WHITE PAPER

New Advances in Sonar Diver Detection Systems

The Hidden Threat Facing Military and Civilian Ports

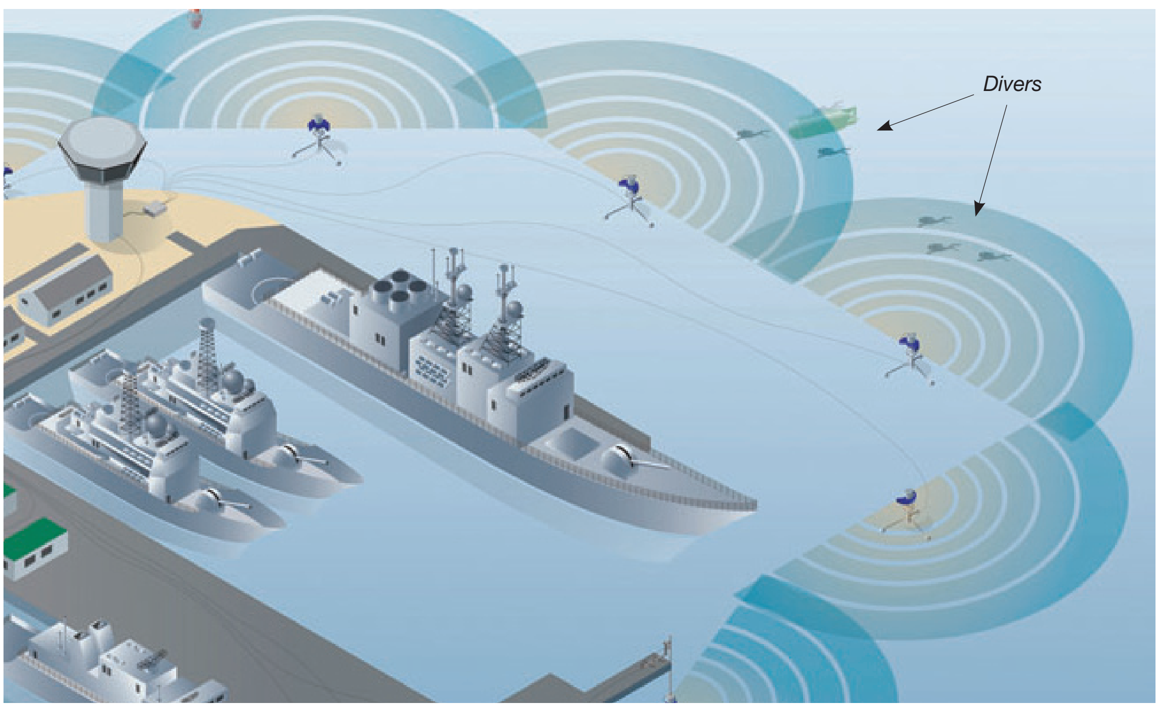
Kongsberg Mesotech Ltd., Port Coquitlam, BC, Canada
Km.sales.vancouver@kongsberg.com
www.kongsberg-mesotech.com

The Mumbai terrorist attacks this past fall have served to highlight a potential Achilles' heel in the soft, watery underbelly of military and civilian port defences, making it clearer than ever that these areas are not well protected against incursion by terrorist or enemy special forces divers. Unfolding events continue to confirm the sub-surface weakness of ports — a soft target since at least World War II, when navy frogmen first began to use them as points of attack.

In May 2008, for example, news reports indicated that the Tamil "Sea" Tigers had successfully blown up a Sri Lankan naval ship in the heavily guarded Trincomalee harbour with a powerful pre-dawn undersea explosion. The Tigers claimed responsibility for the attack as the work of their underwater naval commandos.

And in another attack in March 2008, a sea mine sank a Sri Lankan naval fast attack craft off Nayaru. Again, the Tigers claimed responsibility for a sea battle — launched by their Sea Tigers suicide squad — that left three of its members and fourteen Sri Lankan sailors dead.

While the exact means of this attack are unknown, experts speculate that a human suicide torpedo may have destroyed the ship. Conversely, a group of divers may have affixed a mine to the hull of the ill-fated vessel (the suicide squad could have been dropped off hours earlier to await a strike opportunity). Whatever the strategy, the prospect of enemy divers entering ports or coastal waters undetected to attack naval and civilian ships or piers is troubling, not only for navies and military forces but also in



This graphic of navy vessels moored alongside demonstrates how a diver-detection system can be set up as a security perimeter around these high-value assets to protect against enemy divers and submersibles. The sonar system is mobile and can be quickly deployed from a pier, ship or truck and moved as required to provide full coverage.

terms of the safety and security of civilian global trade and shipping.

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"The increased use of divers to attack from the water demonstrates a belief that underwater access presents an easier way to enter ports and attack ships anchored at dockside," said Phil Andrew, manager of underwater security for Kongsberg Mesotech, a leading global provider of sonar technologies that has provided sonar to the U.S. Coast Guard through its Underwater Port Security Project. "Drug smuggling and the rise of terrorist threats over the last ten years have increased the need to monitor the underwater lanes of our ports using sonar and other technologies. Fortunately, recent sophisticated innovations are helping to address this problem."

IMPROVING THE SPEED AND QUALITY OF DETECTION IS CRITICAL

In the past, and still in many places today, diver confirmation has been performed by scrambling a crew of combat divers in a high-speed RIB craft. The crew enters the water and searches the area, an expensive and time-consuming task. Sonar saves money and — even more important — time.

In detection, time is of the essence: often these hostile divers are moving rapidly, assisted by underwater vehicles. To thwart a sabotage mission, a hostile diver's incoming signal must not only be separated out from all the extraneous underwater objects, it must also be analyzed as quickly as possible. As was seen in Sri Lanka, seconds can equal life or death in these situations.

In light of the increased threat, waterside security issues are receiving much greater emphasis than in the past. It is very clear that active, high-frequency, multi-beam sonar technology is the most effective approach for protecting high-value targets from underwater threats.

Complementary sonar technologies, such as limited range "3D" sonars, can lend support to this effort. However, the number of 3D units required to secure an area make this prohibitively expensive. For restricted, high-reverberation environments where multi-beams cannot operate effectively, e.g., canals, single-beam scanning sonars can focus a narrow beam to either supplement diver detection systems or provide highly mobile sonar.

While diver detection ranges have been pushed out considerably over the years, they are now approaching the theoretical limits restrained by the physics of diver detection. However, where advances do continue to be made is in the reliability and consistency of that detection. Technology improvements in sonar systems over the past decade have focused on improvements in these key areas: hardware, tracking software and data fusion and systems integration.

HARDWARE ADVANCES INTO PORTABILITY AND INCREASING RANGE OF SONAR

The most readily apparent advance in hardware over the last few years has been toward expanding the horizontal field of view — from 90 degrees to 180, and now to 360 degrees.

This enables the user to monitor a wider field or search a larger area more quickly. Interestingly, some sonar technologies have the ability to adjust the vertical field of view, enabling the beam to be expanded or narrowed in the vertical dimension and even "steered" up or down to address various monitoring challenges and range conditions.

U.S. Navy studies have confirmed that the frequencies best suited for diver detection surveillance lie between 85 and 100 kHz. Kongsberg Mesotech's DDS 9000 operates in this range.

Additionally, the development of smaller, mobile sonar units is another excellent advance that allows sonar units to be moved around to different locations in the port, or to a dock to protect temporary sites (such as a visiting, high-value ship or an important event on a pier).

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In addition to the use of multi-beam technology, single-beam sonar can supplement a standard multi-beam installation in two ways: first, by providing coverage in confined areas; and second, as an imaging tool for providing short-range diver confirmation. Single-beam (mechanically scanned sonar) operates much like radar sweeping an area, with a narrow, high-intensity beam that provides high-resolution images — and with the Kongsberg 1071 can provide detection and tracking functions.

Multi-beam sonar, on the other hand, "fires" a number of beams simultaneously to cover a broader field of view with a single "ping," operating at frequencies ranging from 70 to 200 kHz. Operating at lower frequencies than scanning sonar — but with higher energy — results in a multi-beam sonar with a longer reach, increasing its effectiveness in diver detection. However, there is a trade-off in range versus resolution.

Advances in computer hardware — particularly the development of dual and quad processors — have meant that processor hardware cost and size have been dropping steadily. The widespread availability and reliability of network servers can now both reduce costs and improve system reliability, delivering higher-quality monitoring. In addition, "blade" servers enhance system reliability through distributed processing, with the capability to re-assign tasks to individual processor boards (blades) if there is a problem, automatically providing processing backup through redundancy.

Confirmation of divers can be accomplished through the use of a small, torpedo-like ROV that launches at the push of a button to investigate a threat, navigating automatically to the target on a steady stream of data from the diver detection system — a capability that was unheard of just a few years ago. From there, the target is dealt with according to protocol and, if simply an innocent swimmer or diver, given the opportunity to leave a high-security zone. Underwater "loudhailers" are now available to speed this process along.

SOFTWARE IMPROVES IMAGE RESOLUTIONS AND REDUCES FALSE ALARMS

One of the biggest goals in diver detection has been reducing the number of false alarms triggered by marine life. There are two discrete types of software programs employed in the diver detection process. The Sonar Processing software operates the sonar head and processes the returned data.

Given the potential negative outcomes, the purpose of today's technology is to offer as much early warning as possible toward prevention of an attack.

The other, referred to as *Automated Detection and Tracking* (ADT) software, utilizes this data to detect, track and classify potential threats. The built-in algorithms incorporate elements of artificial intelligence to logically select only those targets with the characteristics of underwater or surface swimmers. Other detection parameters may be incorporated to broaden the variety of targets considered threatening. Advances in this area include better reliability, fewer false alarms, and the ability to specifically identify the target as a SCUBA, vehicle-assisted or CCBA diver.

It is possible to use multi-beam or single-beam sonar without automatic target detection and tracking software, but this requires a significant contingent of trained operators to constantly view the sonar images. These skilled people must also work in short shifts in order to maintain alertness, mandating an increased and ongoing investment in training and staffing — an unrealistic and costly expectation.

One of the major challenges navies face today is a shortage of qualified personnel to operate the detection systems. Increasingly, they are looking for sophisticated yet easy-to-use technology, both to fill the gap and to aid in training. One plus of some of today's technologies is the ability to play back diver tracks in simulation for training purposes.

The recent development of significantly more sophisticated auto-detection algorithms and advanced computing power means that the reliability of these systems is improving rapidly, and commercially available, off-the-shelf or COTS technology has now reached a level considered acceptable for long-term naval use.

The U.S. Navy developed one of the earliest and most effective anti-frogman systems: the AN/WQX-2. In this system, the sonar head is combined with a sonar processor and auto-detection and tracking software to distinguish divers clearly. More recently, Kongsberg Mesotech has combined the latest generation of sonar head, the DDS 9000, with its Defender II automated detection and tracking software. Output of targets and target track data can be fed into the Defender X software, which has the ability to combine the data from up to ten systems.

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On an even larger scale, data from diver detection sonar, radar and Automatic Identification Systems (AIS) can be amalgamated to provide a much larger picture of Maritime Domain Awareness using the C-Scope software from Kongsberg NorContol.

In addition to the auto-detection and tracking of targets, today's advanced software is capable of displaying the output in a standard military format to enable a surveillance system display, or to be output to other command and control (C2) systems. The benefit here is that all tracking data on targets can be merged on a single C2 display screen for fast action. Once the target is detected, the operator should receive an alarm, along with additional information regarding the target's tracking path.

After detection, the system will make a series of signal measurements to determine whether the target meets the criteria of the tracking algorithms. If it does, it is up to the command structure to decide how to react to the approaching threat. Given the potential negative outcomes, the purpose of today's technology is to offer as much early warning as possible toward prevention of an attack.

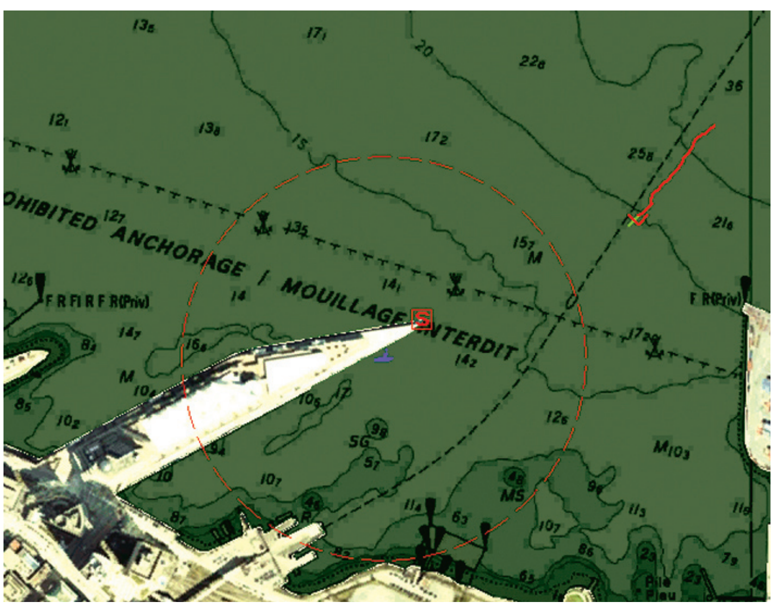
In today's expanded military environment, where terrorists are taking the attacks to more vulnerable port cities, shorelines and ships at dockside, a few seconds can literally mean the difference between a propaganda victory of sinking a ship and the successful elimination of a diver threat.

DATA FUSION AND SYSTEMS INTEGRATION

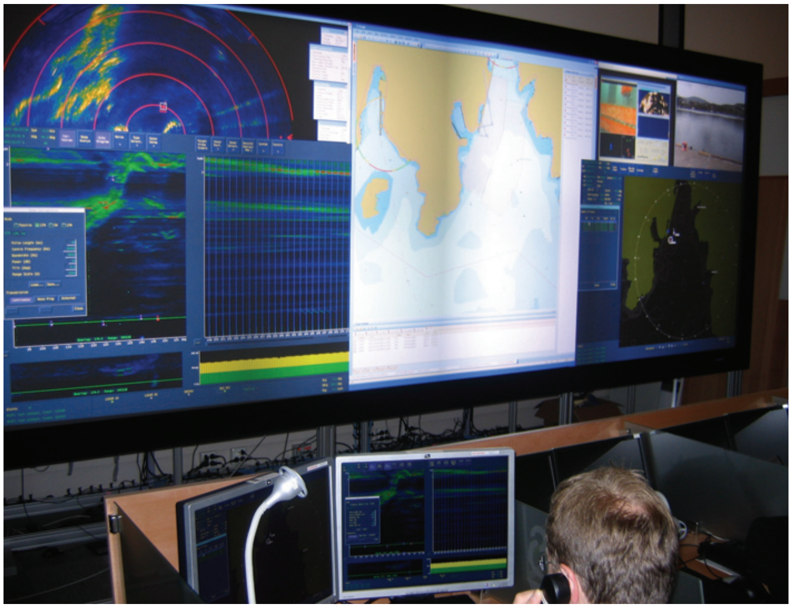
The dual challenge of detecting a target as small as a human diver at extended ranges and maintaining constant contact are being addressed through the combination of data from multiple sensor types. Using active and passive sonar in conjunction with radar or other sensors can increase the probability of detection by integrating complementary functions.

One example is the combination of surface radar, sonar and AIS data in systems to provide exactly this type of "Maritime Domain Awareness" (MDA), identifying friendly surface craft, unknown surface craft and underwater threats.

This concept can be extended further by providing a complete system of overall MDA to port authorities and law enforcement as in Kongsberg's C-Scope software. These systems typically involve multiple sonar, radar, EO/IR (electro-optics infrared), AIS (automatic identification systems), and satellite data inputs. These features operate on a real-time basis, working together in a multi-faceted,



This screen combines a Defender II with electronic chart display (ECD) of the Vancouver harbour and Canada Place cruise ship terminal. The red line tracks the movement of a diver toward a designated ship (blue icon) docked at the facility. S *designates the location of the sonar head.*



In a command centre setting, it's useful to integrate many different types of data, including multiple sonar types both active and passive, radar, electro-optical (EO) and infra-red (IR).

What's termed "data fusion" combines and evaluates all the inputs shown on the wall display screens into a single "picture," while enabling fast, at-a-glance viewing for confirmation and quick decision-making. In this case, a variety of different Kongsberg technologies and products have been integrated into one system.

fully integrated system for dealing with surface and subsurface attacks.

Encouragingly, integrated advances in hardware and software technologies have made diver detection systems much more effective in addressing port underwater security issues. As other terrorist groups observe the exploits of organizations like the Tamil Sea Tigers and continue to refine and enhance their own techniques and tactics, the possibility exists for a large expansion in port attacks and terrorism. Thankfully, advances in diver detection systems are keeping pace in the race to protect the soft underside of our global ports. ■

ABOUT KONGSBERG MESOTECH LTD.

Kongsberg Mesotech Ltd. (KML) is a division of Kongsberg Maritime Subsea and a world leader in sonar diver detection systems and technologies. KML supplies a worldwide customer base with a range of products for defence, fisheries, oilfield, scientific and other underwater acoustic applications. Products are designed and manufactured in Port Coquitlam, British Columbia.

Kongsberg Defense and Aerospace, with Kongsberg Maritime, forms Kongsberg Gruppen, a publicly traded company on the Oslo stock exchange.

1598 Kebet Way
Port Coquitlam, B.C.
V3C 5M5 CANADA

TEL +1 604 464 8144
FAX +1 604 941 5423
EMAIL km.sales.vancouver@kongsberg.com
WEB www.kongsberg-mesotech.com

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