Pervasive sound
A new paradigm for ASW sonar

making a difference
**Understanding the 21st century ASW threat**

It was during the First World War that the submarine first demonstrated its true potential as an ‘asymmetric’ weapon, and heralded a profound change in the conduct of naval warfare. A century on, the submarine threat endures. Operating in the acoustically challenging waters of the littoral, and around strategic maritime chokepoints, the submarine constitutes a potent anti-access and area denial threat that can deliver a military and political effect out of all proportion to its cost.

The latest generation of conventionally powered boats have married the intrinsic attribute of stealth with other tactically advantageous technology enablers: extended submerged endurance (<200m depth) environment of the littorals in which naval forces must increasingly operate. Characterised by a complex and fragmented seabed geography, significant non-uniformities in the water column, and high levels of background noise, these acoustically poor and contact-density conditions have historically complicated initial detection and, given the greater prevalence of non-submarine contacts, made classification far more difficult.

So, in an age where the sea is a superhighway for the global economy, and a manoeuvre space for naval units and combat logistics, submarines present a clear and constant risk. Accordingly, governments across the globe recognise the need to invest in a credible anti-submarine warfare (ASW) capability to deter or defeat the underwater threat.

Yet it is the case that traditional platform-centric approaches to ASW based on standalone monostatic sonar systems are expensive, consume disproportionate force structure and do not provide full coverage through the water column. To meet these challenges, and overcome the inherent limitations of legacy monostatic sonar systems, Ultra Electronics Sonar Systems has pursued a new and radically different approach to the ASW problem in the shape of the Integrated Sonar System (ISS). Designed to fully exploit the performance realisable from a fully integrated, multi-sensor, multi-frequency sonar system, and to make optimum use of information from all available sensors, the ISS is flexible, modular and inherently scalable to suit different platforms and specific operational requirements. Furthermore, it has been designed from the outset to provide maximum operator support by means of an intuitive, geographically-oriented Human Machine Interface (HMI) and embedded tactical decision aids.

**INTEGRATED SONAR SYSTEM**

**KEY BENEFITS**

- Increased probability of detection: because the ISS is able to transmit on multiple frequencies, and in multiple modes simultaneously, the probability of detection is significantly increased. This gives the operator increased confidence in classifying a submarine as a probable submarine.
- Wide area ASW surveillance: the incorporation of multistatic active processing, providing the ability to incorporate distributed sensors such as sonobuoys into the ISS, enables the detection and tracking of targets over much greater area than is possible with a traditional monostatic system.
- Reduced ship installation footprint: the ISS incorporates an active variable depth sonar, a Quad Receive Passive Array and a towed torpedo countermeasure into a single flexible tow which is steered on, and deployed from, a single lightweight (<10 tonne) winch. The result is a ship installation that saves weight and space, simplifies handling arrangements, minimises maintenance requirements and improves safety.
- Optimised Human Machine Interface: geographically-oriented, interactive and animated displays present the underwater picture in an intuitive and accessible format to maximise situational awareness.
- Integrated torpedo defence: the ISS provides seamless integration with torpedo warning and countermeasures.
- Scalable sonar implementation: the constituent components of the ISS can be installed as separate modules, or aggregated as part of an integrated ASW suite. This provides an opportunity to scale, and over time grow, a capability aligned to operational needs, platform requirements and budget resources.

**Delivering game-changing ASW capability**

Ultra’s ISS breaks the kill chain, providing the capability to detect and deter the threat submarine, and to defeat the heavyweight torpedo threat. The ISS is a single sonar with multiple sensors. Whereas previous sonar outfits have tended to operate as discreet and essentially independent systems, the ISS takes a more holistic, capability-led approach by fusing information from multiple sensors – both active and passive – into a single sonar picture. As such, it leverages two overarching concepts – Distributed ASW and Pervasive Sound – that have been developed and matured by Ultra over the past decade.

Distributed ASW is based on the exploitation of all ‘in-band’ sonar energy, from any source or receiver element, onboard or offboard, in a generic common processing engine. Pervasive Sound, building on the precepts of Distributed ASW, refers to sonar energy, which is diverse with respect to frequency, time, and space (depth or position), that can be detected and processed multistatically across a geographic area, with an emphasis on the realisation of multiple low-power sources rather than a few high-power sources.

The ISS is therefore able to receive and exploit raw sensor data from a multitude of active sources and passive receive arrays, both onboard and offboard. In capturing such and every fragment of acoustic energy, and so realising many more detection opportunities, the probability of detection, and of maintaining a robust track over time, is greatly increased through the integration gain achieved in processing.

Ultra’s transformative technical approach is founded on the company’s extensive background in sonobuoy processing and specifically the quantum leap in wide area ASW surveillance achieved by multistatic active processing techniques. The ISS leverages this approach to simultaneously process inputs and fuse data from both own-shp and offboard sensors to build a complete underwater tactical picture. Its design adaptively maximises water column ensonification, exploiting multiple sources and receivers, including mutually co-operating monostatic sonar systems.

Through matching of operating frequencies within its design, the ISS delivers bi-static sonar capability between the hull-mounted and towed array sonar elements (providing enhanced coverage above and below the surface layer). It also facilitates interoperability with other sensors on co-operating platforms, and incorporates multistatic ASW active and passive sonobuoy processing.

Ultra’s ISS also capitalises on the company’s rich heritage in reactive torpedo defence, from sensor to soft-kill countermeasures. The proven Sea Sentry surface ship torpedo defence (STSD) system, already selected by three navies, can be fully integrated into the ISS architecture, or implemented as a standalone system.
All-aspect ASW: explaining the ISS approach

The ISS has been designed to solve the ASW problem from all aspects by combining information from each individual sensor, and reaping maximum advantage of sensor diversity in frequency, time and space.

Inherently scalable, the ISS consists of one or more of hull-mounted sonar, active and passive variable depth towed array sonar, underwater communications, sonobuoy processing, torpedo detection and countermeasures, mine obstacle avoidance sonar and bathymetograph. These individual components are integrated in an open architecture founded on the OMG-compliant Data Distribution Service standard.

This distributed approach brings a number of advantages when compared with traditional monostatic sonar systems. Sharp negative thermoclines limit maximum detection range achievable by monostatic sonar, regardless of the power source level or directivity gain built into the system. Acoustically layered conditions may offer good detections in one layer, but virtually none in another, leaving the submarine with the opportunity to hide in sonar ‘shadow’ zones.

In contrast, the employment of multiple sources and receivers increases ensonification in all areas of the water column. Furthermore, remote sensors can be readily employed to plug coverage gaps.

Multistatic active processing provides the ability to utilise remote and distributed sensors to both enhance the probability of detection and increase the range of detection. Whereas a monostatic sonar has a co-located transmitter and receiver, which means it will only receive returns from one aspect, multistatic sonar uses widely separated sources and receivers. This expands the number of sonar paths, thus providing many more detection opportunities.

This separation of the active source from the receiver also brings a tactical advantage; while the threat submarine will be aware of active transmissions, it does not know where passive receivers are located and so cannot manoeuvre to avoid detection. Furthermore, transmit and receive sensors may be placed at various depths and relative ranges, making it very difficult for the submarine to exploit acoustic propagation conditions as it attempts to avoid detection.

Use of active sonobuoys confers a further advantage in that, unlike surface ship active sonars, the sources are stationary relative to the water. This makes it possible to detect relatively small target motions or Doppler.

The ISS incorporates the following key elements:

- **Hull Mounted Sonar**
  A dual-frequency hull-mounted sonar, based on innovative digital stave technology, providing both ASW and obstacle/mine avoidance capabilities.

- **Variable Depth Sonar**
  A modular, multi-frequency system incorporating a Dual Frequency Active Towed array and a Quad Passive Receive Array. The system uses flexible in-line elements to save on weight and space and simplify ship handling.

- **Multistatic Active Sonobuoy processing**
  An active and passive sonobuoy processing capability utilising traditional single buoy processing as well as multistatic processing techniques using multiple buoys for the detection, classification and localisation of submarine and torpedo threats.

- **Torpedo Detection, Classification, Localisation and Countermeasures**
  A comprehensive sensor-to-countermeasure capability combining a passive detection array and towed and expendable acoustic countermeasures. The system uses threat evaluation and tactical data to optimise evasive manoeuvres and countermeasures employment.

- **Single Flexible Tow**
  A single flexible in-line tow, using a lightweight single-drum winch, removes the need for dual or multiple tow streaming. It also minimises the space/weight footprint on the quarterdeck, reduces manning requirements and improves safety.
Optimising sonar operator performance

The adoption of an operator-centric HCI ensures that the full performance of the integrated sonar system can be realised.

Ultra has taken an innovative approach to ISS sensor processing, information display and operator support.

Sonar systems have traditionally required highly skilled operators to assimilate and interpret complex acoustic data presented in multiple standalone display formats. Understanding this complexity incurs a significant overhead with regard to operator training and increases the risk that the full capability of the system is not properly exploited because tactically useful information cannot be easily accessed.

Ultra has adopted a very different philosophy in defining an intrinsically geographic HMI for the ISS that is both relevant and accessible to a generation of operators well-versed in an ‘apps’ culture. By capitalising on continued advances in COTS data and signal processing, the company has engineered an operator interface embodying advanced automation techniques, an intuitive user-friendly dashboard style presentation, and an easily assimilated Plan Position Information display and operator support.

One innovative feature of the ISS is an embedded ‘Ping Wizard’ tool. This simplifies optimum active sonar mode selection according to the specific operational scenario and prevailing environmental conditions. This means that a large number of pings of various types can be in the water simultaneously.

Multistatic Ping Wizard display

detections or analyse the ‘energy map’. Automated filter settings aid pattern matching and situation assessment, with a zoom and drill-down facility available for analysis of specific contacts.

ISS sensor information is integrated at the acoustic, processing and display levels, the multi-source, multi-frequency processing capability available to the operator now allows for the correlation of individual detections, thus resolving the Acoustic Situation. Automation simplifies training and operation; several different sonars can be managed by one or two operators.

Contacts of interest are overlaid onto a geographic view, with the operator given the option to view geo-spatial overlays and multiple display filters to aid underwater situation integrated with track assessment, with a zoom and drill-down facility available for analysis of specific contacts.

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Embedded command planning aids enable the full exploitation of ASW sensors (for example, through the calculation of predicted bathymetric conditions and sensor performance). Marine mammal monitoring software is also incorporated.

The ISS can support the display of the full undersea tactical situation integrated with track data from the combat system. All sensor data captured by the ISS is recorded to facilitate replay, review and post-mission analysis.

Ultra Electronics has an outstanding track record in the delivery of capable and cost effective ASW solutions from which the ISS draws its core functional components:

- A multi-sensor variant of the ISS is being delivered by Ultra to meet the Integrated Sonar Suite requirement for Australia’s Hobart class Air Warfare Destroyer programme
- The UK Ministry of Defence has selected a variant of the ISS hull-mounted sonar for the Sunar 2050TR programme for the Royal Navy’s Type 23 frigate upgrade and, in due course, the Type 26 Global Combat Ship, with options for integration of hull-mounted sonar and towed array sonar processing.
- Ultra’s multistatic active processing module is being integrated into the Royal Navy’s Merlin HM.2 helicopter as part of a wide area acoustic upgrade.
- A variant of the Sea Sentry SSTD system, known in service as Sonar 2170, equips major Royal Navy platforms under a managed fleet rotation.
- The Sea Sentry SSTD system has been selected by Turkey for the MILGEM national ship programme, and for two new Landing Ship Tank vessels.

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Synthesising proven, low risk technology

Based on mature, off-the-shelf components, the ISS architecture is futureproofed for extension and growth.

The improved detection, classification and tracking performance afforded by the ISS puts ASW forces back on the front foot. The enabling concepts of distributed ASW and pervasive sound are transformative, but the technology embodied in the ISS is based on proven in-service equipment, high TRL sonar components and standard MOTS/ COTS products. The system is integrated in an open systems architecture, using generic high performance, multi-core processors or a common shared computing environment.

The end result is a flexible, affordable and low risk technical solution based on a generic open architecture that is inherently sustainable, mitigating hardware and software obsolescence impacts through-life. What is more, this architecture is both scalable and adaptable, enabling the exploitation of future technologies and techniques as requirements dictate.

This means that the ISS can keep pace with continued innovation in the ASW domain, such as increasing the frequency overlap between platform and offboard systems, and between surface ship and airborne systems. Furthermore, the incorporation of multistatic active processing offers the potential for rapidly deliverable low-cost ISS solutions for small surface craft. In this case, sonobuoys may be deployed over-the-side, by ships in consort, from small boats, and/or from unmanned vehicles operating at range.

Ultra is a customer-focused company with a long track record in successful programme delivery of large, complex projects. This pedigree includes hull-mounted and towed sonar systems, SSTD delivery and fleet rotation, airborne acoustic processing systems, and the design and development of both active and passive sonobuoys.

Therefore, Ultra has a proven through-life support capability, and is able to offer a range of in-service support solutions. This includes full-service Contractor Logistic Support arrangements designed to ensure the delivery of capability to the front-line when and where required.
Sonobuoy miniaturisation for unmanned ASW

Ultra is leading work to demonstrate and de-risk small-size sonobuoys suitable for carriage and deployment from unmanned vehicles

Unmanned vehicles will play an increasing role in the future maritime battlespace as navies move away from legacy platform-based thinking and embrace new operational concepts underpinned by remote offboard systems.

ASW is no exception, with the unmanned air vehicles (UAVs), unmanned surface vehicles (USVs) and autonomous underwater vehicles (AUVs) offering the potential to serve as payload carriers and sensor nodes. In particular, long-endurance UAVs bring new options for sonobuoy delivery at range to support wide area underwater surveillance based on multistatic active processing.

However, the size and weight of current generation sonobuoys impacts significantly on UAV payload/radius. To overcome this constraint, Ultra Electronics Sonar Systems has worked with the UK Defence Science and Technology Laboratory (Dstl) and industry partners to explore the potential for Sonobuoy System Miniaturisation.

Phase 1 of the Sonobuoy Miniaturisation project involved system-level studies to quantify the effects on performance, and examine integration with UAV platforms. This stage resulted in the development of a series of high-level design options for miniaturised sonobuoys and associated UAV payload pods. During Phase 2, Ultra has de-risked key technologies and built hardware prototypes for demonstration. This outcome of this work has been to mature designs for a new generation of ‘G-size’ and ‘F-size’ buoys, which are ½ and ⅓ of the standard NATO ‘A-size’ buoy usually carried on large maritime patrol aircraft but with equivalent or better performance. A planned Phase 3 will fully demonstrate Sonobuoy System Miniaturisation technology and capability.

Under a separate Dstl study package, Ultra has successfully demonstrated the deployment, operation and recovery of a tethered ‘dipping sonobuoy’ from a novel solar-powered USV platform. This demonstration was based on a ruggedised A-size CAMBS buoy, but the concept is adaptable for use with the G-size and F-size source and receiver buoy concepts emerging from the Sonobuoy Miniaturisation project. Capitalising on these innovations in sonobuoy technology and deployment, the ISS architecture offers the potential to realise the vision of a remote ASW network, using tactical networks and satellite links to interconnect various levels of sensor data (raw, processed and track). This would exploit the use of unmanned vehicles as sensor and weapon carriers, while allowing tactical control and ASW data analysis to be performed from a single platform or shore facility.