Jane's Underwater Warfare Systems

End Of Year Report 2010

Image: BAE Systems

David Ewing – Editor, Jane's Underwater Warfare Systems

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By David Ewing

Introduction

No review of the previous twelve months can escape without mention of the continuing global financial situation and ongoing conflicts in Iraq and Afghanistan, where coalition focus on the land battlespace continues. Perhaps it is a salutary lesson, therefore, that the issues of torpedoes, submarines, midget submarines and mines were brought back into focus with the sinking of the South Korean corvette *Chon An* in the Yellow Sea on 26 March 2010.

The action was initially unattributable and only after an extensive international investigation, supported by the evidence of the recovered hull, was there the possibility to reach the conclusion that the sinking was caused by a CHT-02D torpedo manufactured by North Korea. Although neither North nor South Korea could probably be regarded as having an underwater warfare capability on a par with the strongest nations, the loss of the *Chon An* has served as a reminder that to lower the Anti-Submarine Warfare (ASW) guard leaves open opportunities for a state or non-state actor to achieve dramatic results for relatively little investment.

US Sailors assigned to the USS *Blue Ridge* examine the wreckage of the *Chon An* in Pyeongtaek, South Korea (source: US DoD)

Turning to the theme of defence funding and acquisitions, the year has been punctuated with a series of almost contradictory headlines from around the globe. Governments have been declaring the need to reduce expenditure, increase security

and get better value for money, whilst at the same time cancelling defence programmes.

There appears to be a growing divide between the BRIC (Brazil, Russia India, China) nations and developed economies in Europe and North America. Whilst the BRIC countries expound ambitions to increase their underwater warfare capability through the acquisition of new submarines, upgrading of existing forces and development of indigenous weapons, the US and the UK sought to review defence spending with their respective Quadrennial Defense review and Strategic Defence and Security Review (SDSR). Furthermore, most Euro Zone nations declared severe spending cuts, which have inevitably had a significant impact on defence expenditure.

The Underwater Battlespace

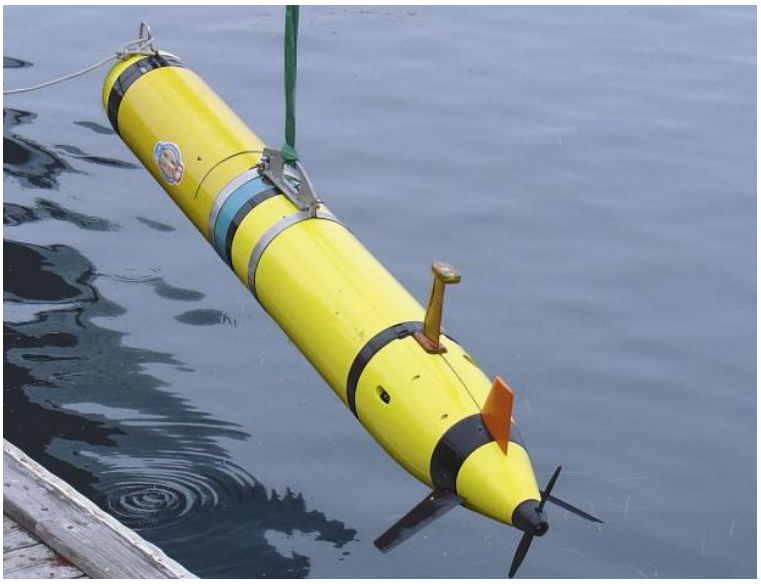
Potential risks are growing and proliferating, particularly in key choke points through which a large volume of global trade must pass. There is also growing alarm over the threat posed by small coastal and midget submarines, and the clear challenge is how to match limited resources to growing demands. ASW has traditionally been a 'platform-intensive' team game requiring airborne, surface and subsurface assets to prosecute the threat.

Longer-range sensors, the benefits accruing from bi-static and multi-static acoustic processing techniques, and more 'forward leaning' tactical doctrine all offer useful gains and have resonance in tactical development. It is also necessary to note that there are implications from climate change and the need to operate in different regions such as Arctic waters as the ice caps retreat.

Abandoning existing ASW systems and platforms in their entirety is not an option, rather navies are seeking to augment existing resources with affordable yet operationally effective systems that exploit networked off-board sensors. It is hoped that this will allow fewer platforms to be freed up for more complex tasks.

Principle threats are diesel electric submarines operated by unstable nations, stealthy UUVs, quieter submarines and low frequency active sonar

The emerging global underwater warfare situation can be characterised by a growing array of low cost options and superior stealth technology, creating a multitude of possible risks. Principally these threats are: increased numbers of diesel electric submarines in the hands of politically unstable nations; more and more capable, stealthy Unmanned Underwater Vehicles (UUV) and small submersible vehicles; quieter modern submarines and wider use of low frequency active sonar. These trends are likely to continue in the near future.



Hydroid's REMUS 600, selected to meet the UK Royal Navy's reconnaissance UUV requirement

Underwater warfare market shifting towards Asia and Latin America

With the reduced resources for defence procurement in the traditional maritime nations, the market for underwater warfare capability has shifted towards the Far East, India, China and South America. The major European, US and Russian manufacturers are all focused towards this increasingly important market. Design and technological innovation however continues to be led by major established manufacturing nations, but it is also clear that developing countries are seeking to develop indigenous capability and either to assemble the hulls, or build them under licence. German, French Spanish and Russian designs are now being manufactured worldwide.

Technology Trends

Roles and Missions

The fundamental issues of the sonar equation prevail across all aspects of underwater warfare. This demands the understanding of the underwater environment, the physics of sound travelling through a medium of infinitely variable density and controllable and uncontrollable external factors. Success at underwater warfare demands mastery of all, and there is an acknowledged need to sustain skills and maintain the ability for co-ordinated ASW operations.

While simulated training has its weakness, the paucity of quality live training has dictated close examination and provision of training functionality within equipment and, at a more significant level, to distributed networked systems. In many navies the reduction in live exercises has seen a significant drop off in operator skill just at the time when the 'enemy' becomes more capable, effective and elusive.

With well trained and experienced operators it is also necessary to exploit the controllable elements of the environment to one's advantage. Bandwidth, source level, receiver sensitivity, frequency, transmission formats and hydrophone and transducer design have to be matched and improved in order to maximise results.

Underwater warfare is increasingly required as part of the wider Joint picture

Underwater warfare increasingly needs to be incorporated into the concepts of Joint Warfare as a net-centric and co-ordinated element of naval operations. To maintain the advantage there needs to be sophisticated acoustic models to support the complex tactical decisions being demanded by multi-statics and integrated command information systems able to deliver situational awareness. The command systems are becoming increasingly complex with the need for interoperability and are an essential element in facilitating integration of the underwater warfare forces into the battle group.

With the exception of a land-attack capability the roles of the submarine have, in essence, remained constant. The ability to strike land-based targets has been delivered by weapon developments and improved C4ISTAR, and it is from this enhanced performance and capability of sensors and weapons that the value of the submarine as a capital ship has increased. The tactical and operational procedures to prosecute both new and old roles have demanded changes in philosophy and attitude in order to incorporate the submarine and Mine Countermeasures Vessel (MCMV) into the integrated joint battlespace.

Ultra Electronics' Sea Fox ROV on the UK Royal Navy's Hunt-class MCMV HMS *Chiddingfold*

The greatest constraint has been the ability to communicate the volume of data at the speed required to and from submarines and the smaller ASW and MCM vessels. Improved C4I is vital to the command and while the submariner must maintain a stealth advantage, they can no longer be regarded as an individual operator and

must be confident in the ability to integrate the submarine's weapons systems into the Task Force.

Mine warfare threat remains constant and unpredictable

In Mine Warfare the threat has remained constant and unpredictable – declaration of a defensive minefield around an objective is a relatively inexpensive and effective way of disrupting the plans of an invading force. Modern operations cannot be delayed for weeks while mine sweepers strive to complete route survey and clear the area for the arrival of the high value shipping. The MCM task is required to be completed 'in stride' with the operational tempo of the force.

Successful MCM relies on good MCM data bases and route survey as well as the ability to detect, identify and dispose of the weapons at safe range from friendly forces. The challenge in accomplishing this is to do the task with greater security, at a faster rate and with the remainder of the force in closer proximity than before. Again it is the capability and improvements to the sensors – and especially the development of UUVs rather than changing mission parameters – which is driving new tactics and requirements.

Platforms and Designs

Cost is the main driver of modern submarine design

The current technological challenge in the design of submarines is undoubtedly the desire to drive down unit production costs, not only to remain competitive in export markets but also to meet government demands. There has been considerable pressure on US manufacturers to reduce costs of the Virginia-class hulls and, while progress has been made to reduce build times, there have been the inevitable cost increases associated with general levels of inflation. Reports in December 2010 indicate that unit cost has increased by 2.1%.

The UK is faced with the demands of keeping open manufacturing facilities while demanding only seven Astute-class hulls. Long lead items are being pursued for hull five, and although the SDSR did not cut the final number of hulls from seven, there is an awareness that another defence review will be conducted before 2015. While a 10% reduction in build time has been reported, costs are understood not to have been similarly reduced.

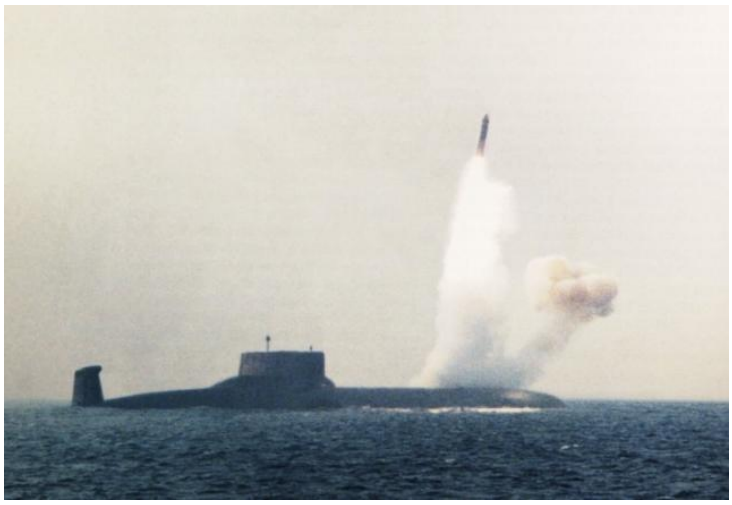
Brazil, Russia, India and China are less constrained by budget problems caused by the financial crisis than the US and European nations

The BRIC nations appear to have been less afflicted by financial problems and budget cuts. China continues to progress on an aggressive submarine construction programme and India continues to develop the Arihant Advanced Technology Vessel (ATV) SSN. In addition, India seeks further conventional submarines and is looking to the Russian Federation and the European constructors to respond to the request for proposals issued in the Autumn. It is expected that India will insist on technology transfer and the opportunity to develop local shipyards in order to complete manufacture of up to six hulls.

The second Astute-class submarine, *Ambush*, under construction in Barrow

Brazil is progressing development of its SSN programme with DCNS advising on hull design, and has also progressed with the development of the indigenous Pressurised Water Reactor (PWR) for the boat. Strong relations also exist with DCNS for the production of the Scorpène SSK, for which construction is scheduled to start in 2011.

For the domestic Russian market four Borey-class SSBNs are in the pipeline, although the Bulava (SS-N-X-32) (R-30) missile has failed several more test flights and is severely delayed. Two Yasen hulls have been laid down and the first is expected to be commissioned in 2011. Project 667 Lada SSKs are seen to be the next avenue for extensive export sales; one is in service with the Russian Navy and a further two will commission in the next 15 months. The export version is called the Amur and is being offered in two versions in an attempt to reach the market for small 950-ton vessels and the medium sized 1,650-ton standard SSK.



A Bulava SS-NX-30 ballistic missile being test launched from the Typhoon-class submarine *Dmitriy Donskoy*

The technical changes seen over the year are evolutionary rather than revolutionary. The never-ending efforts to reduce the hull signature and increase endurance have continued. All operators of SSKs are either including an Air Independent Propulsion (AIP) upgrade to existing submarines or as a priority requirement for new vessels.

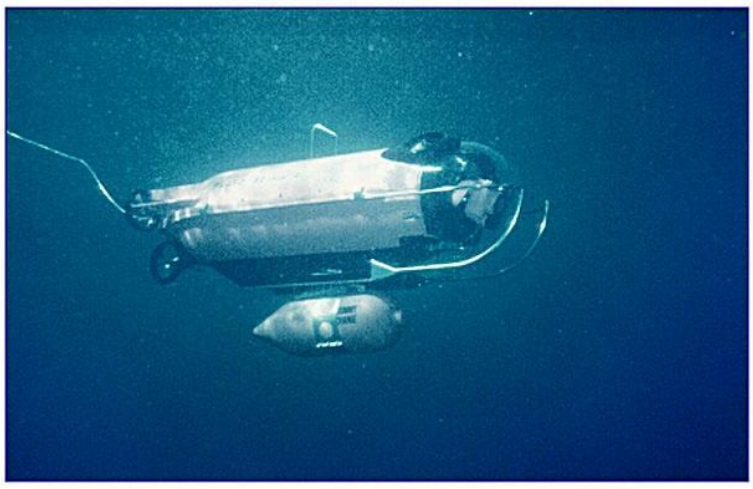
The MCM building programme has also slowed dramatically. Many emerging nations, particularly the new NATO navies, have bought, leased or been given second-hand MCM vessels by established NATO nations with a view to providing an initial interoperable maritime capability. This has enabled considerable work in refurbishing older hulls, but there is little activity in designing or building new ships. The exceptions are the Swedes, who have begun to introduce the Visby-class MCM capability, and the Finnish Navy with the Katanpää class.

UUVs and mine warfare

Driven by the long-held desire to remove human operators from the danger zone, technological advances are leading to rapid enhancements in the over-the-horizon military capability of unmanned, autonomous platforms. These vehicles offer potential solutions to a wide range of maritime defence needs, such as ISR, MCM and even weapons delivery. The emergence of this technology not only provides military capability, but also offers significant cost savings over traditional methods of fulfilling mundane, dirty or dangerous tasks.

UUVs are moving towards more multi-role capability

Mine warfare doctrine is moving away from the concept of stand-alone mine countermeasures vessels operating within the mined area, to multi-role vessels deploying a variety of dedicated mission packages. This is being made possible by the development of, and growing operational experience with, a number of different types of unmanned vehicles or vessels, including UUVs, Unmanned Surface Vessels (USVs) and semi-submersibles, which can be controlled from multimission vessels but allow the "mother vessel" to undertake other operational tasks.



Gaymarine's Pluto Plus remote-controlled mine disposal vehicle

Although a number of countries have national R&D programmes, most thinking on UUVs has been driven by the USN UUV Master Plan, published in November 2004. This analysed the application of these platforms in relation to MCM missions. The authors of the Master Plan said this was prompted by the need of the US fleet to rapidly establish large, safe operating areas, transit routes (Q-routes) and lanes, typified by long Sea Lines Of Communication (SLOC), offshore operating areas (including both carrier and amphibious operating areas) and littoral penetration areas (such as assault breach and port break-in).

The range of MCM mission types was identified as including: reconnaissance (detection, classification, identification and localisation), clearance (neutralisation and breaching), sweeping (mechanical and influence) and protection (spoofing and jamming).

Acoustics

The evolution of open architectures and lower frequency active sonar has presented the greatest opportunities for increased underwater warfare performance. In both ships and submarines there is a desire to incorporate 'sonar suites' to cover the active, passive, mine avoidance and torpedo warning requirements in one system. All manufacturers are offering such 'packages', and in the majority of cases the individual component sonars are tuned to complement the frequency coverage and are fully integrated with command systems and decision aids.

US Navy sonar technicians on board the guided-missile destroyer USS *The Sullivans* (source: US DoD)

Open, modular "plug-and-play" architectures enable rapid capability upgrades

The past year has seen incremental rather than dramatic change in acoustic performance. Frequently easily installed 'plug and play' upgrades are incorporated in open systems to deliver rapid capability improvements, thus avoiding the cost and delay of taking platforms out of service to replace obsolescent equipment. The ability to install revised databases, new processing and system algorithms have been a particular advantage in responding to the development of tactics and procedures,

especially those associated with multi-statics and the resolution of the tactical picture.

An assessment of today's technology in the commercial market shows it to be far more capable than the military bespoke hardware, as civilian requirements now drive the process rather than the monolithic defence contracts of the Cold War. Even in 2011 as systems evolve, advances in processing power will be based on COTS devices and the challenge will be to encapsulate growing capability in a civilian environment to meet military requirements. Areas where further advantages could be applied were identified at the ClarionASW Conference in London during December 2010 and included:

- Sonar Processing converted to run as part of the combat control system
- Outboard and external interfaces
- Sonar applications run as "virtual machines" on a Shared Computing Environment (SCE)
- Sonar applications run on an SCE alongside other combat system applications (e.g. Command System, navigation System)
- SCE based on Blade Server technology

ASW Weapons

The principal Western manufacturers of heavyweight torpedoes continue to market well-proven weapons that are undergoing spiral upgrades. The widely sold Raytheon Mk 48 is available in a variety of standards and has now reached the Mk 48 ADCAP Mod 6. The Mk 48 ADCAP has advanced homing and wire guidance designed to destroy fast, deep-diving nuclear submarines and high-performance surface ships. The Mk 48 ADCAP has improved target acquisition range, anti-torpedo countermeasures, and enhanced effectiveness against surface ships. The latest upgrade that can be applied to existing weapons provides a Common Broadband Advanced Sonar System (CBASS) kit, which takes advantage of broadband signal processing.

The Whitehead Alenia Sistemi Subacquei (WASS) Black Shark remains in service with Chile, Singapore and Malaysia, and Diehl BGT Defence has completed a series of tests with the IDAS submarine-launched anti-ship/helicopter missile. The US Naval Surface Weapon Center has further validated the ability of a submerged submarine to engage aircraft and small surface targets using a variant of the AIM-9X air-to-air missile demonstrating the potential for other existing air- or surface-launched missiles.

A cut-away model of the WASS SpA Black Shark torpedo, on display at Euronaval, France

Technical detail of mines and mine systems is rarely made available by the operating nations or the manufacturers. Current trends in development are associated with reducing detectable signatures through use of stealthy shapes, non-reflective or absorbent coatings/casings and the incorporation of insensitive munitions. Sensors and detection algorithms are, as with all aspects of ASW, benefitting from the advances in computing and miniaturisation of processors to produce increasingly intelligent weapons.

Communications

US places emphasis on sensors over weapons and on networks over platforms

The US Navy announced its development priorities as 'putting sensors over weapons' and 'network over platform', which was founded on the principal that 'Limitations in current weapons and sensor integration have driven today's ASW operations toward "force on force" engagements that place our forces at risk. Far better that in a network-capable force the intent is to apply network-centric warfare to dominate the environment by using unmanned vehicles, common operating pictures and stand-off precision weapons.'

As with most C4I issues the NATO community embraced the concepts and started to apply Alliance (in the form of the NATO Undersea Research Centre) and national research to the issues. While the US has developed a series of technologies into Persistent Littoral Undersea Surveillance Network (PLUS Net) other solutions are now emerging.

The UK has completed a series of trials with the Raytheon Deep Siren to achieve networked communications at range between strategic HQ, aircraft, surface and underwater forces. The system uses Iridium satellite communications, acoustics, sonobuoys, slot buoys and Low Frequency Active Sonar (LFAS). Further work has also

demonstrated an extension of the system capable of communicating at range with swimmers/SDVs. This is a significant area for continued research and development and undoubtedly other solutions are under development.

National Programme Highlights

Brazil

Brazil has progressed plans to build a nuclear reactor and realise the ambition to operate SSN forces. The industrial plants at Aramar and Resende are capable of enriching the uranium for nuclear applications and associations continued with DCNS over the design of the hull, which will be based on the Barracuda, though there will be no French involvement in the development and construction of the nuclear reactor, which is being undertaken and trialled by the Brazilian Navy and NUClebras Equipamentos Pesados SA (NUCLEP).

The requirement for three SSNs is driven by the National Defence Strategy 2008. This stipulated the need to build a second flotilla to operate off the northern coast and protect the growing oil wealth and Brazil's economic strength. The programme includes a further need for a force level of 15 conventional submarines. The Franco-Brazilian military co-operation has also extended to the procurement of four Scorpène SSKs, which will be partly constructed in France and assembled in Brazil.

Greece

The saga of Hellenic Navy (HN) submarine upgrade and procurement programmes was a persistent thread throughout 2009 and 2010, but despite massive economic problems Greece has completed the acquisition of the Type 214 submarines from HDW. After protracted contract agreements Greece has now accepted all four Type 214 boats, including *Papanikolis*, which had previously been destined for sale on the international market.

Greece's *Papanikolis* prior to launch at Kiel

India

The ATV project has seen progress, and construction of the first vessel in the Arihant class continues. Speculation continues that this will become accepted as a "technology demonstrator" rather than an operational asset, and that there will be three hulls in the class. It is believed that the submarine is derived from the Russian Victor/Akula classes. The boats are being built jointly by the state-owned Defence Research and Development Organisation (DRDO), the Department of Atomic Energy (DAE), the private Mumbai-based defence contractor Larsen and Toubro and the Indian Navy (IN).

The slippage in the programme to locally build six Scorpène submarines at Mazagon Dock Ltd under a technology transfer agreement signed with France in 2005 has continued. In August 2009 IN sources told Jane's that the programme had been pushed back by 24-28 months. It is believed that the first of class had been laid down during 2010, but further progress has not been reported. The revised schedule would see the first boat in service around 2014-15 and the sixth in 2019-20.

On 29 September 2010 the US Senate approved the transfer of two Osprey-class minehunters (*Kingfisher* (MHC-56) and *Cormorant* (MHC-57)). Both were decommissioned in 2007 and are now awaiting transfer to India where they are likely to undergo upgrading and refit. No announcement has been made over further tranfers/sales to complete the requirement for 10 vessels.

Japan

The Souryu-class SSK construction programme for the Japan Maritime Self-Defense Force (JMSDF) has continued and the second submarine was commissioned in March 2010. The third boat, *Hakuryu*, is expected to commission in early 2011, and the fourth hull has been launched.

The *Hakuryu* during its launch ceremony at Mitsubishi Heavy Industries, Kobe (source: Japanese MoD)

Concern over the threat from North Korea and China has seen a revised defence strategy that includes increasing the submarine force. The Mid-Term Defence Programme review has called for an increase in the Souryu-class numbers from five boats to 11, matching the number of Oyashio-class boats. This is the first Japanese SSK class fitted with AIP from build (using four Stirling engines in each) and the boats boast almost double the range and endurance of the older Oyashio-class.

Pakistan

The acceptance of the Agosta 90B submarine *Hamza* on 26 September 2008 gave Pakistan an SSK with an AIP capability. The MESMA system is to be retrofitted in the first two boats of the class, *Khalid* and *Saad* during their next major refits, from about 2011.

Pakistan wishes to acquire a further three AIP equipped SSKs. This plan has been under discussion and political scrutiny for three years with possible options quoted as the HDW Type 214, DCNS Scorpène, or even a Chinese design. Despite a planned start in 2010 no progress has been observed.

Sweden

A mid-life update for the two Gotland-class boats is to commence in 2010; *Uppland* and *Halland* will be refitted and return to service by the end of 2014. *Gotland* will remain in service but unmodified. Two Stirling Mk 3 AIP systems will replace the existing AIP Mk 2.

The HMS *Gotland* at sea

The SSK *Södermanland* completed her planned upgrade, which started in 2008 and her sister ship entered refit this year.

The two-year project definition phase for the Next Generation Submarine (Nästa Generation Ubåt/ NGU) or A 26 programme is on course ahead of a final decision on construction due in 2011. The decision to proceed to build will be significantly influenced by cost and the availability of a similar capability from other suppliers.

Sweden continues to evaluate the Kockums SAM 3 unmanned minesweeping drone, ahead of a possible RSwN in-service date around 2011-12.

Conclusion

As the cost of technological research continues to increase, there is a growing realisation of the need for inter-governmental collaboration, industrial teaming and consortia arrangements amongst manufacturers to deliver capability at sensible cost.

It is also evident that in contrast to the Cold War, the most significant contributions and technological advances are now emerging from non-defence sectors. Undersea exploitation has delivered significant progress in a number of fields and the entertainment industry has seen enormous progress in graphics and simulation. Many manufacturers are now developing in-house products at their own risk and looking to governmental endorsement to impact the overseas market as the quantity of directly government-sponsored work dries up.

The rapid incorporation of this commercial technology has only become a feasible option through the acceptance of Commercial Off-The-Shelf (COTS) standards over military standards and the evolution of open architecture in military systems. Across the defence environment, and especially in underwater warfare equipment, the scope to include upgrades and software and hardware changes is greatly eased by this progress at almost always reduced costs and in shorter timescales.

This End Of Year Report has been abridged. The full 10,000 word report is available from either Jane's Underwater Warfare Systems online or Jane's Defence Equipment and Technology Intelligence Centre.

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