control Simulator (SCS) 618
Submarine Control Trainer (SCT) 618
Vanguard simulator 619

Thales Underwater Systems, Australia
Acute 9000 underwater telephone unit 263
Kariwara towed thin-line array 132
Narama towed thin-line array 132
Petrel 5425 133
RASSPUTIN sonobuoy 197
Wayamba MCM vehicle 462

Thales Underwater Systems, France
Acoustic ranges 554
Albatros/TMS 4530 torpedo alert system 138
AN/AQS-22 ALFS Airborne Low-Frequency Sonar 190
AN/SQQ-32 sonar system 443
Anaconda/TSM 2980 TACTAS system 139
Angler towing and handling systems 139

Calas ASW training target vehicle 633
CAPTAS 20/TSM 2651/2652 sonar 139
CAPTAS Mk 2 UMS 4229/4249 Captas Mk 2 139
Diodon/TSM 2630 sonar 140
DLT-D3 submarine torpedo fire-control system 103
DSBV 61B sonar 140
DSBV 62C sonar 141
DSUV 62A/62C-TSM 2933/Lamproie sonar 172
DUAV-4 helicopter sonar 189
DUAV-4 helicopter sonar, upgraded 189
DUBA 25/TSM 2400 sonar 141
DUBM 21B/TSM 2021 sonar 438
DUBM 41B (IBIS 41)/TSM 2050 sonar 438
DUBM 42 (IBIS 42) sonar 439
DUBV 23D/UMS 4110CL sonar 141
DUBV 43B/C sonar 141
DUUX-5 Fenelon sonar 173
EVEC 20 data handling system 422
FLASH dipping sonar 189
Gudgeon sonar/TSM 2362 surveillance sonar 142
HS 12 helicopter sonar 190
HS 312 ASW system 190
IBIS 41 minehunting sonar system 438
IBIS 42 mine detection sonar system 439
IBIS 43 mine surveillance system 439
IBIS systems 423
IBIS VII PVDS sonar system 473
Impact MU 90 torpedo 318
INCA Interactive classification aid 142, 173, 208
Lamproie sonar/TSM 2933 172
Magnetic ranges 557
Magnetic treatment systems 569
MIR 2000 ranging system 563
SADANG sonobuoy signal processing and display system 208
Salmon sonar/TSM 2640 system 142
Sea Defender/TMS 4550 227
Seafalcon 5 echo sounder 594
Seafalcon 11 echo sounder 595
SLASM sonar system TSM 2670 142
SLAT underwater warfare system 228
Spherion B sonar/TSM 2633 143
Swan towing and handling systems 143
Sygame audio training 625
Symen sonar training 625
TMS 2000 COTS-based processors 208
TMS 4530 Albatros torpedo alert 138
TMS 4550 Sea Defender 227
TMS 9001 Sygame 625
TSM 2021 sonar 438
TSM 2022 Mk I/II: minehunting sonar system 440
TSM 2022 Mk III Family sonar systems 440
TSM 2023N sonar 441
TSM 2050 sonar 438
TSM 2054 sonar 441
TSM 2055 Fenelon (DUUX-5) 172
TSM 2061 tactical system 423
TSM 2072 data handling/weapon control system 106
TSM 2233 sonar system 173
TSM 2253 sonar 173
TSM 2362 Gudgeon surveillance sonar 142
TSM 2400/DUBA 25 sonar 141
TSM 2630 Diodon sonar 140
TSM 2633 Spherion B sonar 143
TSM 2640 Salmon sonar system 142
TSM 2932 sonar 141
TSM 2933 Lamproie towed array 172
TSM 2980 TACTAS system 139
TSM 5152A, 5152B transmitter/receivers 263
TSM 5421B sonar 174
TSM 5423 sonar 174
TSM 5425 Petrel sonar 133
TSM 5740/5750 Doppler log 642
Type 209 simulator 605
Type 2019 intercept sonar 182
UMS 4229/4249 Captas Mk 2 139

Thales Underwater Systems, United Kingdom
Acoustic countermeasures 234
AQS-901 sonobuoy processing system 209
AQS-903/AQS-930 series processing systems 210
AS 2105 sonar stimulators 626
AS 2107 sonar trainer 626
AVXD Submarine SATCOM multifunction antenna 254
CHIP Concurrent High-speed Integrated Processor 152
COMTASS towed array system 152
CRISP acoustic analyser 211
ECB-680(1) communications buoy 267
Honeypot beacon 643
Magnetic signature measurement 560
Minehunting performance prediction system 587
MSK 5030 demodulator 255
Noise ranges 555
Onboard sonar trainer 626
PMS 26 sonar 153
RTOF communications buoy 267
SAINT training system 627
Sea Guardian sonar system 220
Sea Scout minehunting sonar 445
Sonar principles trainer 628
SPUD analytical system 672
Submarine communications and NAVSTAR antenna 256
Submarine communications mast 256
Transducers 661
Type 193M/193M Mod 1 sonar 446
Type 2016 sonar 154
Type 2020 submarine sonar 183
Type 2026 sonar 183
Type 2031Z sonar 155
Type 2046 sonar 184
Type 2050 sonar 155
Type 2054 sonar 184
Type 2069 sonar 192
Type 2074 sonar system 184
Type 2076 sonar 185
Type 2087 towed array sonar 155
Type 2093 sonar 447
Type 2193 sonar 448
VIMOSPlus monitoring system 575

THORN EMI (Australia) Ltd
Mulloka sonar 132

Thyssen Nordseewerke
Dolphin class submarine design 41
TR 1700 (Santa Cruz) series submarine designs 42
Type 201 Ula class design 47
Type 212A patrol submarine 44

TNO
Scientific and technological research 677
Sea Dragon submarine simulator 607
Socrates towed acoustic underwater source 636

Tod, W & J
Acoustic tiles 574
Sonar domes 153

Triathlon Inc, Richmond, BC
Canadian minehunting system 462

Triton Elics International Inc
ISIS sonar image processing system 451

TRW
SOSUS fixed sound surveillance system 222

Typhoon International Ltd
New Concept drysuit 536

U

UDS International
SUBTICS submarine tactical integrated combat system 104

Ultra Electronics, Dartmouth, Canada
AN/SSQ-36B bathythermograph 578
AN/SSQ-53D(2) sonobuoy 197
AN/SSQ-53D(3) sonobuoy 198
AN/SSQ-53E sonobuoy 198
AN/SSQ-53F sonobuoy 198
AN/SSQ-62 series DICASS 199
AN/SSQ62RO sonobuoy 200
AN/SSQ-77C (VLAD) sonobuoy 200
AN/SSQ-110B sonobuoy 200
AN/SSQ-536G bathythermal buoy 577
AN/SSQ-553G sonobuoy 197
AN/SSQ-937C bathythermal buoy 577, 579
Barrel Stave Projector (BSP) 657
Depth-compensated RingShell Projector (RSP) 658
Free Flooded Ring (FFR) 657
Horizontal Projector Array (HPA) 657
LFHUSS acoustic sound source 137
Resonant Pipe Projector (RPP) 657
Sonar Research Projector (SRP) 659
SUBTASS towed array sonar 172

Ultra Electronics, Flightline Systems, NY
AN/ARN-146 sonobuoy receiver 212
AN/ARR-75 receiver 212
AN/ARR-84 sonobuoy receiver 213
AN/ARR-502 sonobuoy receiver 213
R-624(V) receiver 213
R-1651/ARA receiver 214
VHF sonobuoy receiver 214

Ultra Electronics, Loudwater
SWIM weapon interface equipment 118
Torpedo launch controller 118

Ultra Electronics Ocean Systems, Weymouth
ADC Mk 2/3/4 countermeasures 235, 236
ATARS transportable acoustic range 574
MFS-7000 sonar 146
RASAT sonar target 636
Sonar 3000 sonar (RN Type 2053) 600
Sonar 3010/T (Minescan) sonar 449
Sonar 3050 (Widescan) sonar 600
SUBSCUT torpedo decoy 229
TONES Transportable Overside Noise Evaluation System 574
Type 2031Z sonar 155
Type 2034 sonar 600
Type 3050 (Widescan) 600
Ultrascan 5000 sonar 601
Wideline 200 series recorder 674
Widescan III sonar 600

Ultra Electronics Power Magnetics & Electronic Systems Ltd
3-Axis magnetic sensors 498
ATAHS heading sensor 670
EFS 1 electric field sensor 671
EFS 3 electric field sensor 671
FACDAR degaussing/acoustic range 563
FEMAP magnetic analysis 570
LNS4-3 magnetic sensor 360
Magnetic gradient sensors 671
MUWS sensors 566
OBDG Onboard Degaussing System 570
SMARTTRAK acoustic tracking 555
SoundTrak series target simulator Type 2058 638
TRANSmag range 566
Type 2019 intercept sonar 182
Type 2082 intercept sonar 185
UDAMS 556
VMAG 3-axis magnetic sensor 673

Ultra Electronics Sonar and Communication Systems, Greenford
ALFEA SSQ-926 sonobuoy 201
AN/ARR 970-AN/ARR-502 series sonobuoy telemetry receivers 209
AQS 970/971 sonobuoy acoustic processing system 210
ARR-502 series sonobuoy telemetry receivers 209
ARR-970 sonobuoy telemetry receiver 211
Bandfish expendable torpedo countermeasures system 235
LEAD torpedo countermeasure effector 233
MEAD/MSCAD torpedo countermeasure effector 233
RTOF 255
SSQ-906G LOFAR sonobuoys 201
SSQ-926 ALFEA sonobuoy 201
SSQ-937C bathythermal buoy 579
SSQ-954C/E DIFAR sonobuoy 201
SSQ-955A/C HIDAR sonobuoy 202
SSQ-963C/D CAMBS sonobuoy 202
SSQ-981E Barra sonobuoy 203
Type 2066 Bandfish 235
Type 2090/IBIS Integrated Bathy Information System 585
Type R605 receiver 211
Type R612 receiver 212

Umoe Mandal
Alta/Oksoy classes MCMV 405

UnderSea Sensor Systems
ADAR AN/SSQ-101 206
AN/SSQ-53D(3) sonobuoy 198
AN/SSQ-53E sonobuoy 198
AN/SSQ-53F sonobuoy 198
AN/SSQ-57B sonobuoy 204
AN/SSQ-62 series DICASS sonobuoy 199
AN/SSQ-62RO 200
AN/SSQ-110B sonobuoy 200
AN/SSQ-937C 579

United Defense, Armaments Systems
Focused pressure wave mine neutralisation 511
SVTT Mk 32 torpedo launcher 337

For details of the latest updates to *Jane's Underwater Warfare Systems* online and to discover the additional information available exclusively to online subscribers please visit
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Universal Shipbuilding Corporation, Tsurumi
Sugashima class minehunter/sweeper 403
Uwajima class minehunter/sweeper 403
Yaeyama class minehunter/sweeper 404

University of Hawaii
SAUVIM AUV 490

US Naval Surface Warfare Center
Mk VIII SEAL delivery vehicle 70

V

Vallon GmbH
MW 1630/MW 1630B mine detectors 525

van der Giessen de Noord see **Giessen de Noord, van der**

VHB Industriebatterien GmbH
Double-Decker submarine battery 89

Vladivostok Shipyard
Sonya class coastal minesweeper 409

Vodtranspribor
Arktika (MG-100), Arktika-M (MG-200) 181
Feniks (MG-100, Feniks-M (MG-10M) 181
Rubikon (MGK-400) 181
Shelon dipping sonar 151

Vosper Thornycroft
Sandown class minehunter 413

W

Whitehead Alenia Sistemi Subacquei (WASS)
A184 heavyweight torpedo 319
A244/S torpedo 317
ACTs 101A loop simulator 621
ATS series control systems 108
B515 torpedo launching system 318
Black Shark heavyweight torpedo 320
BSS mobile target 635
C303/C303/S torpedo countermeasures 231
C309 torpedo countermeasures 232
C310 torpedo countermeasures 232
Circe anti-torpedo countermeasures 228
CTS 106 artificial target 635
DMSS2000 LF sonar system 146
Impact MU 90 torpedo 318
MDS mine disposal system 475
MIN Mk 2 ROV mine disposal system 475
MIN Mk 2 ROV sonar 444
MIST torpedo target 635
ORACOM torpedo countermeasures 668
PANOR acoustic range 554
PTR tracking range 555
PUAPS acoustic positioning system 555
SLAT anti-torpedo warfare system 228
SNA-2000 sonar system 146
SPS115 109
SQQ-14IT sonar 444
STS series control systems 109
TBI torpedo board interface 111
TCU torpedo launching system 111
Underwater surveillance system 219

Woods Hole Oceanographic Institute
SAHRV hydrographic reconnaissance 490

Y

Yugoimport–SDPR
M66 mine 355
M70 mine 355
M71 mine 356

Yukdaeso-ri Shipyard
Yugo class midget submarine 53

Z

Zeiss Optronic GmbH
OMS 100 optronics mast 276
SERO 14 search optronics periscope 277
SERO 15 modular attack periscope 277
SERO 400 STAB modular periscope system 278

Zvezda
APR-2E lightweight torpedo 321

Alphabetical index

To help users of this title evaluate the published data, *Jane's Information Group* has divided entries into three categories.
NEW ENTRY Information on new equipment and/or systems appearing for the first time in the title.
VERIFIED The editor has made a detailed examination of the entry's content and checked its relevance and accuracy for publication in the new edition to the best of his ability.
UPDATED During the verification process, significant changes to content have been made to reflect the latest position known to *Jane's* at the time of publication.
Items in italics refer to entries which have been deleted from this edition.

3-Axis magnetic sensors ... 498
3M-10 (SS-N-21 Sampson/RK-55 Granat) ... 293
3M-54E (SS-N-27) Klub S cruise missile ... 292
9 MJ 400 minehunting system ... 429
12 PA4 series supercharged diesel engine ... 85
15-300 series submarine HF system ... 254
21 HS series COTS sonar ... 156
21 HS-WB series bistatic sonars ... see juws.janes.com
21UUV ... 482
65-73/-76 ASV torpedoes ... 321
265 R exercise fuze ... 494
396 series turbocharged diesel engine ... 89
600 series diver's heaters ... 527
921-A ESM equipment ... 241

A

A184 Mod 3 heavyweight torpedo ... 319
A244/S torpedo ... 317
AA34030 sonobuoy command transmitter ... 209
ABLO36 underwater telephone ... 265
Acoustic antenna ... 505
Acoustic countermeasures (Thales UK) ... 234
Acoustic ranges (Thales) ... 554
Acoustic Support Function (ASF) ... 586
Acoustic tiles ... 574
Acoustic Tracking System (ATS) ... 422
ACTs 101A ... 621
ACTS Astute class training service ... 617
Acute 9000 underwater telephone unit ... 263
Adaptive noise cancellation ... 573
ADAR SSQ-101 sonobuoy ... 206
ADC Mk 1 countermeasures ... 235
ADC Mk 2/4 countermeasures ... 235, 236
ADC Mk 3 countermeasures ... 235
ADF system ... 250
ADS advanced deployable system ... 220
Agate acoustic sweep ... 505
Agosta class submarine design ... 39
AGUS ASW trainer ... 605
Air training systems ... 622
Airborne ASW trainers ... 621
AIS 11 sonar ... 442
Albatros/TMS 4530 torpedo alert ... 138
Alecto ASW system ... 369
ALFEA sonobuoy ... 201
ALISS sweep system ... 510
Alkan launchers ... see juws.janes.com
ALP-365 Flexi-Pinger ... 662
Alpha Doppler log ... 642
ALST sonar transponder ... see juws.janes.com
Alta class MCMV ... 405
AMAS system ... 501
AMNS mine neutralising system ... 511
Amur class submarine (Project 1650) ... 56
AN/37U-1 mechanical sweep system ... 510
AN/AES-1 ALMDS ... 455
AN/ALQ-219 SWIMS minesweep system ... 511
AN/AQH-4(V)2 system ... 192
AN/AQH-9 system ... 192
AN/AQH-11 system ... 193
AN/AQS-13 helicopter sonar ... 193
AN/AQS-14A, AN/AQS-14(V1) minehunting sonar ... 449
AN/AQS-18 helicopter sonar ... 194
AN/AQS-18A helicopter sonar ... 194
AN/AQS-20 side-scan sonar ... 449
AN/AQS-20/X side-scan sonar ... 450
AN/AQS-22 ALFS–Airborne Low-Frequency Sonar ... 190
AN/ARN-146 sonobuoy receiver ... 212
AN/ARR-75 sonobuoy receiver ... 212
AN/ARR-78(V) sonobuoy receiving system ... 212
AN/ARR-84 sonobuoy receiver ... 213
AN/ARR-502 sonobuoy receiver ... 209, 213
AN/ARR-970 series receiver ... 209
AN/ASQ-81(V) ASW magnetometer ... 285
AN/ASQ-208(V) MAD system ... 286
AN/ASQ-504(V) AIMS system ... 285
AN/BLD-1 DF system ... 247
AN/BLQ-10 ESM system ... 247
AN/BLQ-11 LMRS mine reconnaissance vehicle ... 483
AN/BPS-15 submarine radar ... 652
AN/BPS-16 submarine radar ... 652
AN/BQQ-5 sonar ... 185
AN/BQQ-6 sonar ... 185
AN/BQQ-10 sonar ... 186
AN/BQR-15 sonar ... 186
AN/BQR-15 9080 sonar ... 186
AN/BQS-13 sonar ... 186
AN/BQS-14A submarine sonar ... see juws.janes.com
AN/BRD-7 DF system ... 248
AN/BRR-6 submarine-towed buoy communications antenna ... 267
AN/BRT-6 communications system ... 267
AN/BSY-1(V) submarine combat system ... 118
AN/BSY-2 advanced submarine combat system ... 119
AN/BVS-1 electro-optic mast ... 281
AN/FQR-503 towed array mission simulator ... 623
AN/PQS-2A sonar ... 542
ANS ... see juws.janes.com
AN/SLQ-25A Nixie countermeasures ... 236
AN/SLQ-48 MNS mine disposal system ... 483
AN/SLQ-53 sweep system ... 510
AN/SLX-1 MSTRAP ... 156, 236
AN/SQQ-14 sonar ... 450
AN/SQQ-28 sonar signal processing ... 156
AN/SQQ-32 sonar system ... 443
AN/SQQ-89 integrated ASW combat system ... 119
AN/SQQ-89(V) trainer ... 628
AN/SQQ-504 towing condition monitor ... 183
AN/SQQ-T1 sonar training set ... 629
AN/SQR-17A signal processor ... 157
AN/SQR-18A(V) TACTAS sonar ... 157
AN/SQR-19 TACTAS sonar ... 158
AN/SQR-501 CANTASS towed array sonar system ... 134
AN/SQS-35 sonar ... 158
AN/SQS-53 sonar ... 158
AN/SQS-56/DE 1160 sonar ... 159
AN/SQS-510(V) sonar system ... 134
AN/SSN-2(V) PINS ... 431
AN/SSQ-36B bathythermograph ... 578
AN/SSQ-41B sonobuoy ... 204
AN/SSQ-41N sonobuoy ... 204
AN/SSQ-53D(2) sonobuoy ... 197
AN/SSQ-53D(3) sonobuoy ... 198
AN/SSQ-53E sonobuoy ... 198
AN/SSQ-53F sonobuoy ... 198
AN/SSQ-57B sonobuoy ... 204
AN/SSQ-57M sonobuoy ... 204
AN/SSQ-57SPC sonobuoy ... 205
AN/SSQ-58B moored sensor buoy ... 205
AN/SSQ-62 series DICASS sonobuoy ... 199
AN/SSQ-62RO sonobuoy ... 200
AN/SSQ-77C (VLAD) sonobuoy ... 200
AN/SSQ-86(XN-1) downlink communication sonobuoy ... 268
AN/SSQ-110B sonobuoy ... 200
AN/SSQ-536G bathythermal buoy ... 577
AN/SSQ-553G sonobuoy ... 197
AN/SSQ-937C bathythermal buoy ... 577, 579
AN/SSQ-801B Barra sonobuoy ... see juws.janes.com
AN/UQN-4 sonar sounding set ... 601
AN/UQN-5 SANS swimmer area navigation system ... 543
AN/URR-76 VLF receiver ... 257
AN/UYQ-65 data processing and display set ... 653
AN/UYQ-70 Advanced Display System (ADS) ... 654
AN/UYQ-501(V) Shinpads display ... 653
AN/UYS-503 sonobuoy processor ... see juws.janes.com
AN/UYS-504 COTS sonobuoy processor ... 207
AN/WLD-1 remote minehunting vehicle ... 484
AN/WLQ-4(V)1 SIGINT system ... 248
AN/WLR-8 EW receiver system ... 248
AN/WLR-9A acoustic intercept ... 187
AN/WLY-1 acoustic intercept ... 236
AN/WQC-2A communication set ... 257
AN/WQX-2 sonar ... 220
AN/WSQ-6 series mini-buoy ... see juws.janes.com
AN/WSQ-11 torpedo defence system ... 237
Anaconda/TSM 2980 TACTAS system ... 139
Angler towing and handling systems ... 139
ANS Ambient Noise Sensor ... see juws.janes.com
AP-4 acoustic minesweep ... 504
APR-2E lightweight torpedo ... 321
APS Attack Periscope ... 274
AQQ-T501 tactical acoustic trainer ... 623
AQQ-T502 training system ... 624
AQS-901 processing system ... 209
AQS-902/AQS-920 series processing systems ... see juws.janes.com
AQS-903/AQS-903A series processing systems ... 210
AQS 970/971 sonobuoy acoustic processing system ... 210
Aquashuttle Mk III data acquisition ... 598
AR-700(S)5 ESM and direction-finding system ... 249
AR-900 ESM and direction-finding system ... 249
Archerfish self-propelled MCM munition ... 480
ARCS AUV ... see juws.janes.com
ARR-502 series sonobuoy telemetry receivers ... see juws.janes.com
ARR-970 sonobuoy telemetry receivers ... 211
Arktika (MG-100), Arktika-M (MG-200) sonars ... 181
AS-228 depth charge ... 365
AS360 sonar ... 445
AS 2105 sonar stimulators ... 626
AS 2107 sonar trainer ... 626
ASA 92 series ACTAS sonar ... 144
ASDS advanced SEAL delivery system ... 68
ASK 4000 series positioning systems ... see juws.janes.com
ASLS sonar ... 451
AS0 83-86 series sonar systems ... 145
ASO 90 series sonar systems ... 144
ASR Acoustic Self-Ranging system ... see juws.janes.com
ASRC sonobuoy remote control ... 208
AST acoustic systems trainer ... 626
Astra (torpedo sonar head ... 320
ASTT action speed tactical trainer ... 610
'Astute' class nuclear-powered submarine ... 62
Astute Combat Management System (ACMS) ... 115
ASW-601 system ... 370
ASW Crew Trainers (ACTs) ... see juws.janes.com
ASW rocket ... 368
ASW rocket launchers ... 368
ASW team tactical trainer (Device 14A12) ... 611
AT-2/-3/-5/-6 acoustic sweep ... 506
AT0-2(E53-72) ASW torpedo ... 322
ATAHS heading sensor ... 670
ATARS transportable acoustic range ... 574
ATAS V1/V2/V3 sonar ... 151
ATC-1 torpedo decoy ... 229
ATC-2 torpedo decoy ... 230
ATD-III LIDAR system ... 455
ATDS torpedo defence system ... 230
ATMS track management system ... 589
ATS series torpedo control systems ... 108
ATV nuclear-powered attack submarine ... 47
AU-506 ESM antenna ... 249
Aurora towfish ... 462
Australia
  acoustic ranges ... 553
  ASW combat information systems ... 103
  general navigation equipment ... 641
  mine clearance systems ... 501
  mine warfare combat management ... 422
  mine warfare trainers ... 613
  mine warfare vessel designs ... 392
  miscellaneous equipment ... 667
  research and development ... 675
  sonobuoys ... 197
  submarine escape and rescue systems ... 76
  surface ship sonar systems ... 132
  underwater telephones ... 263
  underwater vehicles ... 462
Avalon DSRV 2 ... 80
'Avenger' class MCMV ... 415
AVXD Submarine SATCOM multifunction antenna ... 254
AWSS surveillance system ... see juws.janes.com
AWU 206A SCTT attack trainer ... 605
'Aydin' class minehunter ... 397
AZL radar mast ... 651

B

B515 torpedo launching system ... 318
Bandfish expendable torpedo countermeasures system ... 235
'Bang Rachan' class MCMV (Type 48) ... 398
Barra sonobuoy SSQ-801B ... see juws.janes.com
Barracuda attack submarine ... 40
Barracuda torpedo decoy ... 233
Barrel Stave Projector (BSP) ... 657
BARS Bearing Ambiguity Resolution Sonar ... 152
BASAR breathing apparatus ... 532
Bathy 500 echo-sounder ... 602
Bathy 2000/2000P signal processing ... 602
Bathyscan depth sounder ... 599
Batteries (Greece) ... 92
Batteries (UK) ... 96
BBT500 broadband transducer ... 660
BBT900 broadband transducer ... 660
BDC 103 underwater charge ... 370
BGM 100 Rockan mine ... 357

BGM 600 mine ... 358
BGM 601 (Bunny) mine ... 358
BH series carbon dioxide scrubbers ... 527
BIBS (SUBS) BU ... 532
Black Shark torpedo ... 320
BMM 80 mine ... 359
BMP 200 data acquisition platform ... 564
BMP 201 measuring platform ... 565
BMP 202 data acquisition platform ... 565
BPAUV ... 485
Brazil
  mines ... 344
BSS underwater target ... 635
Buddyphone communication system ... 533
Buddy through-water communicator ... 533
Bulava SS-NX-30 ballistic missile ... 297
Bulgaria
  mines ... 345
BWA Buoyant Wire Antenna ... 257

C

C-100 sensor ... 645
C303 torpedo countermeasures ... 231
C303/S torpedo countermeasures ... 231
C309 torpedo countermeasures ... 232
C310 torpedo countermeasures ... 232
Calas training target vehicle ... 633
Canada
  airborne acoustic processing & receiving systems ... 207
  consoles and displays ... 653
  divers' equipment ... 515
  environmental measuring systems ... 577
  machinery & platform control ... 85
  magnetic anomaly detection systems ... 285
  minehunting sonar systems ... 437
  mine warfare vessel designs ... 393
  miscellaneous equipment ... 667
  ocean survey equipment ... 591
  research and development ... 676
  sonar equipment trainers ... 623
  sonobuoys ... 197
  static detection systems ... 217
  submarine sonar systems ... 172
  surface ship sonar systems ... 133
  transducers ... 657
  underwater vehicles ... 462
Canadian minehunting system ... 462
CANTASS PAS post-mission analysis system ... 135
CAPTAS 20/TSM 2651/2652 sonar ... 139
CAPTAS Mk 2 UMS 4229/4249 ... 139
CCS Combat Control System Mark 2 ... 121
CCSM submarine combat system ... 120
CE2F/X100 Chariot ... 49
CETUS II AUV ... 485
'Challenger' class submarine ... 57
Chile
  ASW rockets & depth charges ... 365
China, People's Republic
  electronic warfare ... 241
  guided ASW/ASUW weapons ... 302
  mines ... 346
  mine warfare vessel designs ... 394
  strategic and cruise missiles ... 290
  submarine & submersible designs ... 38
CHIP Concurrent High-speed Integrated Processor ... 152
CIC combat information centre simulator ... 606
Circe anti-torpedo countermeasures ... 228
CK032/037/039/041 periscopes ... 279
CK038 periscope ... 279
CK043/093 periscopes ... 279
Class 4/5 SDVs ... 62
CM010 series optronic masts ... 280
CM101-CAP countermining charge ... 495
CM102-ECP explosive cutter ... 496
CM104-CAP countermining charge ... 496
CM106-EMCO countermining charge ... 497
CMAS-36/39 mine detection and avoidance sonar ... 437
CMB 3280 Coastal Monitoring Buoy ... 579
CMOD/Waves drifting buoy ... see juws.janes.com
Coastal Surveillance Display System (CSDS) ... 218
COBRA-TAC ... 543
Collins class submarine design ... 58
Combat drysuit ... see juws.janes.com
Combat information centre simulator ... see juws.janes.com
Combined Influence Sweep (CIS) (UK) ... 507
Command console ... 653
Compact periscopes (CK series) ... 279
Component range ... 557
Compression chambers ... 533
COMTASS–towed array sonar system ... 152
COOP minehunting system ... see juws.janes.com
Control & instrumentation ('Astute' class) ... 85
CORIS-TAS ... 146
C-Pearl-S ESM/ELINT system ... 243
CRISP acoustic analyser ... 211
Croatia
  submarine & submersible designs ... 38
CS-3701 ESM and radar surveillance ... 250
CSA Mk 2 launcher ... 237
CSAS-80 platform-mounted sonar ... 217
CSDS-85 platform-mounted sonar ... 217
CSM battery cell ... 89
CSR submarine radar ... 649
CSS-N-3 (JL-1) IRBM ... 290
CSS-N-4 (YJ-1/C-801) Sardine SSM ... 302
CSS-NX-5 (JL-2) ICBM ... 290
CSU 3-4 sonar ... 175
CSU 83 sonar system ... 175
CSU 90 sonar system ... 175
CTASP towed array signal processor ... 667
CTD-12 plus probe ... 578
CTS-24 ASW OMNI sonar ... 135
CTS-36/39 OMNI sonar ... 135
CTS 106 dual-purpose artificial target ... 635
Cutthroat submarine test vehicle ... 69
CY-1 ASW surface-launched missile system ... 302

D

DAMDIC Mk 1 mine disposal charge ... 493
DARPA UUV ... 485
DC 55 breathing apparatus ... 519
DC 101-MS500 anti-submarine charge ... 366
DC 103-HAF anti-intruder defence ... 367
DCB submarine tactical data handling and integrated fire-control system ... see juws.janes.com
DCG(R) submarine tactical data handling ... see juws.janes.com
DCM weapons interface equipment ... see juws.janes.com
DCM 12 Doppler current meter ... 579
DCSC diving system ... 533
DCSC-2 command and surveillance system ... see juws.janes.com
DE 1160(I) sonar systems ... 160
DE 1164 sonar ... 160
DE 1167 sonar ... 161
DE 1191 sonar modernisation ... 161
DEBRA beach reconnaissance aid ... 534
Deepscan 60 sonar ... see juws.janes.com
Defence Research & Development Canada ... 676
Defence Research Establishment Norway ... 678
Defence Science & Technology Organisation (DSTO) ... 675
DEG-CAD modelling system ... 558
Deg-Comp Mod 1 degaussing system ... 569
Degaussing technology (USA) ... 571
Denmark
  ASW combat information systems ... 103
  general navigation equipment ... 641
  minehunting sonar systems ... 437
  mine warfare combat management ... 422
  mine warfare vessel designs ... 394
  ocean survey equipment ... 592
  submarine radar ... 649
  underwater vehicle ancillary equipment ... 493
DESO 14/25 echo-sounders ... 595
Device 14A12 ASW team tactical trainer ... 611
Device 14E35 acoustic operator trainer ... 629
Device 14G1 sonar trainer ... 629
Device 21A42 Trident command and control trainer ... 611
DHS-100 sonar ... 543
DINAMO, ambient noise prediction model ... 586
Diodon sonar/TSM 2630 ... 140
DIPS information & positioning system ... 534
Distress submarine location equipment ... see juws.janes.com
Divator Mk II ... 535
DIVEGUARD Mk 2 ... 526
DLT-D3 submarine torpedo fire-control system ... 103
DM2A3/4 Seehecht torpedo ... 315
DM 19 A3 explosive minesweeping cutter ... 504
DM 51 anti-invasion mine ... 346
DM 59/DM 69 Remote-Controlled Explosive Cutter (RCEC) ... 494
DM 61 influence mine ... 346
DM 119/DM 129 Remote-Controlled Explosive Cutter (RCEC) ... 494
DM 211, DM 221 depth charges ... 366
DM 1002-3009 A2/A3 remote-controlled fuze ... 495
DME acoustic depth measuring ... 498
DMSS2000 LF sonar system ... 146
Dolphin class submarine ... 41
Dolphin semi-submersible ... 464
Dorado semi-submersible ... 465
Double-Decker submarine battery ... 89
Double Eagle mine disposal ROV Mk II ... 479
Double Eagle mine disposal ROV Mk III ... 479
DPL-275A pinger/receiver ... 544
DR 2000 U ESM receiver ... 241
DR 3000 U ESM system ... 241
DR 4000 U ESM system ... 241
DRI-267 transponder interrogator ... 662
DRS diver recall signal ... 535
DRT (Double Resonant Transceiver) ... 663
Dry Deck Shelter for SDV ... 69
DS1200 series trainers ... 629
DS25/30 naval gun system ... 670
DSBV 61B sonar ... 140
DSBV 62C/TSM 2932 sonar ... 141
DSE 1 sonar camera ... 520
DSN-450/DSL-250 sonar speed log ... 645
DSQS-11 M sonar ... 442
DSQS-21 (ASO 83-86) series sonars ... 145
DSRV1/2 rescue vehicles ... 80
DSTA (Singapore) ... 678
DSUV 62C-TSM 2933/Lamproie sonar ... 172
DUAV-4 helicopter sonar ... 189
DUAV-4 UPG helicopter sonar ... 189
DUBA 25/TSM 2400 sonar ... 141
DUBM 21B/TSM 2021 sonar ... 438
DUBM 41B/TSM 2050 (IBIS 41) sonar ... 438
DUBM 42 (IBIS 42) ... 439
DUBV 23D sonar/UMS 4110CL ... 141
DUBV 43B/C sonar ... 141
DUUX-5 (Fenelon) sonar ... 172

E

E14 acoustic torpedo ... 312
E15 acoustic torpedo ... 312
E 67/E 67 Mod 1 firing transmitter ... 495
ECB-680(1) communications buoy ... 267
EFS 1 electric field sensor ... 671
EFS 3 electric field sensor ... 671
EL050 (Type 2056), EL057, EL067 series deep-phone underwater telephones ... 541
Electric propulsion motor ... 86
Electronic Chart display unit (ECDIS) ... 643
ELF Extremely Low-Frequency communications programme ... 258
ELMA magnetic sweep ... 505
ELP-362D emergency locator beacon ... 663
EM 52/55 rising mine ... 346
EM 120 multibeam sonar ... 597
EM 121A bathymetric mapping sonar ... 597
EMD mine destructor ... 486
EMTC turbulence control ... 575
Ensdorf/Kulmbach class minesweepers ... 398
ERATO torpedo recovery vehicle ... 467
ERUS MIL.COM underwater communications ... 519
ESAX-2A sonar locator beacon ... 659
ES system ... 250
EVEC 20 data handling system ... 422
Exocet SM 39 missile ... 302

F

F17 wire-guided torpedo ... 312
FACDAR degaussing/acoustic range ... 563
Fansweep 20 swath surveying system ... 596
FAS 3-1 sonar ... 176
FCS Mk 3 submarine command and control systems ... 110
FDS 700 degaussing system ... 569
FEMAP magnetic analysis ... 570
FEMS fleet exercise minelaying system ... 614
Feniks/M (MG-10, MG-10M) ... 181
FFISTS II tactical decision set ... 121
FFR Free Flooded Ring ... 657
Finland
  degaussing systems ... 569
  magnetic ranges ... 557
  mine clearance systems ... 502
  static detection systems ... 217
  surface ship sonar systems ... 137
  targets ... 633
Fixed sonar systems (RFAS) ... 219
FL 1800 U submarine ESM/DF system ... 242
FLASH dipping sonar ... 189
Flextensional transducers (BAE) ... 661
Flextensional transducers (Raytheon) ... 663
Flying Bell ... 521
Flyvefisken class MCMV ... 394
FMS 20/21 active sonar ... see juws.janes.com
FMS series sonar systems ... see juws.janes.com
Focused pressure wave mine neutralisation ... 511
FOI (Sweden) ... 679
France
  acoustic control ... 573
  acoustic decoys ... 227
  acoustic ranges ... 554
  airborne acoustic processing & receiving systems ... 208
  airborne dipping sonars ... 189
  ASW rockets & depth charges ... 365
  ASW combat information systems ... 103
  command team trainers ... 605
  degaussing systems ... 569
  divers' equipment ... 519
  electronic warfare ... 241
  electro-optical sensors ... 274
  general navigation equipment ... 641
  guided ASW/ASUW weapons ... 302
  machinery & platform control ... 85
  magnetic anomaly detection systems ... 285
  magnetic ranges ... 557

mine clearance systems ... 504
mine warfare combat management ... 422
mine warfare trainers ... 613
minehunting sonar systems ... 438
miscellaneous equipment ... 667
multi-influence ranges ... 563
ocean survey equipment ... 594
prediction systems ... 585
sonar equipment trainers ... 625
strategic and cruise missiles ... 290
submarine communications systems ... 253
submarine & submersible designs ... 39
submarine sonar systems ... 172
surface ship sonar systems ... 138
targets ... 633
torpedoes ... 312
transducers ... 659
underwater telephones ... 263
underwater vehicles ... 467
underwater vehicle ancillary equipment ... 493
Frankenthal class minehunter ... 399
FTAS ... 207
Fuel cell ... 85

G

G 732 Mk II underwater telephone ... 265
G 733 SLUTT target ... 637
G 738 decoy ... 234
G 750 sonar ... 153
'Gacta' class minehunter ... 401
Gas exhaust valves ... 92
Germany
acoustic decoys ... 227
ASW combat information systems ... 107
ASW rockets & depth charges ... 366
command team trainers ... 605
degaussing systems ... 569
divers' equipment ... 520
electronic warfare ... 242
electro-optical sensors ... 276
general navigation equipment ... 642
magnetic ranges ... 557
machinery & platform control ... 89
mines ... 346
mine clearance systems ... 504
mine warfare combat management ... 424
mine warfare trainers ... 613
mine warfare vessel designs ... 396
minehunting sonar systems ... 442
miscellaneous equipment ... 668
ocean survey equipment ... 595
static detection systems ... 218
submarine communications systems ... 253
submarine & submersible designs ... 41
submarine equipment trainers ... 617
submarine sonar systems ... 175
surface ship sonar systems ... 144
targets ... 634
torpedoes ... 314
transducers ... 659
underwater vehicles ... 471
underwater vehicle ancillary equipment ... 494
GIB-DPS ... 520
GIB-FT tracking range ... 554
GIB-ROV ... 493
Gigas mine disposal vehicle ... 474
Gipsy SEWACO VIII weapon control system ... 111
GIS-1 grenade ... 368
GKT-2/-3/-3MP mechanical sweeps ... 506
Gotland class submarine ... 59
GPS 40-18 receiver ... see juws.janes.com
Greece
machinery & platform control ... 92
Gudgeon sonar/TSM 2362 surveillance sonar ... 142
GyroTrac digital compass ... 646

H

'Harushio' design of submarine ... 52
HAS-2154 LF sonar ... 162
Haux-Deepstar 80/C diving system ... 521
Haux-Medistar 1250/5.5 ... 522
Haux-Profi-Medicom recompression chamber ... 522
Haux-Spacestar 1300/5.5 Dome ... 523
Haux-Starcom recompression chambers ... 523
Haux-Super-Transstar recompression chamber ... 524
Hawk Eye LIDAR system ... 455
Helium-3 ASW magnetometer ... 286
Helium magnetometer ... 286
Helras long-range dipping sonar ... 195
Herdla test range and training facility ... 564
HF antenna ... 258
HI-TASS simulation & training system ... 624
HNSAS simulator ... 606
HOD HOD 1/2 communication systems ... 525
Honeypot beacon ... 643
Horizontal Projector Array (HPA) ... 657
HOTTorp training torpedo ... 333
HS 12 helicopter sonar ... 190
HS 312 ASW system ... 190
HSCP-600 current profiler ... 581
Hugin 3000 AUV ... 477
Hunt class trainer ... 614
Huon class MCMV ... 392
HUS 001 APSOH ... see juws.janes.com
Hyball remotely operated underwater vehicle ... 480
Hydra 2000 diving simulator ... 524
Hydra MSS sonar ... 136
Hydroacoustic coastal range ... 218
Hydrocom speech processor ... 544
Hydromap hydrographic system ... 596
Hydromap Susy software system ... 596
Hydrosweep DS-2 sonar ... 596
Hydrosweep MD-2 sonar ... 597
HYSUB ATP series ... 465, 466

I

IBIS 41 minehunting sonar system ... 438
IBIS 42 mine detection sonar system ... 439
IBIS 43 mine surveillance system ... 439
IBIS MCM systems ... 423
IBIS VII PVDS system ... 473
ICS integrated communications system ... 253
IDA weapon control & information system ... 427
Impact MU90 torpedo ... 318
IMS Infra-red Mast ... 274
INCA Interactive classification aid . 142, 173, 208
India
acoustic decoys ... 227
mines ... 347
strategic and cruise missiles ... 292
submarine & submersible designs ... 47
torpedoes ... 316
INSIGHT sonar performance model ... 586
Integrated communication system ... 253
Integrated Navigation and Tactical Plotting System (INTPS) ... 643
International
acoustic decoys ... 228
airborne dipping sonars ... 190
ASW combat information systems ... 108
electro-optical sensors ... 278
environmental measuring systems ... 578
guided ASW/ASUW weapons ... 303
minehunting sonar systems ... 443
mine warfare combat management ... 425
mine warfare laser systems ... 455
mine warfare vessel designs ... 400
multi-influence ranges ... 563
prediction systems ... 585
sonobuoys ... 197
static detection systems ... 218
strategic and cruise missiles ... 292
submarine & submersible designs ... 47
submarine radar ... 649
surface ship sonar systems ... 146
torpedoes ... 317
underwater vehicles ... 473
International air training systems (Lockheed) ... 622
Iran
divers' equipment ... 525
IRR radio room ... 259
ISCMMS and SCC-200 ... 94
ISCS integrated ship communication system ... 667
ISCWS integrated system ... 121
ISIS sonar image processing ... 451
Israel
acoustic control ... 573
acoustic decoys ... 229
divers' equipment ... 526
electronic warfare ... 243
electro-optical sensors ... 278
surface ship sonar systems ... 146
ISUS 90 integrated combat system ... 107
Italy
acoustic decoys ... 231
acoustic ranges ... 554
airborne dipping sonars ... 191
aircraft ASW equipment trainers ... 621
ASW combat information systems ... 110
ASW rockets & depth charges ... 366
command team trainers ... 607
electronic warfare ... 244
machinery & platform control ... 92
magnetic ranges ... 560
mines ... 347
minehunting sonar systems ... 444
mine warfare combat management ... 426
mine warfare vessel designs ... 401
miscellaneous equipment ... 668
sonar equipment trainers ... 625
static detection systems ... 219
submarine & submersible designs ... 49
submarine radar ... 649
surface ship sonar systems ... 146
targets ... 635
torpedoes ... 319
underwater vehicles ... 474
underwater vehicle ancillary equipment ... 495
IU-2/IT-3 mine detector/destructor ... 506

J

Japan
mine warfare vessel designs ... 403
submarine sonar systems ... 178
submarine & submersible designs ... 52
surface ship sonar systems ... 146
torpedoes ... 321
JL-1 ballistic missile ... 290
JL-2 ballistic missile ... 290

K

KAFS submarine combat information and fire-control system ... 115
Kanaris submarine fire-control system ... 108
Kariwara towed thin-line array ... 132
KE 8 hydrophone ... 659
KE 9 hydrophone ... 660
Kilo class submarine ... 54
Kingfisher sonar ... 162
Kingston class MCMV ... 393
Klub S 3M-54E (SS-N-27) cruise missile ... 292
Korea, North
submarine & submersible designs ... 53
Korea, South
mine warfare vessel designs ... 404
'Kormoran' class minehunter/sweeper ... 407
Kristall-fuel cell ... 93
'Krogulec' class minehunter/sweeper ... 407
K-ster mine destructor vehicle ... 468

L

L3 acoustic torpedo ... 313
L5 dual-role torpedo ... 313
'Lada' class (Project 677) submarine designs ... 56
Lamproie sonar/TSM 2933 ... 172
Land range for magnetic measurement ... 557
'Landsort' class MCMV ... 410
LARSC Launch and Recovery Smart Crane ... 497
LAT anti-torpedo jammer ... 227
'Lat Ya' class minehunter ... 402
LBVDS sonar ... 162
LCS Launcher Control System ... 103
LDUUV ... 486
LEAD torpedo countermeasure effector ... 233
Lead/acid batteries ... 96
LESCUT – torpedo decoy ... 228
LFATS active towed sonar ... 163
LFHUSS acoustic sound source ... 137
LG 360 Wet bell diving system ... 527
Lida class MCMV ... 407
Limbo AS Mk 10 anti-submarine mortar ... 371
LIMIS diver sonar ... 544
Limpet Mine Disposal Equipment (LMDE) ... 508
Limpet mine (C-TEC) ... 347
Limpet mines (AMS) ... 360
Limpet mines Mk 414/430 ... 348
Littoral sea mine ... 362
LM series recompression chambers ... 528
LMRS mine reconnaissance vehicle AN/BLQ-11 ... 483
LNS4-3 magnetic sensor ... 360
Lopas passive sonar ... 176
LORES (France) ... 667
Los Angeles class nuclear submarine ... 69
Low-frequency Transmit Subsystem (LTS) ... 663
LR 5 rescue vehicle ... 78
LS 370 wet bell dive system ... 528
LS-4096 laser underwater imaging system ... 456
LSE 800 sonar transducer ... 660
LUNDAR sensor platform ... 563

M

M-4 ballistic missile ... 290
M8 submarine torpedo fire-control system ... see juws.janes.com
M-51 SLBM ... 291
M66 mine ... 355
M70 mine ... 355
M71 mine ... 356
Machinery simulators ... 617
MACTIS MM/SSN-714(V)2 ... 426
MAD Mk III detector ... 285
MAD-1 anti-invasion mine ... 351
Magic Lantern minehunting system ... 456
Magnetic gradient sensors ... 671
Magnetic ranges (Thales) ... 557
Magnetic signature measurement ... 560
Magnetic Sweep ... 502
Magnetic treatment systems ... 569
Magtronic ... 86

MAINS system (Elesco) ... 503
Mandarin/Solo sonar trainer ... *see juws.janes.com*
Manta data handling system ... 116
Manta ESM system ... 244
MANTA test vehicle ... 487
Marine sound signal Mk 8 ... 672
Maritime Underwater Future Capability ... 64
Mark-Trak navigational system ... 545
Marlin AUV ... 481
MAS exercise limpet mine ... 351
MAS mine avoidance sonar ... 442
Mast antenna ... 259
MAST Multi-Application Sonar Trainer ... 625
Master Yeoman electronic chart table ... 644
MASTT (MPS Action Speed Tactical Trainer) ... 608
MASWT (MPS Anti-Submarine Warfare Trainer) ... 608
Matrix modular mines ... 356
MCA 30/MCA 45 cable antenna ... *see juws.janes.com*
MCF-100 moored contact mine ... 344
MCM 2000 mine countermeasures weapon system ... 424
MCM command & control system ... 422
MCOT minehunting command and operator trainer ... 613
MCS minesweeping control system ... 641
MCT limpet mine ... 344
MCT machinery control trainer ... 617
MDB Modular DataBus ... *see juws.janes.com*
MDC 605 mine disposal charge ... 498
MDE military display equipment ... 654
MDM series seabed mines ... 354
MDS mine disposal system ... 475
MEAD/MSCAD torpedo countermeasure effector ... 233
MEDUSA diving simulator ... 524
Merlin Acoustic Trainer ... 621
Merlin ASW equipment trainer ... 622
Merlin sonar trainer ... *see juws.janes.com*
Mermaid Marine Environmental Model And Integrated Database ... 587
MERS signature measurement ... 566
MESA Multiplexed Extended Sensor Array ... 576
MESMA closed Rankine-cycle engine ... 87
MFI influence mine ... 345
MFPS MineField Planning System ... 669
MFM antenna ... 259
MFS-7000 sonar ... 146
MG-10/M (Feniks)/M ... 181
MG-100/200 (Arktika)/M ... 181
MG 110 midget submarine ... 54
MG 120/ER midget submarine ... 50
MG-335 (Platina) sonar ... 151
MGK-400 (Rubikon) ... 181
MGS-900 signature measurement range ... 557
MHAP-20 minehunting autopilot ... 426
MICOS minehunting command system ... 428
MILA-6B limpet mine ... 356
Milas missile system ... 303
Mine disposal vehicles training simulator ... 613
MIN Mk 2 ROV mine disposal system ... 475
MIN Mk 2 ROV sonar ... 444
Mine data centre ... 427
Mine Warfare ... 419
Mine Warfare Forces ... 375
Mine Warfare Command Support System (MWCSS) ... 425
Mine warfare testing range ... 560
Minehunting performance prediction system ... 587
Minescan sonar ... 449
Minesniper expendable mine destructor vehicle ... 478
Minetac MCM command & control system ... 423
Minicin inertial navigation ... 641
MINTACS software ... 422
MIR 2000 ranging system ... 563
MIST torpedo target ... 635
MIUW surveillance system ... 220
MJ 2000 minehunting system ... 400
Mk 5 enclosed mine lift bag ... 361
Mk 6 dead reckoning tracer ... 646
Mk VIII SEAL delivery vehicle ... 70
Mk 11 depth charge ... 371
Mk 16 UBA ... 545
Mk 30 Mod 2 ASW training target ... 638
Mk 37 Mods 1 and 2 torpedoes ... 333
Mk 39 EMATT target ... 639
Mk 44 torpedo ... 333
Mk 46 torpedo ... 333
Mk 48 ADCAP torpedo ... 334
Mk 50 torpedo ... 335
Mk 54 anti-submarine rocket ... 365
Mk 54 lightweight hybrid torpedo (LHT) ... 336
Mk 56 seabed mine ... 363
Mk 62/63/64/65 Quickstrike series ... 363
Mk 98 strategic missile FCS ... 122
Mk 105 airborne minesweep ... 512
Mk 116 ASW control system ... 122
MM/BPS-704 submarine radar ... 649
MM/BPS-804 submarine radar ... 650
MMA influence mine ... 351
MMC Modular Multifunction Console ... 654
MM/SSN-714(V)2 MACTIS minehunting system ... 426
MMMCA contact mine ... 352
MMS Marine Mammal System ... 513
MMSS MPS Multibeam Sonar Simulator ... 625
MN 102 Murena mine ... 348
MN 103 Manta mine ... 349
MN 105 Seppia mine ... 350
MO-90 moored mine ... 357
Mobile multifunction countermeasures device ... 237
Mobile overrun range ... 558
Model 15-750 variable depth sonar ... 137
Model 30 high-powered projector ... 663
Model 40 flextensional transducer ... 664
Model 76 periscope ... 281
Model 86 optronic mast series ... 282
Model 90 optronic periscope system ... 282
Model 260-TH side scan sonar ... *see juws.janes.com*
Model 353X communications system ... 535
Model 505 emergency underwater telephone ... 265
Model 560 series side scan sonar ... *see juws.janes.com*
Model 610 sonar ... 163
Model 700 series sonar ... 163
Model 780 series sonar ... 164
Model 980 series sonar ... 164
Model 997 series sonar ... 165
Model 1110 sonar ... 187
Model 1120 sonar ... 187
Model 1525 CTFM sonar ... 188
Model 2433A beacon ... 661
Model 3040 Doppler velocity log ... 646
Model 3220C two-diver telephone ... 535
Model 3342C helium speech unscrambler ... 536
Model 3500 helium speech unscrambler ... *see juws.janes.com*
Model 4240 Doppler sonar velocity log ... 646
Model 5400 underwater telephone ... 266
Model 6280 diver-held pinger receiver ... 536
Model 6281 surface and diver pinger receiver ... 536
Model 9057 (AN/UQN-4) sonar sounding set ... 601
MoDive dive monitoring system ... 526
MOLS open-loop sweep ... 513
Mora Sym magnetic ranging system ... 558
Morpheus AUV ... 487
MP-2 limpet mine ... 352
MP-80 sea mine ... 350
MPAST sonar training systems ... 621
MR-80 sea mine ... 350
MRK-50 Series submarine radars ... 650
MRCS Console System ... 655
MRUUV Mission Reconfigurable UUV ... 488
MS 106 mechanical sweep ... 507
MS 900/900D sonar ... 591
MS 1000 sonar processor ... 591
MSC mine warfare support centre ... 668
MSF class mine countermeasures drone ... 395
MSHM continental-shelf mine ... 354
MSI-90U submarine basic command and weapons control system ... 112
MSI-90U Mk 2 submarine basic command and weapons control system ... 113
MSI FC tactical picture compilation and weapon designation system ... 113
MSK 5030 demodulator ... 255
MSMS system ... 560
MSSA Mk 1 minesweeping system ... 508
MTDS minehunting data system ... 429
MTSS mine warfare tactical support system ... 672
MTSS(R) mine warfare tactical support system ... 672
MU90 Impact torpedo ... 318
MUDSS survey system ... 514
Mulloka hull-mounted scanning sonar system ... 132
Murena ground mine ... 348
MUST Lab underwater test laboratory vehicle ... 488
MUWS sensors ... 566
MVASP acoustic processor ... 207
MVU-110EM Uzel/Murena command system ... 113
MW 1630/MW 1630B mine detectors ... 525
MWR ... 350
MWS 80 minehunting weapons system ... 425
MWS minefield planning support system ... 427
MWSIM mine warfare training simulator ... 615
Mystic DSRV 1 ... 80

N

NAE beacon Mk 3 ... 237
Narama towed thin-line array ... 132
NASP non-acoustic sensor platform ... 482
NATAT tactical and command team trainer ... 606
NATO submarine escape and rescue systems ... 76
Natya class MCMV ... 408
NAUTIS-M system ... 430
Nautos platform management system ... 91
Navigation data management ... 641
NDC 1000 machinery control ... 94
NECTA environmental tactical aid ... 587
NEDPS (NIBS) submarine action information and fire-control system ... 113
Neptune RSVP/CTD-1020 sound velocimeter ... 582
Neptune software ... 585
Netherlands
ASW combat information systems ... 111
command team trainers ... 607
prediction systems ... 585
research and development ... 677
submarine & submersible designs ... 53
submarine radar ... 650
submarine sonar systems ... 179
surface ship sonar systems ... 148
targets ... 636
New Concept drysuits ... 536
New Zealand
mines ... 351
NHP mast and snorkels ... 92
Night vision equipment ... *see juws.janes.com*
Nite Eye thermal imager ... 278
NMRS mine reconnaissance vehicle ... 489
Noise ranges ... 555
Non-penetrating masts ... 92
Non-retractable periscope (RFAS) ... *see juws.janes.com*
Norway
ASW combat information systems ... 112
ASW rockets & depth charges ... 368
command team trainers ... 608
divers' equipment ... 526
environmental measuring systems ... 579
mine clearance systems ... 505
minehunting sonar systems ... 444
mine warfare combat management ... 427
mine warfare vessel designs ... 405
miscellaneous equipment ... 669
multi-influence ranges ... 564
ocean survey equipment ... 597
research and development ... 678
sonar equipment trainers ... 625
surface ship sonar systems ... 148
underwater vehicles ... 477
NSRS rescue vehicle ... 76
NST-58 lightweight torpedo ... 316
NT 37 C torpedo ... 336
NT 37G Seahuntor torpedo ... 337
NVC Navigation and Vessel Control equipment ... 424

O

OASIS (AN/ALQ-220) minesweep system ... 511
OBDG degaussing system ... 570
OCIDAS-1 Ocean Intervention and Data Assimilation System, Phase 1 ... 588
OE 0285 submarine ice operation camera ... 280
OE-538/BRC Antenna ... 259
OE 1324 ROV camera ... 499
OE 2700 ROV cameras ... 499
OE 9020 Seahawk diver TV system ... 536
Offshore series recompression chambers ... 529
OH-5001/SQS-505 (V) 6 simulator stimulator ... 624
Ohio class SSGN ... 71
Oka-2, VGS-3 ... 191
'Oksoy' class MCMV ... 405
OLISTER subsea mine warfare system ... 468
OMS 100 optronics mast ... 276
OMS optoradar Mast ... 274
Onboard sonar trainer ... 626
Open range overrun measuring system ... 559
Optronic sensors ... *see juws.janes.com*
OPUS 2 console ... 653
OQR-1 towed array sonar ... 147
OQR-2 towed array sonar ... 147
OQS-3/-4/-5 sonar systems ... 147
OQS-8 sonar system ... 147
OQS-101 hull-mounted sonar ... 147
OQS-102 hull-mounted sonar ... 147
ORACOM torpedo countermeasures research ... 668
Orca swimmer delivery vehicle ... *see juws.janes.com*
OSDI data interface ... 116
'Osprey' class MCMV ... 416
OTS-90 avionic sonic system ... 191
OWL Mk II remotely controlled marine vehicle ... *see juws.janes.com*
Oxydive breathing apparatus ... 537
Oxymax 3 diving set ... 537
'Oyashio' class patrol submarine ... 52

P

P-500 Granit (SS-N-19) cruise missile ... 294
Pakistan submarine and submersible designs ... 54
Panor acoustic range ... 554
PAP Mark 5 ROV mine disposal system ... 469
PAP Plus remotely controlled vehicle ... 470
PAPSIM ROV simulator ... 613
Parasound survey system ... 597
Passive acoustic analysis trainers ... 630
Pathmaker mine warfare system ... 451
PDM-2H anti-invasion mine ... 345
PEM AIP fuel cell ... 90
PEMT-4 magnetic loop sweep ... 506

Periscope simulator 618
Permanent Magnet Motor 314
PERMASYN electric propulsion motor 91
Petrel 5425 sonar system 133
Phantom series ROVs 489
PHS-32 sonar 148
PHS-36 sonar 148
Physics and Electronics Laboratory 677
Pinger locating devices 661
Pinguin B3 ROV mine disposal system 471
Piranha SDV 71
PJ-10 anti-ship missile 292
PL 13 control console 88
Platina (MG-335) sonar 151
Pluto Plus ROV mine disposal vehicle 477
Pluto ROV mine disposal vehicle 476
PMAR portable range ..... see juws.janes.com
PMK-1 rocket-powered torpedo 355
PMS 26 sonar 153
Pneumatic ram discharge device 314
Poland
  mine warfare vessel designs 407
  underwater vehicle ancillary equipment 498
Porpoise ESM equipment 245
Prairie/Masker 576
Pressure sweep 507
Primary batteries 314
Pro-Am/Pro-HD dry diving suits 539
Pro-CBX 450 drysuit 539
Pro-HRM 1200 rubber suit 539
Pro-VSN 1100 drysuit 539
Project 257 minesweeper (Kormoran) 407
Project 677.1650 submarine designs 56
Propulsion machinery simulators 617
PRS-02 pathfinder 585
PRS 3-15 sonar 177
PSU 83 sonar 177
PTR tracking range 555
PUAPS acoustic positioning system 555

Q

QinetiQ Group Ltd 680
QSUA-4A acoustic noise monitoring system 573

R

R-1 diver submersible (SDV) 57
R-2 two-man diversionary submersible 38
R-624(V) receiver 213
R800B VLF/LF receiver system ..... see juws.janes.com
R-1651/ARA receiver 214
RAMICS mine clearance system 514
RASAT sonar target 636
RASSPUTIN sonobuoy 197
RCM 9 Mk II Recording Current Meter 580
RD 2300 hyperbaric chamber complexes 530
RECA mine disposal charge 494
Reconfigurable, Scalable Multiprocessor (RSM) 667
RICE 10 internal communications 255
RK-55 Granat 'Sampson' cruise missile 293
RO-308/SSQ-36 data recorder 582
Rockan BGM 100 mine 357
Romania
  acoustic decoys 232
  ASW rockets & depth charges 368
  mines 351
ROV simulator 614
ROV/Diver Trak 499
ROV-Homer 499
ROV-TRAK 499
RPP Resonant Pipe Projector 657
RS5D acoustic positioning system 553
RS 910 series aoustic positioning system 553
RSM-40 Vyosta ballistic missile 293
RSM-50 Volna ballistic missile 294
RSM-52 Sturgeon ballistic missile 295
RSM-54 Sineva ballistic missile 295
RSP depth compensated RingShell Projector 658
RTOF communications buoy 255, 267
Rubikon (MGK-400) 181
RUM-139A VL-ASROC ASW rocket 305
RUR-5A ASROC missile system 305
Russian Federation & Associated States
  airborne dipping sonars 191
  ASW combat information systems 113
  ASW rockets & depth charges 368
  guided ASW/ASUW weapons 304
  machinery & platform control 93
  mines 352
  mine clearance systems 506
  mine warfare vessel designs 407
  sonobuoys 201
  static detection systems 219
  strategic and cruise missiles 292
  submarine & submersible designs 54
  submarine radar 650
  submarine sonar systems 179
  surface ship sonar systems 149
  torpedoes 321

S

S-3V depth charge 369
S-10 (SIVA) oxygen rebreather 516
SA 950 sonar 444
SACTIS MM/BSN-716 110
SADANG sonobuoy signal processing and display system 208
Safe Barrier intruder security system 670
Safety flare 76
Sagarika cruise missile 292
SAHRV hydrographic reconnaissance 490
SAINT training system 627
Salmon sonar/TSM 2640 142
SAM remote-control minesweeping drone 411
Samcon 600 multi-influence mine 356
SAMHADS message processing system 255
'Sampson' (RK-55) cruise missile 293
'Sandown' class minehunter 413
'Sandown' class trainer 614
'Santa Cruz' class patrol submarine 42
SAP mine disposal system 499
SAR drysuit 539
SARA noise range 553
SARBE 10 personal locator beacon 79
Sardine CSS-N-4 (YJ-1/C-801) SSM 302
SAS synthetic aperture sonar 452
SAT combat system 104
Satyr minefield control system 429
Sauro class submarine 51
SAUVIM AUV 490
SAV class minesweeping drone 396
SAWCS acoustic warfare system 182
'Sawfly' (RSM-40 Vyosta) ballistic missile 293
SC-12 solid-state salinity chain ..... see juws.janes.com
Scanter navigation radars 649
SCC-200/ISCMMS steering/management control 94
SCCS Mk 2 combat system ..... see juws.janes.com
'Scorpene' design of submarine 47
Scorpio 45 rescue vehicle 79
SCOTT submarine combat trainer 606
Scout sonar 177
SCTAS 182
SCTT submarine command team trainer (AMS) 609
SCTT submarine command team trainer (STN) 607
SCTT submarine command team trainer (TT&S) 610
Scubaphone 515
Scubaphone Vox 515
Scutter expendable torpedo decoy 230
SD204 STD/CTD 580
SDU Special Diver Unit 518
SDV-X and Piranha 71
Sea Defender/TMS 4550 227
Sea Dragon submarine simulator 607
Sea Guardian sonar system 220
Sea Keeper 439
Sea King ASW sonar trainers 621
Sea Piper communications system 539
Sea Scout minehunting sonar 445
Sea Sentinel Undersea Coastal Surveillance System (UCSS) 221
Sea Sentry 221
Sea Shadow diver propulsion vehicle 72
Sea Siren decoy system 233
Sea Sting mine disposal system 500
SeaBat 6012 sonar 437
SeaBat 8100 mine avoidance sonar 437
SeaBat 8101 echo-sounder 592
SeaBat 8111 echo-sounder 593
SeaBat 9001 echo-sounder 593
SeaBat 9002 echo-sounder 593
SeaBat 9003 echo-sounder 594
SeaCams video camera systems ..... see juws.janes.com
Seafalcon 5 echo-sounder 594
Seafalcon 11 echo-sounder 595
Seafox mine disposal vehicle 472
Seahake and Seehecht (DM2A4) torpedo 315
Seahake Mod 4 torpedo 315
Seahawk diver TV system OE 9020 536
Seahorse AUV 491
Seahuntor torpedo 337
Sealion ESM system 245
SeaLites underwater lighting systems ..... see juws.janes.com
Seapike anti-submarine weapon 314
SEASOAR data acquisition vehicle 599
Seavision intensified CCD camera ..... see juws.janes.com
Seawolf class submarine 72
Security Eye sonar system 178
Seehecht (DM2A3) torpedo 315
Segura class minehunter 409
Seicam 1001 audio distribution system 253
SEIE Mk 10 escape unit 77
SEMT-1/ST-2 magnetic solenoid sweep 506
Serbia and Montenegro
  mines 355
  submarines & submersible designs 357
Series 5 modular sonar systems (Thales) ..... see juws.janes.com
Series 7 oceanographic instruments 581
Series 5000 sonar imaging 453, 500, 602
SERO 14 search optronics periscope 277
SERO 15 modular attack periscope 277
SERO 400 modular periscope system 278
Sesub 940A submarine combat system 114
SET combat system 104
SEWACO VIII submarine data handling and weapon control system 111
SH 100 minehunting sonar 454
Shadow Excursion 540
Shaped charge mine disposal system (Sea Sting) 500
Shelon dipping sonar 151
'Shipwreck' (P-500 Granit) cruise missile 294
Shkval VA-111 torpedo 324
SHOALS airborne lidar bathymeter 591
Shore-Based Information Centre 668
SIASS-1/-2 sonars 179
SICLA acoustic classification system 669
SIGMA 40 INS ..... see juws.janes.com
SIGMA 40 XP 641
Signature Management 549
'Silex' SS-N-14 ASW torpedo 304
Simulation and training system 619
SINBADS submarine integrated battle and data system 112
Sineva (RSM-54) ballistic missile 295
Singapore
  research and development 678
SIVA S-10 diver rebreather apparatus 516
SIVA systems 516
'Skiff' SS-N-23 ballistic missile 295
SLASM sonar system TSM 2670 142
SLAT anti-torpedo warfare system 228
SLD 302 Airone and DC 103 anti-intruder defence 367
SLINS inertial navigation system ..... see juws.janes.com
SLUTT/G 733 target 637
SLWM missile 306
SM-5 containerised dive system 530
SM-5 D12 escape & rescue system 76
SM 39 Exocet missile 302
SM 2000 imaging sensor 457
SM 2000 imaging/profiling sonar 592
SMARTTRAK acoustic tracking 555
SMBPS broadcast processing system 256
SMCS-NG submarine command system 117
SMCS Submarine Command System 116
SMCS operator trainer 610
SMDM series ground mines 355
SMS optronic mast 275
SMUTS submarine-mounted underwater tracking system ..... see juws.janes.com
SMYC combat control system 429
SNA-2000 sonar system 146
SNM 40/120 573
Snoop-type submarine surveillance radars 650
SOAS Submarine Operational Automation System command support software 122
Socrates, towed acoustic underwater source 636
Solarsub towed array sonar 182
Solid-State Transmitter (SST) 166
Sonac AMS acoustic sweep 503
Sonac PFA Passive Fixed Array sonar 217
Sonac PTA Passive Towed Array system 137
Sonar 3000 hydrographic survey 600
Sonar 3050 (Widescan) sonar 600
Sonar domes 153
Sonar handling equipment (Indal) 137
Sonar locator beacon ..... see juws.janes.com
Sonar principles trainer (AMS) 628
Sonar principles trainer (Thales) 628
Sonar procedures trainer 628
Sonar Research Projector (SRP) 659
Sonar simulator 630
Sonobuoy launchers (Alkan) ..... see juws.janes.com
SonTak sonar tactical decision aid 586
'Sonya' class coastal minesweeper 409
SOSUS fixed sound surveillance system 222
SoundTrak series ASW target simulator 638
South Africa
  divers' equipment 527
  mines 356
  mine warfare combat management 429
  submarine escape and rescue systems 76
Spain
  command team trainers 609
  machinery & platform control 93
  mines 356
  mine warfare combat management 429
  mine warfare vessel designs 409
  miscellaneous equipment 669
  submarine sonar systems 182
SPAT acoustic target 639
Spearfish torpedo 327
Speed log system 647
Spherion B sonar/TSM 2633 143
SPIRE III data telemetry and analysis 211
SPS115 surface vessel torpedo launching system 109

SPS search periscope 275
SPS sonobuoy positioning system ..... see juws.janes.com
SPUD spectral analytical system 672
SQQ-14IT sonar 444
SRS INTO integrated navigation and tracking outfit 79
SS 2450 anti-submarine warfare sonar 148
SS 9500 sonar 445
SSE-launched transponder 80
SSE Mk 10 ejector system 234
SSGT 65
SS Mk 1 control console 88
SS-N-8 'Sawfly' (RSM-40 Vyosta) ballistic missile 293
SS-N-14 'Silex' torpedo system 304
SS-N-15 'Starfish' ASW missile 304
SS-N-16 'Stallion' ASW missile 304
SS-N-18 'Stingray' (RSM-50 Volna) ballistic missile 294
SS-N-19 'Shipwreck' (P-500) cruise missile 294
SS-N-20 'Sturgeon' (RSM-52) ballistic missile 295
SS-N-21 'Sampson' (RK-55) cruise missile 293
SS-N-23 'Skiff' (RSM-54 Sineva) ballistic missile 295
SS-N-27 (3M-54E Klub S) cruise missile 292
SSK96 Subskimmer ..... see juws.janes.com
SSMS monitoring system 599
SS-NX-26 Yakhont 296
SS-NX-30 Bulava 297
SSQ-101 ADAR sonobuoy 206
SSQ-906G LOFAR sonobuoy 201
SSQ-926 ALFEA sonobuoy 201
SSQ-937C bathythermal buoy 577, 579
SSQ-954C/E DIFAR sonobuoy 201
SSQ-955A/C HIDAR sonobuoy 202
SSQ-963C/D CAMBS sonobuoy 202
SSQ-981E Barra sonobuoy 203
S-SRV rescue vehicle 77
SST 4 torpedo 316
SSXBT/SSXSV bathythermograph 582
SSXCTD conductivity, temperature & depth probe 582
ST 5 attack periscope 276
ST 240 Toadfish sonar 149
ST 2400 ASW sonar 149
'Stallion' ASW missile 304
Standard periscopes (RFAS) ..... see juws.janes.com
STAR training target 633
'Starfish' ASW missile 304
STAT-100 torpedo decoy 232
Stationary magnetic measuring range 559
Stealth Combat/Stealth EOD rebreathers 540
Steering system 93
Sterne TSM 3850 minesweeping system ..... see juws.janes.com
Sting Ray torpedo 328
'Stingray' SS-N-8 (RSM-50 Volna) ballistic missile 294
Stirling AIP engine 94
STLS shipborne torpedo launch system 329
Stonefish mine 361
Stonefish Mk III mine 362
STS series control systems 109
STTS Submarine Tactical Training Simulator 609
'Sturgeon' (RSM-52) ballistic missile 295
STVTS periscope training system 620
Styrsö class MCMV 412
SUA underwater signalling device 673
SUBICS 900 submarine combat control system 123
Submarine attack team trainer 607
Submarine command team trainer 610
Submarine communications mast 256
Submarine communications and NAVSTAR antenna 256
Submarine control simulator (Germany) 617
Submarine Control Simulator (UK) 618
Submarine Control Trainer (SCT) 618
Submarine design, aspects of 23
Submarine Forces 15
Submarine operations room simulator 609
Submarine platform control system 96
Submarine signal and decoy ejectors 234
Submarine signals 673
Submarine tactical trainer 609
Submarine team trainers 607, 610
Submarines, introduction 3
Sub-Monitor tracking system 546
Subphone 518
Subphone Model 2190 518
SUBSCUT – torpedo decoy 229
SUBTACS submarine tactical communications system 260
Subtas target simulator 634
SUBTASS towed array sonar 172
SUBTICS submarine tactical integrated combat system 104
Subtrack sonar target 637
Sugashima class minesweeper 403
Super SeaROVER ROV 491
SURTASS RDA towed array 166
SUS Mk 84 Sound Signal 268
SUT torpedo 316
SVB 93
SV Plus miniature sound velocity, pressure and temperature probe ..... see juws.janes.com
SVTT Mk 32 torpedo launcher 337
Swallow class MCMV 404
Swan towing and handling systems 143
SWATS X 201 midget submarine 51
Sweden
ASW combat information systems 113
ASW rockets & depth charges 369
machinery & platform control 94
mine clearance systems 507
mines 357
mine warfare combat management 429
mine warfare vessel designs 410
miscellaneous equipment 670
multi-influence ranges 564
prediction systems 586
research and development 679
submarine & submersible designs 57
submarine escape and rescue systems 77
torpedoes 324
transducers 660
underwater vehicles 479
underwater vehicle ancillary equipment 498
SWIM weapon interface equipment 118
Swimmer detection system (USA) 222
Sygame audio training 625
Symen sonar training 625
Synthetic Aperture Sonar (SAS) 452
System 3000 side scan sonar 603
SYVA ASW system 106

T

T Mk 9 Mod explosive cutter 507
T618 Link 11 data terminal set ..... see juws.janes.com
T619 Link 11 data link processor ..... see juws.janes.com
T-1630/SRT SEPIRB radio beacon 81
Table I: submarine construction 1990-2004 6
Table II: operational combat submarines 2004 11
Table III: submarine age as at August 2004 13
Table IV: inventory of submarine equipments in service or on order August 2004 27
Table V: submarine designs September 2004–specifications and electronics 31
Table VI: submarine designs September 2004–weapons 34
Table VII: submarine designs September 2004–machinery 36
Table VIII: operational combat and weapon control systems 102
Table IX: operational surface ship sonar equipments 129
Table X: operational submarine sonar equipments 169
Table XI: operational electronic warfare systems as at August 2004 239
Table XII: operational periscope systems as at August 2004 272
Table XIII: submarine-launched strategic and cruise missiles 289
Table XIV: operational guided ASW/ASuW weapons 301
Table XV: operational torpedoes 310
Table XVI: operational mines 341
Table XVII: MCMV building programme 1994-2004 380
Table XVIII: MCMV age 1970-2004 383
Table XIX: MCMV designs–specifications & electronics 384
Table XX: MCMV designs–mine warfare systems 387
Table XXI: mine warfare vessel designs–machinery 390
Table XXII: operational command & tracking systems 421
Table XXIII: operational sonar equipments as at August 2004 435
Table XXIV: ROV inventory 461
TACTICS combat information systems 103
Tactics trainer 611
Target detection device (TDD) 347
TAS 90 series towed array system 145, 178
TASSEN tactical sensor unit 506
TB-16 towed array 188
TB-23 towed array 188
TB-29A towed array 188
TBI torpedo board interface 111
TC 1000 transport chamber 531
TC 1150 transport chamber 531
TCCR Tactical Command and Control system for Remote Control minesweeping 424
TCD Tactical Command and Documentation equipment 424
TCM 2000 system (Germany) 227
TCU102 surface vessel torpedo launching system 111
TEDAS data acquisition 600
Terfenol-D transducer 660
Terne III rocket-propelled depth charge 368
Test-71 series torpedoes 322
Test-96 torpedo 322
Theseus AUV 466
Thetis ESM system 244
Tigerfish Mod 2 torpedo 330
Timnex II ESM/ELINT system 243
TMS 2000 COTS-based processors 208
TMS 4530 Albatros torpedo alert system 138
TMS 4550 Sea Defender 227
TMS 9001 Sygame trainer 625
Toadfish (ST 240) sonar 149
Toczek countermining charge 498
Tomahawk UGM-109 cruise missile 297
TONES Transportable Overside Noise Evaluation System 574
Torpedo launch controller 118
Torpedo launchers (BAE) 330
Torpedo propulsion system (Saab Bofors) 324
Torpedo recovery system (Bridport) 330
Torpedo steering actuation systems 331
TOSCA towed subsea carrier 471
Toted towed torpedo decoy 227
Towed communications buoys 269
Towed Sound Source (TSS) 633
Tp 45 (43X2) torpedo 324
Tp 46 Grampus torpedo 325
Tp 62 torpedo 326
Tp 617 torpedo 326
TR 1700 (Santa Cruz) series patrol submarine 42
TRAC and CHART systems 644
Trailblazer 25 ROV 467
Transducers (Gearing) 662
Transducers (Thales) 661
Transducers (Ocean Data) 666
Transducers & hydrophones (RESON) 664
TRANSMAG range 566
Trident command and control trainer (Device 21A42) 611
Trident C-4 UGM-96 ballistic missile 297
Trident D-5 UGM-133 ballistic missile 299
Trident training facility 611
Tripartite design minehunter 400
Troika minesweeping system 396
TSM 2021 sonar 438
TSM 2022 Mk I/II sonar system 440
TSM 2022 Mk III Family 440
TSM 2023N sonar 441
TSM 2050 (IBIS 41) sonar 438
TSM 2054 sonar 441
TSM 2055 sonar 172
TSM 2061 tactical system 423
TSM 2072 submarine tactical data handling/weapon control system 106
TSM 2233 sonar system 173
TSM 2253 sonar 173
TSM 2255 Fenelon (DUUX-5) ..... see juws.janes.com
TSM 2362 Gudgeon sonar 142
TSM 2400 DUBA 25 sonar 141
TSM 2630 Diodon sonar 140
TSM 2633 Spherion B sonar 143
TSM 2640 Salmon sonar 142
TSM 2651/2652 CAPTAS 20 sonar 139
TSM 2670 SLASM sonar 142
TSM 2932 sonar 141
TSM 2933 Lamproie towed array 172
TSM 2980 TACTAS system 139
TSM 3850 Sterne minesweeping system ..... see juws.janes.com
TSM 5152A, 5152B transmitter/receivers 263
TSM 5421B sonar 174
TSM 5423 sonar 174
TSM 5740/5750 Doppler log 642
TSMT FES shore-based trainer 631
TSUNAMI sonar 166
TTF Trident training facility 619
TULIP Net communication system 253
TUUM-4 underwater multichannel wireless telephone 263
TUUM-5 portable underwater emergency telephone 264
Type 53 series torpedoes 322
Type 73 lightweight torpedo 321
Type 89 torpedo 321
Type 093 submarine 38
Type 162M sonar 446
Type 182 torpedo decoy 234
Type 184M/P sonar 153
Type 185 throughwater communication system 265
Type 193M/193M Mod 1 minehunting sonar 446
Type 201 Ula class submarine 47
Type 209 patrol submarine 42
Type 209 simulator 605
Type 212A patrol submarine 44
Type 214 patrol submarine 46
Type 312 Futi class minesweeper 394
Type 332 Frankenthal class minehunter 399
Type 333 minesweeper 398
Type 352 minesweeper 398
Type 375 ASW rocket system 370

Type 639 indicator buoys 80
Type 778 echo-sounders 644
Type 780 echo-sounder 645
Type 786/787 echo-sounders 645
Type 1007 radar 651
Type 2007 sonar 182
Type 2016 sonar 154
Type 2019 sonar 182
Type 2020 sonar 183
Type 2026 sonar 183
Type 2031Z sonar 155
Type 2034 sonar 600
Type 2046 submarine sonar 184
Type 2050 sonar 155
Type 2053 hydrographic sonar 600
Type 2054 sonar 184
Type 2058 sonar target simulator 638
Type 2059 acoustic tracking system 431
Type 2066 Bandfish 235
Type 2068 SEPADS 588
Type 2069 sonar 192
Type 2073 underwater telephone 80
Type 2074 sonar system 184
Type 2076 sonar system 185
Type 2082 intercept sonar 186
Type 2087 towed array sonar 155
Type 2090/IBIS Integrated Bathy Information System 585
Type 2093 sonar 447
Type 2193 sonar 448
Type 3010/T (Minescan) sonar 449
Type 3050 (Widescan) sonar 600
Type 7986 transponder 673
Type E53 ASW torpedo 322
Type J periscope 276
Type M48 MCM vessel 398
Type R605 receiver 211
Type R612 receiver 212
Type R613 receiver ..... see juws.janes.com
Type R624 sonobuoy receiver system .... see juws.janes.com
Type TC 1000 transport chamber 531
Type TC 1150 transport chamber 531

U

UAP family of ESM systems 246
UAT-376 acoustic transponder 666
UCC Ultra Compact Console ..... see juws.janes.com
UDAMS 556
UDAS data acquisition 566
UGM-84 Sub Harpoon SLASM 306
UGM-96 Trident C-4 ICBM 297
UGM-109 Tomahawk cruise missile 297
UGM-133 Trident D-5 ICBM 299
UGST heavyweight torpedo 323
UHDLS Under hull diver location system 542
Ula class submarine 47
ULR-741 ESM/ELINT system 244
Ultrascan 5000 sonar 601
UMGT-1 ASW torpedo 323
UMS 4110CL/DUBV 23D sonar 141
UMS 4229/4249 Captas Mk 2 139
Underwater charge Mk 31 347
Underwater charge Mk 41 347
Underwater Sentry 223
Underwater Surveillance System 219
United Arab Emirates
  submarine & submersible designs 62
United Kingdom
  acoustic control 574
  acoustic decoys 233
  acoustic ranges 555
  airborne acoustic processing & receiving systems 209
  airborne dipping sonars 192
  aircraft ASW equipment trainers 621
  ASW combat information systems 115
  ASW rockets & depth charges 371
  command team trainers 609
  communications buoys 267
  consoles and displays 653
  degaussing systems 570
  divers' equipment 532
  electronic warfare 244
  electro-optical sensors 279
  general navigation equipment 643
  machinery & platform control 96
  magnetic ranges 560
  mines 359
  mine clearance systems 507
  minehunting sonar systems 445
  mine warfare combat management 430
  mine warfare trainers 614
  mine warfare vessel designs 413
  miscellaneous equipment 670
  multi-influence ranges 566
  ocean survey equipment 598
  prediction systems 586
  research and development 680
  sonar equipment trainers 626
  sonobuoys 201
  static detection systems 220
  submarine communications systems 254
  submarine escape and rescue systems 77
  submarine & submersible designs 62
  submarine equipment trainers 617
  submarine radar 651
  submarine sonar systems 182
  surface ship sonar systems 151
  targets 636
  torpedoes 327
  transducers 661
  underwater telephones 265
  underwater vehicles 480
  underwater vehicle ancillary equipment 498
United States of America
  acoustic control 575
  acoustic decoys 235
  airborne acoustic processing & receiving systems 212
  airborne dipping sonars 192
  aircraft ASW equipment trainers 621
  ASW combat information systems 118
  command team trainers 610
  communications buoys 267
  consoles and displays 653
  degaussing systems 571
  divers' equipment 542
  electro-optical sensors 281
  electronic warfare 247
  environmental measuring systems 581
  general navigation equipment 645
  guided ASW/ASUW weapons 305
  magnetic anomaly detection systems 285
  magnetic ranges 560
  mines 362
  mine clearance systems 510
  minehunting sonar systems 449
  mine warfare combat management 431
  mine warfare laser systems 455
  mine warfare trainers 615
  mine warfare vessel design 415
  ocean survey equipment 601
  prediction systems 589
  sonar equipment trainers 628
  sonobuoys 204
  static detection systems 220
  strategic and cruise missiles 297
  submarine communications systems 257
  submarine & submersible designs 68
  submarine equipment trainers 619
  submarine escape and rescue systems 80
  submarine radar 652
  submarine sonar systems 185
  surface ship sonar systems 156
  targets 638
  torpedoes 333
  transducers 662
  underwater telephones 265
  underwater vehicles 482
  underwater vehicle ancillary equipment 500
Universal Modular Mast 278
UQQ-2 SURTASS surveillance system 167
URF rescue vehicle 77
USET-95 torpedo 323
USFCS combat information & FCS 125
USK 800 series direction-finding systems 242
UT 2000 underwater communication system 254
UUV (DARPA) 485
Uwajima class MCMV 403
UwEM monitoring system 589
Uzel & Murena 113

V

VA-111 Shkval torpedo 324
Valenta diesel engine 97
Vanguard simulator 619
Vanguard sonar 145
Vastergotland class submarine 61
V-COM system 260
VE 5900 Naval echo-sounder 642
Velebit midget submarine 38
Velox M7 sonar intercept receiver 174
Velox M8 sonar intercept receiver 174
VEMS Versatile Exercise Mine Systems 359
VHF sonobuoy receiver 214
Victoria class submarine 65
Viking class submarine design 49
VIMOSPlus monitoring system 575
Virginia class nuclear submarine 74
Visem MCM training aid 613
VLF/LF antennas 260
VMAG 3-axis magnetic sensor 673
VMS-ECDIS electronic chart system 647
Volna RSM-50 (SS-N-8) ballistic missile 294
VTT-1 (E45-75A) lightweight torpedo 324
Vyosta RSM-40 (SS-N-8 'Sawfly') 293

W

Wadibuoy Wave Directional Buoy ..... see juws.janes.com
Walrus class submarine 53
Wayamba MCM vehicle 462
Weapon handling and launch system 332
Wideline 200 series recorder 674
Widescan III sonar 600
WINSON sonar operator unit 149, 445
Wire sweep Mk 8 509
Wire sweep Mk 9 509
Wire sweep Mk 105 509
Wire sweep monitoring equipment 510

X

X 201 SWATS midget submarine 51
XBT/XSV Bathythermograph system 583
XCP profiler 583
XCTD expendable conductivity, temperature and depth profiling system 584

Y

Yaeyama class MCMV 404
Yakhont SS-NX-26 anti-ship missile 296
Yang Yang class minehunter 405
YJ-1/C-801 Sardine SSM 302
YJ-8/82 anti-ship missiles 302
Yugo class midget submarine 53

Z

ZQQ series sonars 178
ZW07 submarine radar 650

NOTES