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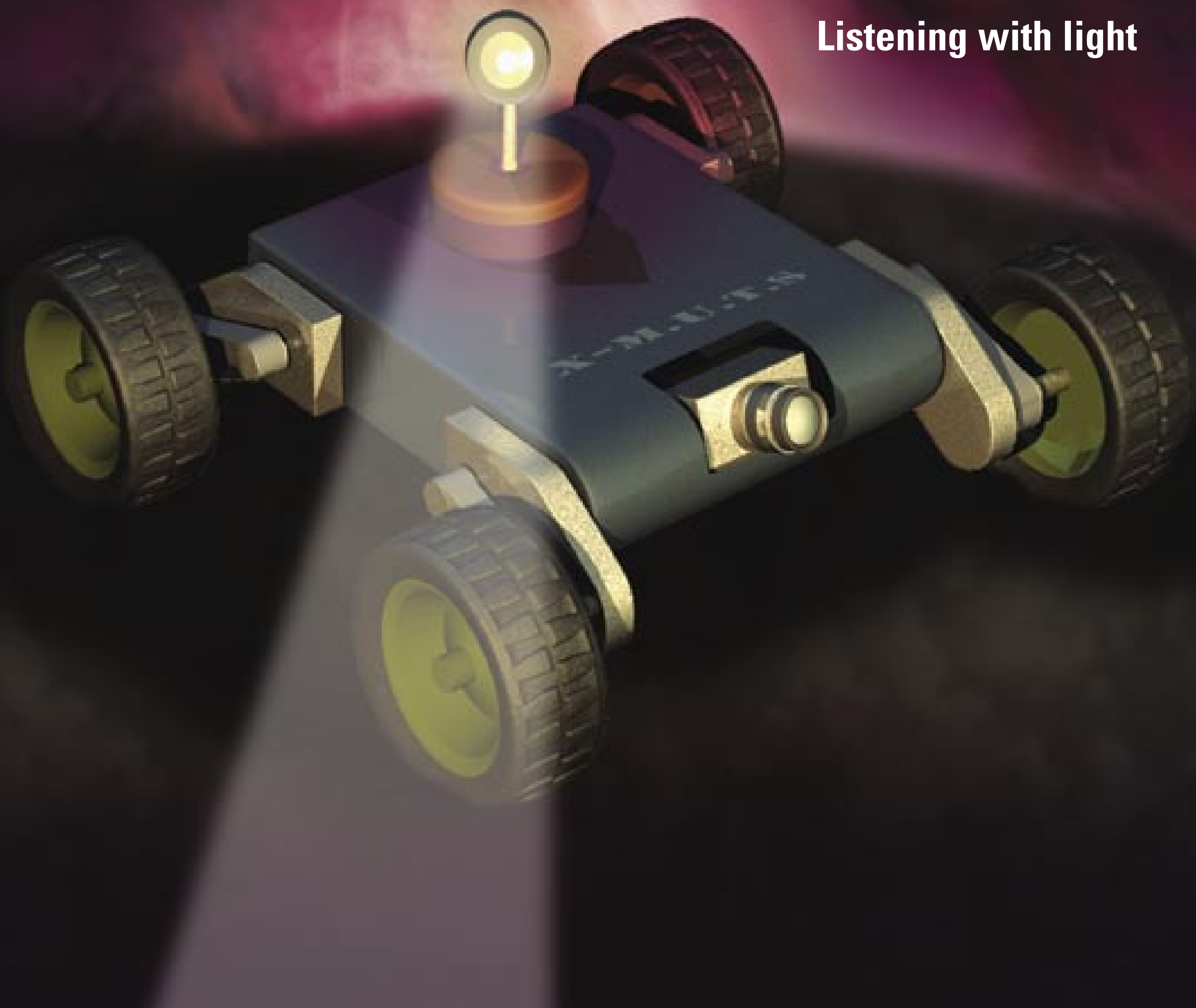
Smart health care for structures

Robots to do dirty, dangerous chores for Army

Listening with light



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Defence Science and Technology Organisation

The Defence Science and Technology Organisation (DSTO) is part of the Department of Defence and provides scientific advice and support to the Australian Defence Organisation. DSTO is headed by the Australian Chief Defence Scientist, Dr Roger Lough, and employs about 2100 staff, including some 1300 researchers and engineers. It is one of the two largest research and development organisations in Australia.

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Studying the Evolved Sea Sparrow Missile in captivity

A new capability has recently been commissioned at DSTO Edinburgh to put the Evolved Sea Sparrow Missile (ESSM) through its paces in different operational scenarios, obviating the need for a large number of costly live firing exercises.

1. ESSM being launched during live firing exercise.
2. Simulation research setup for ESSM in DSTO's Systems Simulation Centre anechoic chamber.

The ESSM armament is deployed on Navy ships to defend against threat missiles and aircraft. In today's increasingly hostile maritime environment, it plays a crucial role in protecting Australian Defence Force (ADF) assets and personnel.

The ESSM was developed from the earlier NATO Sea Sparrow Missile by a consortium of ten nations, in which Australia was a major participant. It is the only guided weapon in the ADF inventory that was partially developed in Australia. Australian companies BAe Systems and ADI, together with DSTO, were significant players in the development of the ESSM.

Development and operational testing of the ESSM was completed in 2002, with the first launch from an operational warship conducted by HMAS Waramanga in the West Australian Exercise Area during April 2003. SAAB Systems undertook the process of integrating the ESSM into the ANZAC 9LV combat system.

Method of operation

The ESSM is a semi-active radar guided missile. After identifying a target, the launch ship illuminates it with a narrow beam of radio frequency radiation. When the missile is launched, its seeker searches for the illumination power reflected from the target, and then homes in on this signal through to intercept.

A feature of this type of system is that the weapon is very closely integrated with the ship combat system and its various sensors. These are used to determine the target information required to launch a weapon and support it through to intercept, and also assess the outcome of the engagement. As such, the missile is just one element of this system of systems, and performance testing is both complex and crucial.

The challenge here for Australian investigators, explains DSTO researcher Dr Colin Coleman, is that the guidance section is of US origin, and is provided to the ESSM consortium nations as government furnished equipment. Consequently, full details of its operation are not generally available to the users for developing tactics and integrating it into ships' combat systems.

Testing and evaluation

"Since testing by live firings is costly and limits the range of scenarios that can be explored, a much smarter way of testing missile performance is to use dynamic hardware in the loop (HWIL) simulation."

"Although the initial costs of setting up a laboratory to perform such testing are high, it's possible to simulate a large number of test flights in a wide range of scenarios very economically. The fidelity of this testing is very high because it makes use of actual missile hardware," he says.

DSTO's Systems Simulation Centre (SSC) has been developed specifically for the HWIL testing of ADF weapons. The ESSM is expected to be a major user of this facility throughout its operational deployment with the RAN.

HWIL testing of the ESSM will include the design and verification of live firing profiles, investigation of anomalous behaviour in practice firings or operations, development and evaluation of weapon tactics, support for combat system integration activities, verification and validation of digital missile models, and performance assessment in an operationally realistic environment.

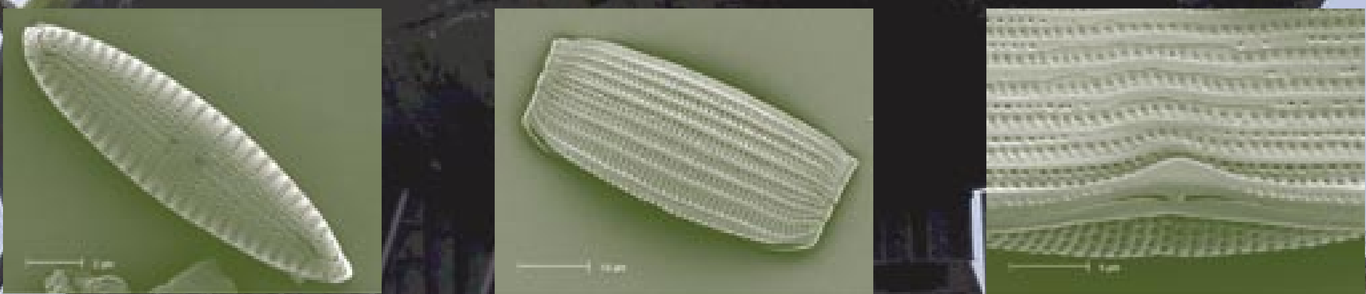
The first closed loop tests of ESSM in the SSC were conducted in March 2005.

The ESSM will be used as the primary self-defence weapon for all ANZAC frigates and for the FFG 7 class following the current upgrade program. It is also expected to be an important component of the weapon suite for the Air Warfare Destroyer, scheduled to enter service in 2013.

Innovative ways to keep bio-fouling at bay

The growth of marine organisms on the hull and internal piping of ships has long been a major problem for Defence and commercial operators alike. Marine growth on hulls causes increased drag that can boost fuel costs by up to 20%, and bio-fouling in seawater pipes can lead to accelerated corrosion and failure of critical cooling systems. DSTO is exploring a range of approaches with the promise of greater effectiveness and more benign environmental side effects.

Bio-fouling on Collins Class submarine.



Microscopic slime-producing diatoms (Photos courtesy University of Melbourne).

The introduced fanworm Sabella spallanzanii.

Hydroides sanctaecrucis *on hull of vessel.*

DSTO researcher John Lewis gives a measure of the scale of the problem.

"Marine organisms rapidly colonise any surface immersed in the sea. When this surface is part of a ship hull, or internal piping of a ship's cooling water system, the bio-fouling growth can impact severely on ship operation and performance."

"In the early 1990s, the annual cost of fuel used by the US Navy was estimated at around $500 million, of which $75 to $100 million was attributed to drag caused by fouling organisms."

"Similar penalties beset commercial shipping. If just 5% of the hull of a 250,000 tonne tanker is fouled, fuel costs increase by 17% or more. Even a layer of microbial slime 1 mm thick can increase hull friction by 80%."

Traditional control measures

Control of bio-fouling on ship hulls and in seawater pipe work to date has mostly involved the use of biocides. Antifouling paint on the hull provides protection through a constant release of control chemicals, and to protect internal piping, intake seawater is dosed with copper or chlorine.

These antifouling biocides are now coming under increasing scrutiny because of the perceived harm they do to marine communities in the surrounding environment. Antifouling paints containing the agent tributyltin (TBT) were recently banned under a new International Maritime Organisation Convention (see *Australian Defence Science Volume 10 Number 2*) and the primary alternatives, copper-based coatings, are under close scrutiny.

Meanwhile, the significant ecological and environmental impact of invasive marine pests in Australian coastal waters, such as the northern Pacific seastar, Japanese kelp, and the European fan worm, urgently requires that substitute technologies be found to prevent unwanted species transfer but without themselves causing environmental damage.

Some of DSTO's research projects into environmentally-friendly solutions are being carried out within the organisation alone, while others are being conducted in collaboration with various Australian universities.

Surface microstructure deterrence power

Collaborative research with James Cook University is investigating the role of surface micro-topography in preventing the attachment of fouling organisms to a surface.

The shells of local mussels are often observed to be free of fouling despite the heavy fouling of nearby surfaces. Examination of shell surfaces by scanning electron microscopy has revealed ridges several microns wide over the shell surface. This has been found to make the critical difference.

A more extensive study of tropical shellfish has confirmed that most fouling-free shells have some form of micro-topography on their surfaces. Silicone copies and artificially constructed mimics of the more effective surfaces also show fouling resistance.

Foiling sticky diatom biofilms

At the University of Melbourne, a second collaborative project is underway to investigate the mechanism of adhesion of diatom biofilms to low surface energy, hydrophobic coatings.

Low surface energy coatings, commonly known as fouling release coatings, reduce the strength of adhesion of attaching bio-fouling organisms so that fouling is sloughed off the hull when the ship is underway. Such coatings are presently seen as the most promising non-toxic alternative to biocidal antifouling paints.

However, some diatoms still adhere to these surfaces, forming a slime that alters the surface properties and interferes with the fouling release performance. Studies undertaken to understand the mechanism of diatom adhesion and the chemistry of diatom glues will enable more effective foul release coatings to be developed.

A related collaboration with the University of New South Wales is looking at the effect of bio-fouling on supra-hydrophobic coatings, and the enhanced antifouling properties offered by nano-modification of these surfaces.

Sound and vibration measures

Studies are also being undertaken within DSTO on the effects of surface vibration and sound on the attachment of bio-fouling organisms. Anecdotal evidence suggests that sound can prevent fouling, but little scientific research has been undertaken on this phenomenon.

Field experiments, using both arrays of small speakers and piezo materials, are being performed on the DSTO marine test raft at Williamstown in northern Port Phillip Bay, Victoria, and some promising results have been achieved in the first summer of testing. The effectiveness of bubble curtains in preventing fouling attachment is also being investigated on the Williamstown raft.

The research overall indicates that future bio-fouling control without biocides is unlikely to be achieved by a single approach. A combination of several of the innovative technologies under investigation by DSTO may provide the answer – for example, micro-texturing a hydrophobic surface onto a material that contains micro electro-mechanical system devices to generate surface vibration.

Theatre Broadcast System sets world standards

The development of DSTO's Theatre Broadcast System (TBS), using commercially available technology, ranks as one of the most outstanding success stories for the organisation. The TBS gained acclaim not only for providing better information services than previous military versions but also for establishing operating protocols taken up by other military systems.

According to DSTO researcher Philip Stimson, "The impetus for development came from observations made during the first Gulf War when it was noted that broadcasts similar to commercial television could be used to improve or enhance military situation awareness."

"The military satellite communications systems were duplex, requiring two-way connections between ground terminals and the broadcast station. The field hardware was expensive, bulky and required specialised support."

Meanwhile, commercial satellite transmission systems were broadcasting high bandwidth streams of video and data using compact and inexpensive equipment, made possible by new-generation satellites with the power and bandwidth to deliver broadband multimedia to receiver dishes as small as 45 cm in diameter. In home settings, a narrow band request link via phone line provided users with simple messaging capability for pay TV functions such as authentication, program selection and billing, and for satellite internet access.

This asymmetric system was the technology the DSTO team sought to adapt for ADF purposes. The project involved two basic components: the development of a suite of TBS hardware using commercial off-the-shelf technology, and the development of a TBS system of information management software to optimise data transfer.

PUSH and PULL

The operating procedures DSTO researchers devised for TBS involved two different modes. It could be used to provide data to deployed forces in anticipation of needs, the PUSH concept, or it could be provided in response to requests from personnel in the field, the PULL concept.

Information sent on a PUSH basis could be made available in different ways. It could be provided on a case-by-case basis where information needs are individual and one-offs, or it could be provided as an automated repetitive process, such as the frequent delivery of weather information to all users in theatre. The effectiveness of this approach was dependent on the extent to which user needs could be anticipated, the extent of preplanning, and on the judgement of strategic commanders in response to changed tactical user requirements.

Where needs could not be anticipated, the PULL capability allowed deployed users to request unplanned broadcasts of information. These requests could be made in two ways – via voice or email to Request Manager personnel, which entailed a delay in response due to the manual processing required, or via user interface instructions, such as mouse clicks, to automated agents that carried out web browsing, database retrievals and data mining tasks and broadcast the findings in real-time, providing users with what amounted to interactive internet functionality.

The request links used varied according to the requirements of the deployments involved. Some used only voice links, some required minimal data links, and others required medium data rate permanent connections. These were implemented with security encryption via fixed line or satellite communications.

Information caches

The information broadcast by TBS was generally received by all units in caches several gigabytes in size. Having this information in cache gave users the advantage of being able to access it immediately at any time without needing to activate request links, meaning that operations could proceed during radio silence.

However, the large volume of information broadcast to all units needed to be carefully managed to avoid overload of both users and storage systems. This was achieved using a combination of customised user profiles and a system of cache management known as 'intelligent caching'.

A user-defined local profile specified the range of information of interest by variables such as location, keyword or time. All information was initially cached by each receiver terminal, but after the cache storage was filled, information not matching the profile of a particular terminal was automatically discarded.

The process of encryption for security provided another means of compartmentalising broadcast information flows.

The services offered on TBS were file transfer, data streaming access, a video/audio channel, and an audio channel. The uses to which the system has been put include transmission of ADF Command and

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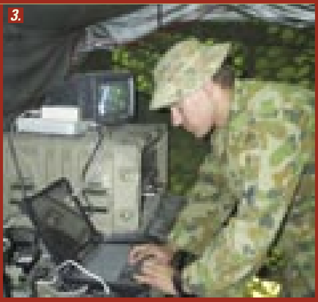

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1. Christopher Cocks, Philip Stimson and Andrew Coutts (3 of 8 research team members) with DSTO's prototype TBS receive unit.

2 & 3. TBS on deployment with Army during Exercise 'Tandem Thrust 2000'.

4. DSTO researcher Andrew Coutts with TBS receive unit in East Timor.

5. TBS on deployment with ADF during UN Peacekeeping Mission in East Timor.

Control support information, situational awareness pictures, military geographic information, other imagery and video, command briefings, and entertainment TV and radio.

The development process

The evolution of DSTO's system involved a spiral development path with the equipment being refined in six major cycles of trials, evaluation and modification.

During one such trial, Exercise 'Predators Chariot' in 1999, the Army top brass were introduced to the system, and immediately recognised the valuable assistance it could give to ADF's upcoming peacekeeping mission in East Timor. DSTO was requested to produce four receive units for this mission, used by forces in Dili, Ocussi, Balibo and Suai. A member of the DSTO team accompanied the units on deployment in a support role.

"The TBS was recognised as providing major contributions to the effectiveness of the whole peacekeeping operation, particularly in the more remote areas outside Dili," says Stimson.

Following the outstanding success of the technology on operations in East Timor, senior Army personnel were keen to have the development of the operational system fast tracked. The Defence Materiel Organisation took over the production of TBS receive units at the end of 2000, continuing development of the Ku-band capability and also building versions that used the Ka-band transponder on the Optus C1/D satellite. Twelve receive units were manufactured.

TBS has since been deployed on Army operations in the Middle East and the Solomons, and for the humanitarian relief operations in tsunami-ravaged Banda Aceh at the beginning of 2005.

Receive units and Transmit/Receive units incorporating a satellite request link have also been fitted to Navy ships including HMAS Sydney, Melbourne, Manoora, Gascoyne and Kanimbla.

Now that the system is operational, DSTO recently celebrated the successful completion of the TBS development and its technical support to the project.

World-leading system

One of the problems DSTO researchers considered when developing the TBS was that the US and UK military versions of these systems used different operating standards, impeding their ability to exchange and share information.

An exercise was conducted in 2002 (JWID 02) to establish whether interoperability between DSTO's TBS and the US Global Broadcast System (GBS) would be possible. It successfully demonstrated that Australian sourced information could be delivered over the GBS and US sourced information delivered over TBS, and commonly sourced information delivered over both.

One notable outcome of the exercise was that the US eventually decided to change its GBS architecture to line up with the Internet Protocol (IP) used by DSTO, making this now the standard architecture for Allied and NATO forces. The UK too has adopted this standard for its Defence Broadcast System.

In JWID 2003 a common IP-based Coalition receive suite was developed and demonstrated by the US GBS and Australian TBS Project Offices. This provided a standard architecture for future systems that was aligned with recently developed NATO Standardised Agreements.

Smart health care for structures

DSTO has made significant advances in the development of a system for monitoring the structural health of ADF ships, aircraft and vehicles. The system uses a range of sensors to detect different forms of degradation, with the sensor data being managed by an electronic device known as the Universal Sensor Interface (USI). The advent of the USI, a key component of the system, enables more effective platform maintenance procedures based on environmental and structural monitoring.

The challenge behind the DSTO research into smart structures is the universal truism that all platforms (ships, aircraft, vehicles) degrade due to fatigue, corrosion and general 'wear and tear'.

This degradation has been traditionally managed by regular inspections and timed replacement, but these procedures are costly in terms of personnel, downtime and the fact that still-serviceable components are being routinely replaced.

More recent approaches for platform servicing involve a regime of monitoring to determine the health and condition of components and structures, with maintenance being performed on an 'as required' basis. The benefits are lower costs, higher safety and, as an added advantage, a better appreciation of how operations affect the life of a platform.

Sensors that read structural damage

DSTO has developed a number of miniature sensors for monitoring corrosion, typically 10 mm by 15 mm in area, and 120 microns thick, utilising features 20 to 150 microns in size created by laser micro-machining.

They can be mounted either on top of a structure, or under protective sealants or paints applied to the structure. A primary feature of these sensors is that they are fabricated from the same material as the structure being monitored. In this way, the corrosion on the sensor can be directly related to that on the structure, unlike other sensors proposed for corrosion monitoring. Devices have been made from aluminium alloy, copper, titanium, gold, platinum and steel, and the technique is applicable to any metal foil.

DSTO is also working on the development of new strain sensor materials.

The measurement of load in a structure is a powerful indication of its condition. The development of cracks, corrosion or other damage generally leads to a change in load distribution. Traditional metal foil strain gauges are not suitable for long-term distributed monitoring of load since they are prone to fatigue, require relatively high electrical power input for operation, and need individual wiring back to sensitive electronics.

The aim is to develop low power, high sensitivity, high fatigue-addressable strain gauges for long term embedding or attachment to structures, capable of operating for a period of years. Devices made of polymers, laser micro-machined metal and silicon are in various stages of development and assessment.

The USI that reads the sensors

The USI is a low profile, robust module that enables a variety of DSTO and commercial off-the-shelf (COTS) structural and environmental monitoring sensors to be interrogated.

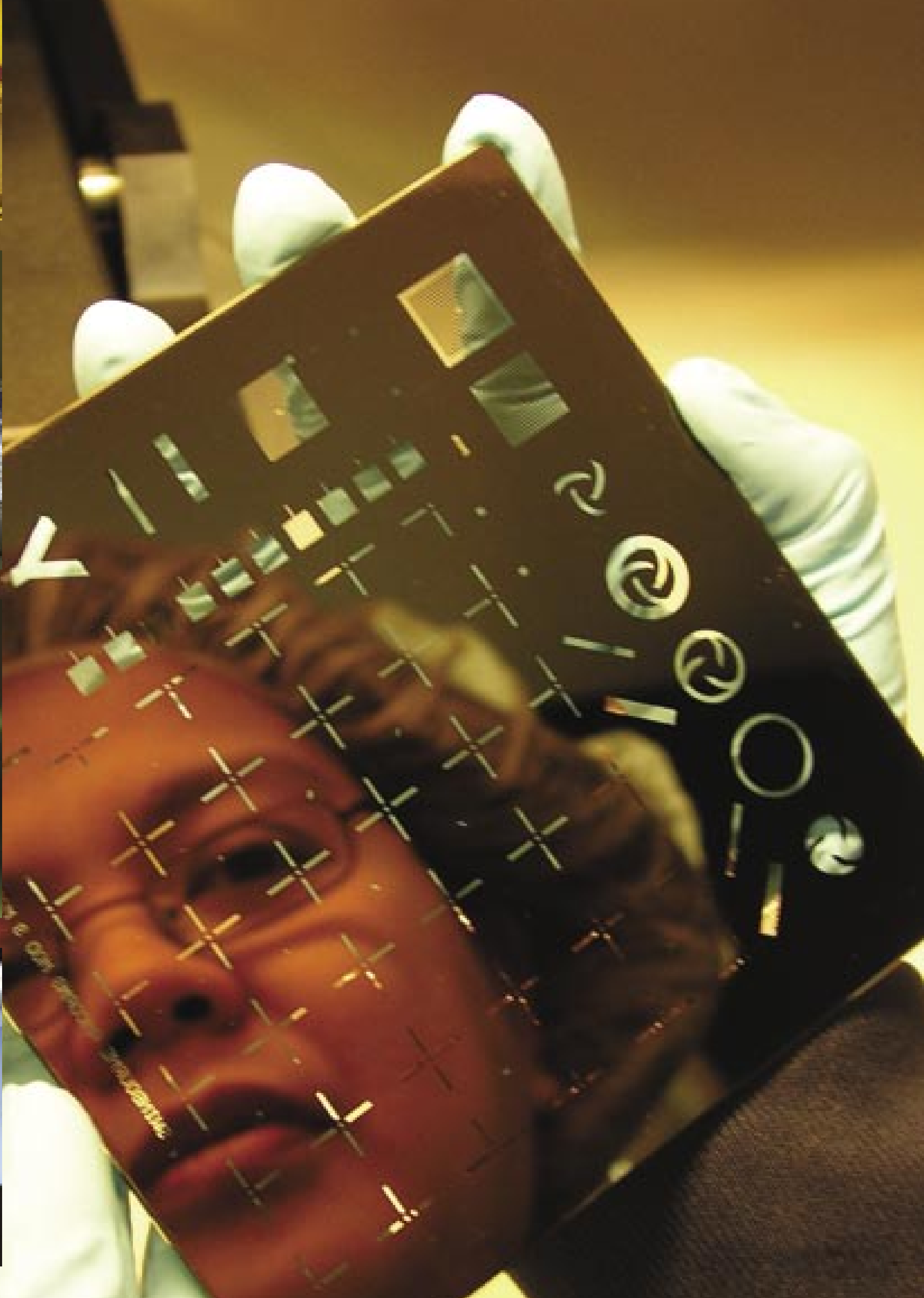
The USI was largely engineered by Invetech Australia working under a DSTO contract funded through the Smart Materials and Structures Key Initiative.

DSTO researcher Alan Wilson, weighing up the advantages of the USI against commercially available units, says, "Commercial products commonly entail the drawback of having to run wires to each sensor individually, do not fulfill the requirement of extremely low operating power, and tend to be bulky. Interfacing to the corrosion sensors is also a challenge since these are low voltage (milliVolt), low current (nanoAmp) devices with a wide impedance range from 100s to 100,000,000s of Ohms."

"By comparison, the USI dimensions are 40 mm by 50 mm; it can measure voltage and current from high impedance sources, and it offers a range of other useful features as well."

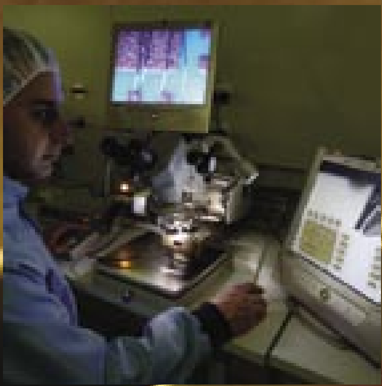
"The recent delivery of the USI represents a major step forward in the development of practical sensor networks for structural health monitoring of ADF platforms," he explains.

Aluminium alloy sensors.



Main photo: a silicon wafer laser mask used to create laser profiles for contouring of polymer sensors.
Inset images: sensor fabrication using micro-machining technologies. Courtesy of MiniFAB

Courtesy of MiniFAB



Courtesy of MiniFAB

Laser micro-machining

Laser micro-machining is a key technology for the fabrication of DSTO's sensors. The laser used by DSTO can machine 20 to 30 micron holes and slots in metal foils less than 200 microns thick. Parts are designed using a standard CAD package to specify the position of the beam on the metal surface being machined. Metal is removed by a combination of ablation and melting. Laser micro-machining is widely applied in other areas of work such as machining of plastics for fluidics, lithography masks and micro-circuit components.

Robots to do dirty, **dangerous chores for Army**

DSTO is developing robotic land vehicles for surveillance, attack and support missions to relieve Army personnel of these arduous and hazardous tasks, making the operations of human combatants safer, more efficient and more comfortable.

In developing new capabilities for Army, explains Dr Brian Jarvis, DSTO's research in robotics is directed not only at anticipating needs but in encouraging the users themselves to develop new applications by giving them the technologies and allowing them to experiment.

"The idea is to put the robots in their hands and see what they come up with," he says.

One scenario in which robotic operatives could have a major role to play is with Improvised Explosive Devices (IEDs) concealed in a vehicle or on a roadside. Most of the casualties incurred in Iraq by Coallition forces and Iraqi government personnel during the current deployment have been caused by such weapons.

Sending personnel to investigate is extremely hazardous since the person investigating can be exposed to enemy fire in the process. As well, many IEDs are remotely detonated to attack passing military vehicles and approaching personnel, which also greatly deters investigation.

Enter X-MUTS

DSTO's eXperimental Multi-role Under-vehicle Tactical Scout (X-MUTS) is a man-portable, four-wheel drive robotic vehicle 12 cm high, 30 cm wide and 40 cm long, fitted with a miniature video camera that can be tilted from horizontal to vertical, enabling a remote operator to guide the robot and carry out surveillance to the front as well as overhead.

Its small size allows it to travel under vehicles with ease, providing unparalleled views of the chassis assembly zone. Previously, the only means of obtaining this view was via handheld mirrors on long poles – a means of inspection made difficult by highly contrasting light levels between the above and below vehicle vistas, as well as lack of general accessibility. This method also places the inspector at great risk.

X-MUTS's wide-angle camera is not only immune to the lighting contrast problem that daunts manual inspectors; it also offers a more thorough, complete and detailed view of the underside of a vehicle. Furthermore, the operator carries out the inspection from a vantage point a hundred metres or more from the suspect vehicle, providing high levels of operator safety.

Another projected use of X-MUTS in a combat zone is to carry out surveillance missions, travelling covertly to a forward position and sending back information about enemy positions via acoustic sensors and daylight and infrared cameras.

In offensive mode, they could be fitted with Claymore command-detonated mines and sent out in hunter-killer packs as a distributed attack weapon. The technology allows for a whole swarm to be controlled by a single operator.

1.

Homeland defence applications

X-MUTS' small size and versatile capabilities also make it very useful for police and special forces operations in urban warfare and siege scenarios as well as for under-vehicle inspections.

Being unobtrusive, man-portable and self-righting, X-MUTS can be readily placed into a building through a window to carry out surveillance. Its equipment range can also provide proactive capabilities. A mobile phone jammer, needing to be placed in close proximity to its target, can be used to bar incoming information flows to those inside. Tear gas canisters and noise generators can be deployed to clear a room.

All of these activities can be carried out clandestinely, and without line-of-sight access. Furthermore, links between the operator and robotic vehicle via fibre optic cables provide a communications conduit that is immune to jamming and 'spoofing' when this capability is critical.

Another range of scenarios in the homeland setting where X-MUTS is seen to be invaluable are those where chemical, biological or radiation-based weapons may be deployed. A robotic vehicle fitted with sensors can be sent to investigate without putting personnel at risk.

The design and construction of X-MUTS uses readily available commercial off-the-shelf components to keep costs down. Its modular format allows components to be readily tailored for different kinds of applications. The X-MUTS system is also comparatively quick to deploy, being operational within just 2 minutes, way ahead of the 20 minutes or more start-up time required for some other robotic vehicles currently in use domestically.

With X-MUTS about to enter Army trials, the work of DSTO to familiarise Army with the use of robots continues apace. According to Dr Jarvis, "It's not a question of 'if' but 'when' our forces will be deploying robotic vehicles on the battlefield, because we're seeing it right now in Iraq and Afghanistan."

1. X-MUTS being used to carry out an under-vehicle inspection remotely.
2. The X-MUTS robotic land vehicle, radio controlled with tiltable video camera eye.

A willing, tireless, ever-ready 'mule'

DSTO is developing a larger type of robotic vehicle using a petrol-powered quad bike fitted with a platform to carry several hundred kilograms of supplies, such as fuel, water, food and ammunition, for a small group of soldiers on deployment. The advent of the mule opens up new concepts for operations, giving the soldiers greater speed, mobility and range in greater comfort and safety, and with less fatigue.

At present, the mule is guided by an operator with a remote control handset. In the near future, the mule will be given the capability to sense the position of a particular soldier and follow at a user-designated distance, either ahead or behind; the mule moves when the soldier moves and stops when the soldier stops. In the longer-term, the mule will be equipped with guidance systems that will enable the mule to navigate its way to a destination by itself, with the ability to negotiate obstacles and determine the best path to take.

Prototype equipment for leader-follower technology was demonstrated in trials at Woomera last September for the Automation of the Battlespace Initiative. (An account of this trial was given in the article 'UAV eyes support networked users' in Australian Defence Science, Summer issue Volume 12 Number 4*)*

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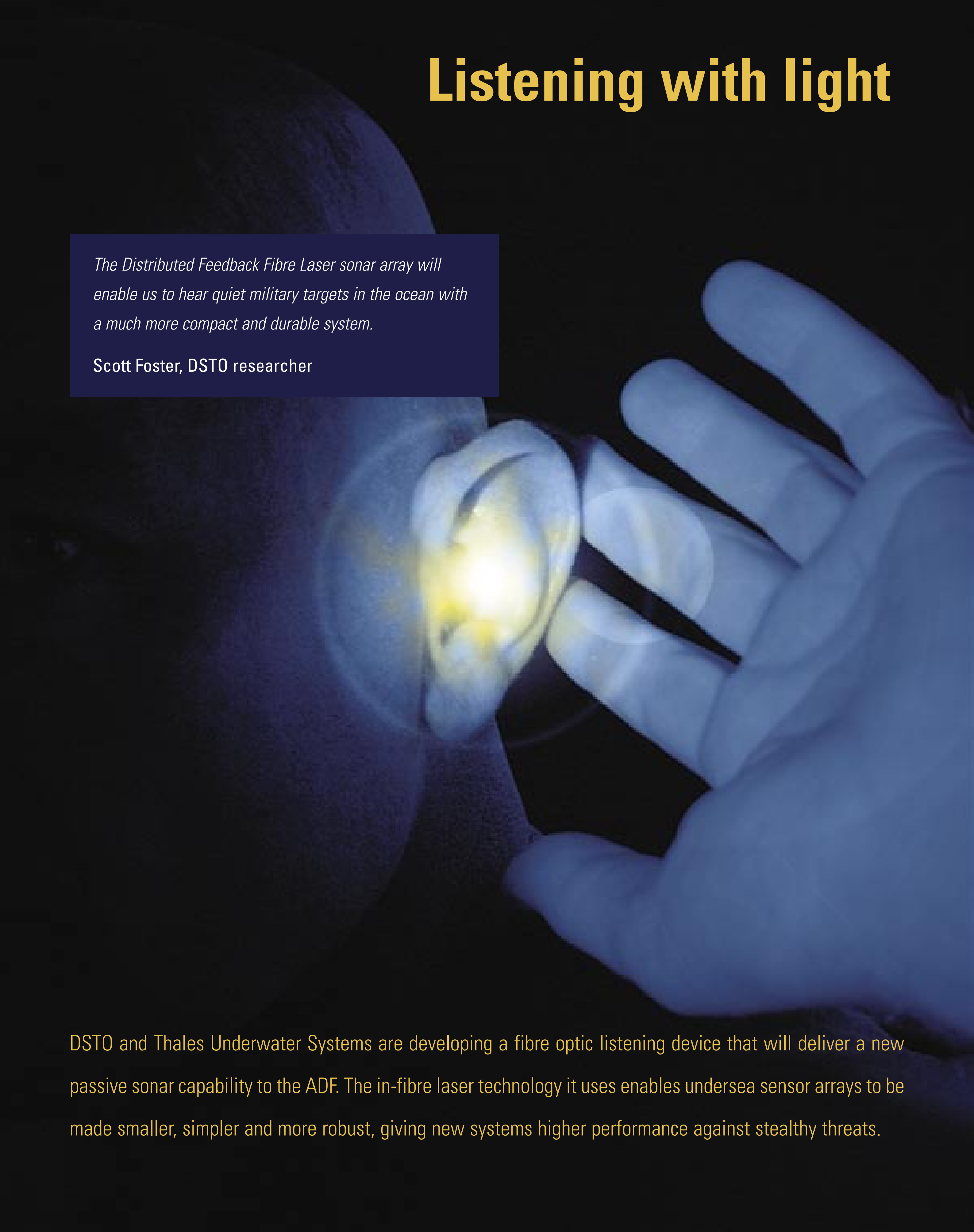
Listening with light



The Distributed Feedback Fibre Laser sonar array will enable us to hear quiet military targets in the ocean with a much more compact and durable system.

Scott Foster, DSTO researcher

DSTO and Thales Underwater Systems are developing a fibre optic listening device that will deliver a new passive sonar capability to the ADF. The in-fibre laser technology it uses enables undersea sensor arrays to be made smaller, simpler and more robust, giving new systems higher performance against stealthy threats.

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Fibre optic hydrophone arrays were first developed in the 1980s, driven by a desire to reduce the complexity and cost of large passive surveillance sonars. Traditionally, fibre optic hydrophones have used a sensing technique called interferometry. This requires a very large amount of optical fibre (up to 100 metres per sensor) to achieve adequate sensitivity, resulting in sensors that are somewhat bulky.

However, according to DSTO researcher Scott Foster, "a new generation of intra-fibre photonic devices, based on fibre Bragg grating technology, are now making possible fibre optic hydrophone arrays with dramatically reduced size, weight and complexity, compared to existing technologies."

An existing in-service sonar array weighs around 4.75 tonnes per kilometre and needs 2.5 cubic metres per kilometre of storage volume on the deployment vessel. But by eliminating the need for local electronics and copper wiring at the 'wet end' of the sensor, the same detection capability may soon be achievable with a fibre optic device weighing less than 40 kilograms per kilometre and requiring storage of 0.02 cubic metres per kilometre.

The Distributed Feedback Fibre Laser

DSTO is currently undertaking research on Distributed Feedback Fibre Laser (DFB-FL) sensors.

DFB-FL are minuscule lasers, fabricated in the core of an optical fibre, that produce light of a very pure colour. Minute strains caused by environmental changes cause the colour of the laser light to shift slightly. By monitoring the wavelength of the laser light, these strains can be detected.

DSTO research has shown that DFB-FL are capable of detecting strains as small as one part in 10^{14} which enable them to sense acoustic sound levels quieter than the noise at the bottom of the deep ocean.

The use of a technique known as wavelength division multiplexing (WDM) enables several laser sensors to be incorporated into a single optical fibre to form an ultra-thin sonar array.

WDM technology involves designing each laser to operate at a different wavelength (colour) so that the signal from each of the individual sensors can be recovered at the receiving end in much the same way that a prism splits white light into different color components.

Government/Industry collaboration

DSTO and Thales began work in 2002 on a jointly funded research program to develop fibre laser hydrophone array technology. The collaboration has so far resulted in a number of important technical developments, including a provisionally patented fibre laser hydrophone.

The fibre laser hydrophone utilises a mere 5 centimetres of optical fibre compared to around 100 metres for a conventional fibre optic hydrophone to achieve the same levels of sensitivity. It is sensitive enough to detect minute acoustic pressure fluctuations (below ocean noise levels) but is designed to be insensitive to mechanical noise and vibration.

DSTO and Thales are currently developing a 16-element concept demonstrator array. The operational concept of the array is for a rapidly deployable, low to mid-frequency array to provide large area surveillance capability in strategic shallow water environs.

Looking ahead, fibre laser technology has the potential to provide capability enhancement across a wide range of future sonar systems where long detection ranges are required within highly constrained cost, weight and power budgets. These include hull mounted sonar arrays, off board deployable sonars, and unmanned underwater vehicle (UUV) deployed sensors.

Commenting on the significance of the work nationally, Michael Clark from Thales says, "Australia is already a considerable force in optical fibre technology research, and it is hoped that the achievements of DSTO and Thales will help to further enhance the position of the Australian industry."

1. DSTO researchers Mark Milnes, Scott Foster (rear) and Philip Jackson working with the in-fibre hydrophone array in test tank.

2. DSTO researchers John Van Velzen and Scott Foster holding an in-fibre laser hydrophone array with previous technology on reels in background.

CUBE – a new tool **for aerospace research**

The Crewed Universal Battle Environment (CUBE) facility recently commissioned at DSTO Fishermans Bend is an important new tool for the investigation of technologies, tactics and procedures used on Australian Defence Force (ADF) aircraft. The CUBE display, adaptable to a wide range of different cockpit scenarios, is one of the largest of its kind in the world.

Internal view of CUBE with aircrew in a Black Hawk simulation cockpit.

The CUBE is a multi-screen rear-projection display system that gives aircrew inside the module an 'out-of-window' view on four sides – front, left, right, and top.

Four Barco high-resolution projectors are used to project computer-generated imagery onto translucent screens that have been specially treated to maintain an even image intensity on the display surfaces inside the CUBE.

The application of rear-projection display technology means that the full display space inside the CUBE can be viewed without shadows on the surfaces, unlike front-projected systems.

The simple design concept for the CUBE display, featuring flat rather than curved surfaces, has helped keep costs to a minimum, making it considerably less expensive than other display systems exhibiting similar field-of-view characteristics.

CUBE's role in the Aerospace Battlelab Framework

The CUBE display is being used together with other simulation technology assets within DSTO's Air Operations Simulation Centre (AOSC) to conduct human-in-the-loop research.

The AOSC in turn brings high-fidelity human-in-the-loop simulation capabilities to the Aerospace Battlelab Framework (ABF), and enables aerospace systems simulation and experimentation to be conducted in conjunction with other DSTO simulation assets.

The ABF will eventually involve the linking of two or more simulators, other training simulators, and ships and aircraft within the real environment. By linking real assets within a synthetic environment, it provides for more extensive training to better equip ADF personnel for peak operational performance. The creation of ABF nodes in several locations around Australia will enable DSTO and ADF personnel to participate in or be exposed to these exercises.

Placing real military operators in synthetic environments has been shown to be a powerful way of studying many aspects of military air operations. DSTO has a distinguished history of human-in-the-loop computer simulation-based research in support of the ADF.

Range of experimentation

The CUBE has already been used to evaluate advanced display concepts for the presentation of electronic warfare (EW) information to aircrew.

Another experiment has been conducted to research multiple-sound-source 3D audio displays.

A further experiment was carried out to evaluate the presentation of EW threat information on digital moving map displays. These human-in-the-loop simulation experiments are part of Australia's contribution to Project Arrangement 10, a collaborative agreement with the US Army to research EW technology. Development of the CUBE facility overall was funded under this Project Arrangement.

The CUBE display has also been used for experiments that support the preparation of the new Tiger Armed Reconnaissance Helicopter for service.

According to DSTO's Systems Sciences Laboratory Director, Dr Nanda Nandagopal, "The commissioning of the CUBE represents a major new research capability for DSTO."

Research assistance for post-tsunami relief effort

Personnel on HMAS Kanimbla approached DSTO for assistance at the beginning of the year to prepare for the ship's participation in the Banda Aceh humanitarian aid mission, Operation 'Sumatra Assist'.

DSTO's Littoral Sea Command Laboratory, based in DSTO Pyrmont, was developed specifically to assist with the integration of Command Support products at the operational level.

The Laboratory and staff were used to acquire, convert and test maps and charts of Banda Aceh for use by Commander Amphibious Task Group (COMATG) staff on HMAS Kanimbla. The data, which was provided by the Defence Imagery and Geospatial Organisation, was processed for integration and the products were forwarded to the vessel.

The COMATG staff onboard HMAS Kanimbla used these products to help plan operations.

HMAS Kanimbla off the Sumatran coast during Operation 'Sumatra Assist'.

Counter-terrorism research pact

A new government collaborative research program involving DSTO, CSIRO, ANSTO and Geoscience Australia has been mounted to boost national security and counter-terrorism measures.

DSTO's involvement will enable it to better support Defence by building on existing expertise and research, and extend its knowledge to support non-Defence agencies.

Under the Publicly-funded Agencies' Collaborative Counter-Terrorism (PACCT) program, DSTO will carry out research into the detection and neutralisation of explosives, protection of civilian aircraft from shoulder fired missiles, and protection of the nation's critical information infrastructure from cyber attack. It will also apply scientific rigour to the conduct and monitoring of exercises undertaken by counter-terrorism agencies.

DSTO has already demonstrated its support for national security and counter-terrorist measures through its involvement in chemical and biological defence.

DSTO has scientists embedded in Defence's Incident Response Regiment providing advice and laboratory support for Australian forces responding to domestic terrorist threats or deployed overseas in environments vulnerable to chemical/biological threats.

SECAR accepted for operational trial

Daronmont Technologies has constructed a high frequency surface wave radar (HFSWR) known as the Surface-wave Extended Coastal Area Radar (SECAR) as a commercial version of an experimental system developed by DSTO in the late 1990s.

HFSWR technology enables detection of both surface and air targets at ranges well beyond the visual horizon by exploiting the conductive nature of sea water to guide the propagation of radar signals around the curvature of the earth.

As such, it offers the possibility of a land-based surveillance capability that fills the gap between the localised picture derived from traditional line-of-sight microwave systems and the broad-area coverage provided by skywave over-the-horizon radar. Military applications include deployment at choke points or focal areas to provide all-weather surveillance of sea and air approaches. Other uses include the detection of illegal entry vessels or unauthorised fishing craft.

Defence and Coastwatch, under the jointly funded project JP 2084, are evaluating the operational benefits of SECAR over the next two years. The SECAR system, first tested in 2000, has been adapted by Daronmont for remote operation from unmanned sites, and has been deployed in the Torres Strait region. RAAF operators from 1RSU operate SECAR using terminals located at the JORN Coordination Centre, RAAF Edinburgh. Tracks are passed to the Coastwatch National Surveillance Centre located in Canberra.

Acceptance testing of the system was carried out by the contractor in December 2004 and the results were reviewed by DSTO early this year. The SECAR system was formally accepted by the Defence Materiel Organisation on 24 February 2005.

CALENDAR

18 - 20 May 2005	Modelling and Simulation Cancun, Mexico Email: calgary@iasted.org
14 Jun 2005	Humanities Security and Counter Terrorism Research Forum Australian National University Canberra, ACT http://www.homelandsecurity.org.au/humanities.html
20 - 22 Jun 2005	Defence + Industry Conference National Convention Centre Canberra, ACT Enquiries: (02) 6280 8122 http://www.defenceandindustry.com.au
20 - 24 Jun 2005	Signal and Image Processing Novosibirsk, Russia Email: calgary@iasted.org
12 - 14 Jul 2005	2005 Safeguarding Australia Conference: The 4th Homeland Security Summit and Exposition Conference National Convention Centre, Canberra, ACT http://www.safeguardingaustraliaconference.org.au/
14 Jul 2005	Science, Engineering & Technology (SET) Summit on Counter-Terrorism Technology National Convention Centre Canberra, ACT http://www.safeguardingaustraliasummit.org.au
3 - 4 Aug 2005	Science Corporate Information Systems TecXpo 2005 DSTO Edinburgh, South Australia Email: tecxpo@dsto.defence.gov.au
22 - 25 Aug 2005	8th International Symposium on Signal Processing and its Applications Sydney, Australia Tel (02) 4221 3065 http://www.elec.uow.edu.au/isspa2005
4 - 8 Sep 2005	2005 European Signal Processing Conference Antalya, Turkey http://www.eusipco2005.org/
25 - 29 Sep 2005	21st Conference on Optical Communications SECC, Glasgow, UK http://conferences.iee.org/ecoc05/index.html
4 - 7 Oct 2005	Land Warfare Conference Gold Coast Convention & Exhibition Centre Broadbeach, Queensland Tel +61 8 8259 5455 Fax +61 8 8259 5196 Email: lwcc@dsto.defence.gov.au

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