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AUSTRALIA

MAGIC competition reveals autonomous technology leaders

Tests with warheads deliver munitions handling safety

***Panorama's* undersea vistas**

Australian Government

Department of Defence

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 Chief Defence Scientist, Professor Robert Clark, and employs about 2500 staff, including some 1300 researchers and engineers. It is one of the two largest research and development organisations in Australia.

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Contents

Cover image: DSTO and Navy personnel with Panorama *display of tools for investigation of individual sensor outputs.*

Defence Science Australia, December 2010, p 6 (Better analytical tools for 'hit or miss' situations) – The colleague referred to in this picture is Arvind Rajagopalan who served for two years as co-developer of the COVAD software with Dr Domenic Bucco.

Panorama provides big-picture view of undersea goings-on

A new sonar processing and display tool developed by DSTO has been acclaimed for its abilities to provide high-level situational awareness of the undersea environment.

The *Panorama* system consists of signal processing software run on a commercially available computer platform that enhances sonar operator usability of signal inputs from towed and hull-mounted sonar arrays.

"The capability edge *Panorama* delivers is through its display of raw sonar data along with sonar contact analysis displays, plus provision of high-fidelity signal audio and bathymetry overlays to assist operators with the task of rapid detection and classification of sonar contacts," explains DSTO researcher Simon Taylor.

"As well as helping an operator detect submarines sooner, it also reduces the number of falsely reported contacts."

One innovation of particular note is that the hydrophone sensors are depicted in three-dimensional graphic form, which enables individual sensor outputs to be investigated.

This facilitates the rapid identification of defective sensors and ship-borne noise sources – a laborious process ordinarily.

Benefits of an evolutionary process

The development of *Panorama* has its origins in steps taken a decade ago to modify the sonar system on the Anzac class frigate, HMAS *Arunta*, to provide a broadband digital interface for data recording and an adjunct data processor.

This was an experimental program aimed at improving the ability to classify sonar signals of submarines by using different active sonar pulse types. It showed that innovative use of modern commercially available processors could provide significant performance gains.

Progress on system development since then was to proceed in incremental evolutionary steps, involving investigation of new ideas followed by implementation and testing of technologies in real-time scenarios using data gathered at sea, and then applying those technologies to *Arunta* for at-sea investigations.

Initial trials on active sonar classification onboard *Arunta* were undertaken in the Timor Sea during anti-submarine warfare (ASW) exercises conducted in 2001, followed by Sonar Self Noise trials and Mine and Obstacle Avoidance sonar trials conducted in 2002 and 2003.

In 2005, a towed array sonar was fitted to HMAS *Arunta* and integrated with the broadband hull mounted sonar as part of a project known as the Network Enabled Undersea Warfare (NEUW) Capability Technology Demonstrator project. A comprehensive sea trial (NEUW 1-05) involving two surface ships, a submarine and an acoustic array deployable on the sea floor was then conducted in the Timor Sea. This revealed the usefulness for sonar operators of being able to draw on data from multiple sensors.

A system to process and display data from multiple sensors was accordingly developed using commercially available components as an in-lab model built to demonstrate the viability of the approach. Having satisfied senior Defence staff that this could provide a valuable capability enhancement, the system, now named *Panorama*, was installed on *Arunta* in 2006.

Due to constant calls on the ship's time for operational purposes, investigations of *Panorama* were not properly undertaken until 2009. Navy has since supported three to four scientific and operational trials each year. During these trials, the abilities of *Panorama* together with broadband hull mounted sonar to detect and classify submarines and torpedoes has become more apparent with each operational use.

On track to enhancing the Fleet's capability

One measure of success is that *Arunta* was awarded the Voyager ASW Trophy after exercises in 2009, with Navy formally acknowledging that this outcome was in considerable degree attributable to the fact that *Arunta* had *Panorama* on board.

Further successful ASW and torpedo defence trials in 2010 supported Navy's decision to fund the development of a pre-production version of the technology, and the use of the *Panorama* system to support ASW and torpedo defence experimentation on other Navy platforms. This program not only provided Navy with an option for future capability development but has fostered the development of suitable skills within DSTO to support the evolution of the ASW capability of the current and future surface combatants. Ω

Above: DSTO and Navy personnel with Panorama *sonar displays.*

Autonomous technologies work wonders at MAGIC 2010

A competition called the Multi-Autonomous Ground-robotic International Challenge (MAGIC) was recently staged in Australia to advance the development of autonomous unmanned ground vehicles (UGVs) for defence purposes.

This venture, initiated two years ago and culminating last November, was jointly sponsored by the Australian Department of Defence and the United States (US) Department of Defense, with the organising role undertaken by DSTO.

The purpose of MAGIC 2010 was to showcase emerging autonomous UGV technologies that can assist dismounted ground forces with the task of zone reconnaissance in an urban environment, thereby delivering greater safety and efficiency along with reduced cost for force operations.

"The point of the exercise essentially was to demonstrate advances in multi-unit UGV technologies that allowed a progression from manual and tele-operation to partial or full autonomy – from a situation of 'one operator-one robot' to 'one operator-many robots'," explains Dr Vinod Puri, a key DSTO organiser working on the competition.

"How capable these systems were in terms of sensor performance or vehicle mobility, meanwhile, was not of major interest."

Above: The five short-listed teams for the November 2010 MAGIC challenge in Adelaide.

Teams from industry and academia throughout Australia and overseas were invited to enter the challenge, which primarily involved applying their technologies to a series of intelligence, surveillance and reconnaissance tasks to be completed within a certain timeframe.

Performance aspects on trial were the ability of the multi-vehicle cooperatives to autonomously and dynamically coordinate activities, plan and re-plan their task allocation and execution strategies against a changing environment and simultaneously provide a unified situational awareness picture.

Contest rules

The task set for each entrant was that their UGVs had to collaboratively undertake to safely and efficiently map a locality, and also detect, classify and possibly neutralise several static and mobile objects of interest.

An entrant's UGVs were to include two types; those that sense the environment for collaborative mapping and situational awareness purposes, and another type known as 'disruptors' that neutralise objects of interest.

Each entrant was required to field at least two of the former with no upper limit set on these, while numbers for the latter could only range between a minimum of one and a maximum of three.

Another proviso was that the environmental sensing capabilities of disruptor units could not be used to contribute to the collaborative mapping operations of the sensor units, only for the purposes of navigation when undertaking to disrupt an object of interest.

Furthermore, the functions of sensor and disruptor could not be transferred between UGVs during an operation. As for the human input factor, supervision of all UGVs was limited to just two operators.

The terrain chosen for the challenge was a mock urban environment 0.5 square kilometres in size comprising typical features such as sealed roads, paths, buildings, trees, grassed areas, sandy ground, trenches, holes, safety barriers, curbs and fences.

Preparations for the fray

Following an announcement in July 2009 by the then Minister for Defence Personnel, Materiel and Science, Greg Combet, alerting entrants worldwide to the challenge, the first step towards participation involved submitting a highly detailed account of the technologies to be applied.

Entrants were supplied with a representative layout of the area over which the competition was to be conducted, showing open, restricted and wooded areas, street and road layout, general topography along with the location, number and area of buildings. In addition, MAGIC conferences were held in Australia, Germany and the US to brief entrants and allow for discussion of ideas in those respective parts of the world.

A total of 23 teams from countries including the US, Canada, Poland, Japan, South Korea, Turkey and Australia engaged with the challenge to the point of sending submissions.

These submissions were analysed by a panel of US and Australian defence robotics experts in order to draw up a short-list of twelve. Ten of these were awarded grants of $US 50,000 to further develop their concept, with another two entrants (both from Australia) being invited to compete on a self-funding basis. In all, four consortiums of Australian researchers reached this stage.

Some months later, the MAGIC technical assessment panel then visited each of the short-listed teams to examine the outcomes of their developmental work. Further analysis was done, resulting in a short-list of five finalists, each of these being given an additional $US 50,000 to develop their concept to prototype form for competition in the MAGIC arena.

The five finalists included the Turkish-US collaboration 'Cappadocia', 'Reconnaissance and Autonomy for Small Robots' (RASR), 'Team Michigan' and the 'University of Pennsylvania' all from the US and 'Magician' from Australia.

Robotic 'rumble' Grand Final

The MAGIC Grand Final event took place at the Royal Adelaide Showgrounds in Adelaide over five days in early November 2010.

The competition was divided into three phases with progressively greater degrees of task complexity, making use of the various buildings, structures and landscape features as the competition arena in this closed-off built environment.

For a team to advance to the next phase, it had to declare completion of each phase, that the area set for the phase had been explored and mapped, and that all the objects of interest had been recognised and neutralised. Additionally, a 3.5-hour time limit was set for completion of all the phases.

The teams were also assessed in terms of a point-scoring system that provided finer gradations of rankings. Scores for UGV performance in the arena had a maximum attainable of 800 points, with a further 200 points attainable for technical submission and presentations to judges, making a total possible of 1,000 points.

Points for technology performance were judged against three over-arching sets of criteria: mission level, systems level and technical success.

At a mission level, criteria for evaluation included the percentage of targets correctly and incorrectly detected, located, recognised and neutralised, the percentage of phase area explored and mapped and the accuracy and timeliness of the mission.

At a systems level, criteria here included the number of UGVs handled by teams, the workload experienced by teams, the human-machine interface, the amount of time spent interacting with the cooperative, the number and nature of these interventions, and the degree to which UGVs autonomously and successfully shared and coordinated their various activities.

At a technical level, the critical criteria were the robustness, reliability and survivability of a team's UGVs, the capacity of the UGVs to autonomously plan, re-plan, and then execute their tasks against dynamically changing priorities, and the navigation and mobility capabilities of the individual UGVs.

"Broadly speaking, high levels of individual and collaborative autonomy were rewarded while human intervention was penalised," says Puri.

"Also, the degree to which the UGV automatons were able to share the workload successfully was rewarded. For example, a cooperative of ten UGVs each mapping ten percent of the area would score more points than one in which one UGV maps ninety percent of the area."

Finally a winner emerges

After five days of competition, interspersed with demonstrations of collaborative autonomous capabilities for an invited audience of defence specialists and VIPs, the judges set about assessing the results.

Their findings were announced a week later at the Land Warfare Conference in Brisbane by Senator David Feeney, Parliamentary Secretary for Defence, who declared that Team Michigan was the winner, with the University of Pennsylvania in second place and RASR third.

The numbers of UGV fielded by Team Michigan included twelve of the sensor type and three of the disruptor type.

Prizes of $US 750,000, $US 250,000 and $US 100,000 respectively were presented to further research and development activities for the prize winners, bringing the total outlay by MAGIC on advancing the state of the technology throughout the venture to $US 1.85 million.

Commenting on the successes to come out of MAGIC, Senator Feeney observed, "This is a trail-blazing moment for our military in terms of how we conduct future combat missions." Ω

***Top left:** The three prize winning teams for MAGIC 2010, from left; RASR (3rd Place), University of Pennsylvania (2nd Place) and Team Michigan (1st Place).*

***Top right:** Team Michigan's robotic UAV team at the start line for a challenge round.*

New way to extract findings from mountains of data

Above: Lani Barnes, 2010 Defence Science Indigenous Scholarship winner, working on beach sediment analysis using curve clustering techniques.

Opposite: Three curve clustering analyses of multi beam swathe sonar acoustic backscatter data collected for a 3.2 x 0.5 kilometre stretch of seabed in Keppel Bay, Queensland.

Opposite top left: Curve clustering analysis of multi beam echo sounder data obtained around the Woody Island group in Recherche Bay, Western Australia, indicating different types of seabed material composition.

Opposite top right: Curve clustering analysis of 17,000 salinity-depth data measurements, showing ten groups of thirty, with bolder curve showing the central tendency of each cluster.

A data analysis approach has emerged from oceanography work within DSTO, promising to revolutionise ways in which processing of large data sets is carried out.

With the gathering and recording of sensor data having burgeoned in the age of digital technology, the challenge for analysts is to sort through the masses of data to find trends and patterns that may lie hidden within.

Modern data acquisition methods routinely collect very large data sets of tens to hundreds of thousands of observations, as DSTO oceanography researcher, Les Hamilton, well knows from handling data sets on phenomena such as wind-wave spectra, sediment grain size distributions, ocean salinity profiles, and seabed echoes.

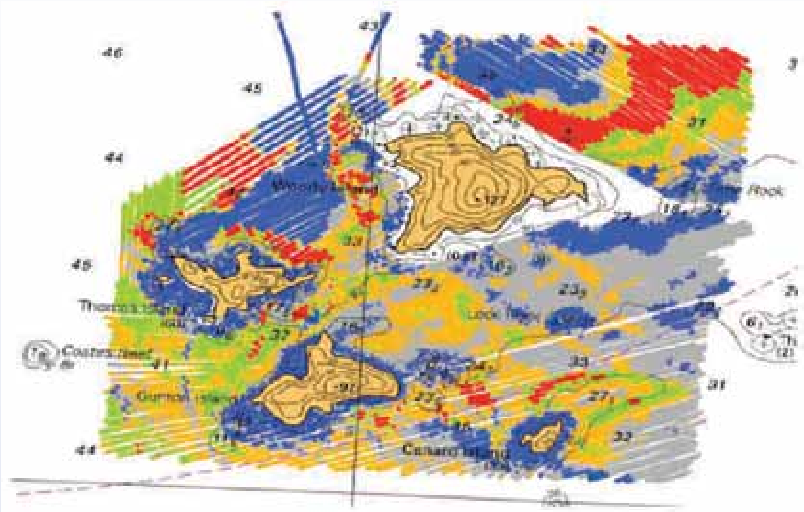
Faced with the problem of data analysis tasks of daunting size, he pondered the possibility of conducting analysis in a more efficient way, and came up with a new approach based on analysis of data sets as clusters or groupings of curves with similar geometrical shapes.

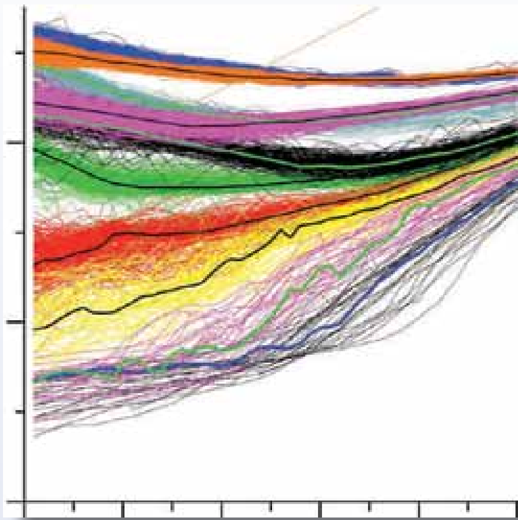
This approach requires that data sets for a particular phenomenon can be expressed by what are known as 'single valued curves'. With these, the X values for each data item can each only have one Y value – not two or more like some curves, such as circles, can have.

Graphic approach to pattern finding

By clustering the data curves into groups of curves with similar shapes, the patterns in a large and complex data set can be seen visually, greatly simplifying the analysis problem. The central tendency (or central curve) for each grouping of curves can be calculated and used for analysis, instead of having to use all the curves in each group.

In this way, a single curve can represent the group properties of hundreds to tens of thousands of curves. This manner of treatment also manages the issues of





'noisy' data – data that is contaminated to a large degree by background noise – and is not affected by curves in a data set overlapping or crossing over each other.

Hamilton's approach is vastly simpler to that of previous methods, which can require complex and extensive data pre-processing before clustering or other statistical analysis is applied. Other techniques typically first apply modelling, curve fitting, and extraction of representative features such as heights, widths and positions of peaks in curves, along with derivation of averages, medians, standard deviations and many other statistical parameters – all this before statistical clustering or analysis of outcomes to arrive at findings.

The innovation Hamilton has conceived is to apply clustering directly to the curves themselves, obviating the need for any data pre-processing and modelling. Curves are used in their entirety, without need for approximation by data reduction or modelling methods that can lead to distortion.

"I'm surprised that the direct clustering of curves approach hadn't already been developed. It seems nobody realised it could be done," he says.

"This approach is not only quicker and easier than other data reduction methods, it's also potentially more accurate since it uses all the original points in a data curve rather than relying on just a few approximated points or features."

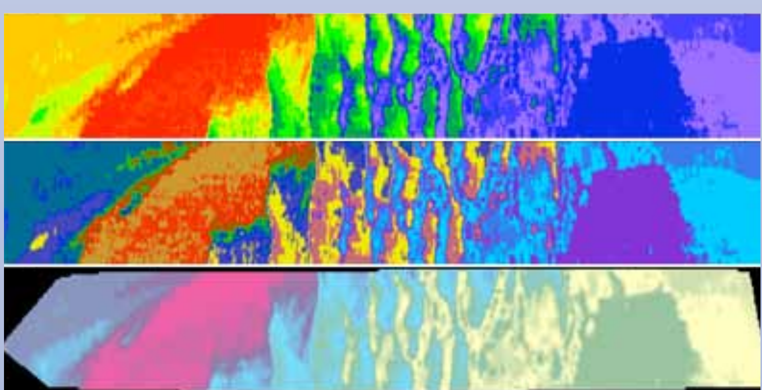
Putting the new approach to work

Hamilton has been investigating its use in the fields of oceanography, geology, and underwater acoustics. Examples of applications undertaken to date include classification of wind-wave energy spectra, classification of acoustic seabed backscatter data for seabed type, and analysis of oceanic salinity-depth measurements for the South Pacific Ocean.

Having transformed the data analysis tasks he is having to manage in his field, he notes that the direct clustering of curves approach can potentially be used in many very different research areas, and he is actively promoting this new statistical technique within DSTO and externally.

One successful uptake of the approach has been by DSTO researchers conducting analysis of hyper-spectral optical data for coastal areas.

Since this approach reduces many complex analysis problems to ones of simple geometrical considerations of the kind – 'Is a curve closer in shape to this one or that?' – Hamilton's expectation is that it will find widespread use as an analysis tool.



Indigenous scholarship student working on sediment analysis with curve clustering

Lani Barnes, recipient of the 2010 Defence Science Indigenous Scholarship, is undertaking work experience at DSTO, using curve clustering for sediment analysis under Les Hamilton's supervision. Her project involves classifying beach sediments and characteristics across northern Australia from Broome to Cooktown.

Part of the research aims to investigate particular grainsize distributions, with the properties of some beaches varying seasonally according to changes in factors such as wind and wave conditions.

Through the use of the curve clustering approach, Barnes' work will assist Defence planners by rendering complex data in easily interpretable form.

Lani Barnes, studying a Bachelor of Environment course at Macquarie University, is the second recipient of the scholarship given to encourage the uptake of full-time tertiary science studies by indigenous students.

The scholarship covers the student's university fees, paid twelve-week annual work experience, and an offer of employment with DSTO after completion of the studies.

When insensitivity is the right answer

Explosives in weapons can become less stable over time, making them dangerous for Defence personnel to handle and use. A series of trials conducted by DSTO has produced outcomes that will help ensure greater safety.

The work is being undertaken as part of the five-nation Technical Cooperation Program (TTCP) research to investigate weapon deterioration processes and the consequences arising.

These trials were the first time such studies had been carried out anywhere on aged munitions at full size.

Giving the rationale for this work, DSTO researcher Ian Lochert says, "The ideal state for a weapon is to be insensitive to various stimuli – such as fire, impact from projectiles, fragments and shaped-charge jets, and even shockwaves from nearby detonations – but to perform as required when personnel want to deploy it.

"If a weapon becomes more sensitive and unpredictable with age, it may be too dangerous to use."

The DSTO investigations involved warheads exposed to two kinds of unplanned stimuli – impact by projectiles, and the detonation of a large explosive weapon nearby. Several warheads of the same type, supplied by an Australian manufacturer, were procured for the experimental program, with half of these being artificially aged by exposure to heat before hand.

Heat and then fire

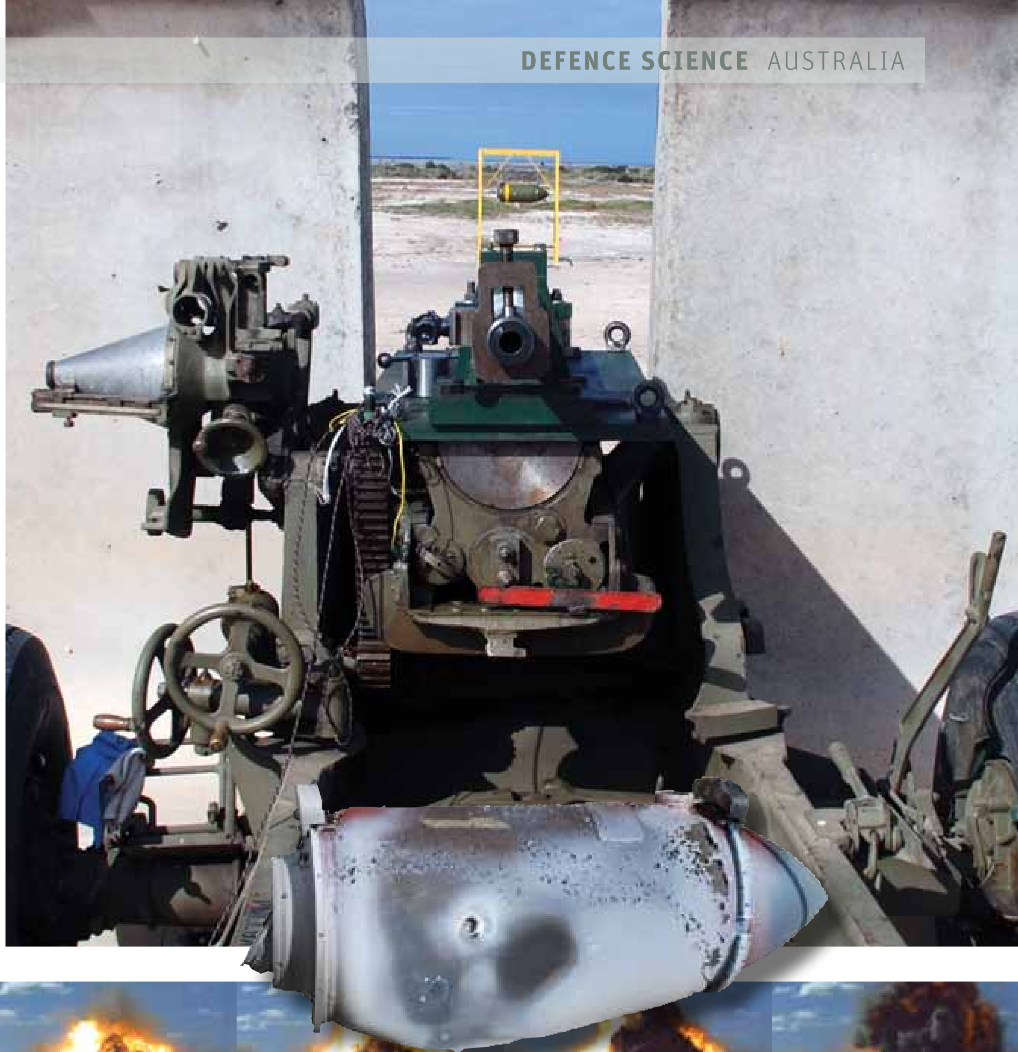
A first set of trials was carried out at the Port Wakefield Proof and Experimental Establishment to study the effects of bullet impact.

The warheads were readied for experimentation by being mounted on a stand, and armour-piercing bullets were then fired at them, with the outcomes recorded on high-speed digital video cameras set up nearby.

The results every time were that the explosive material inside the warhead caught fire with jets of flame venting through the bullet holes and other pathways, burning for up to fifteen minutes.

Post-trial analysis, conducted by examining the burnt-out warhead casing as well as reviewing the video footage, showed no difference in warhead behaviour whether thermally aged or not.

Main photo: A sympathetic reaction trial in preparation at the Woomera Test Range.
Photo montage: High-speed photography of a sympathetic reaction trial detonation.



Bigger bangs for more results

A further set of trials was undertaken at the Woomera Test Range to investigate warhead behaviour when exposed to detonation of a large explosive weapon, otherwise known as Sympathetic Reaction testing.

The experiments were conducted by placing two warheads – one thermally aged and one that was not – at a distance of a few metres either side of a cased explosive device to be remotely detonated and the effects then studied.

The trial process involved a series of experiments in which the distance of the warheads from the central explosive stimulus was increased in steps to find the transition point beyond which one or both warheads did not sympathetically detonate.

Steel plates on stands, known as 'witness plates' were placed around and beneath the warheads to measure the extent of fragmentation (if any) from the warheads, and high-speed digital video cameras were again used to record the experiments.

The first test explosion resulted in both warheads detonating, with parts of the weapons and test setup flying as far afield as a kilometre.

The test was then repeated another four times at different distances with a range of warhead responses observed. The transition point turned out to be the same for both warhead conditions.

The researchers found overall that there was no detectable difference in behaviour of the warhead when exposed to these stimuli, whether exposed to artificial ageing or not.

These findings, combined with those from the international collaboration partners, are expected to contribute to safety of in-service ordnance and the development of safer weapons.

***Top left:** Warhead mounted for trial at the Port Wakefield Proof and Experimental Establishment.*
***Top right:** View of trial setup from behind the firing point for armour piercing gun.*
***Overlay:** The casing of burnt-out warhead after a trial.*
***Right:** DSTO personnel at the Woomera Test Range setting up a sympathetic reaction trial.*

Quick effective way to monitor Navy vessel signatures

DSTO is developing an easily deployable portable system for obtaining readings of hull signatures, thus improving on availability of this information.

The problem this work addresses is that the presence of a maritime vessel is detectable from various kinds of passive emissions including electromagnetism, pressure and sound, which modern mines and torpedos tune into for targeting purposes.

"Being able to accurately measure these signals is crucial to delivering survivability capabilities and strategies for Navy vessels," explains DSTO researcher Andrew Bailey.

To this end, measurement ranges have been developed featuring an array of seabed sensors that capture the various signals emitted as a vessel under survey passes over, with the data thus obtained then relayed to shore-based facilities for collection and analysis.

However, current ranging arrangements allow for only intermittent readings of a vessel's signature, since a ship may not call in at a port where such facilities are permanently based for many months, and those ranges that are relocatable are not easily moved due to the cumbersome nature of the equipment and the large setup-teardown times involved.

Meanwhile, the environments that Navy vessels operate in can vary considerably in cases when missions involve transits over large expanses of latitude and even across hemispheres, which can result in large variations in vessel signatures.

While computer modelling provides a way of predicting the current state of signatures at a given time and place, some uncertainties remain. These uncertainties are seen to be of such concern that another way of approaching the signature measurement problem, involving the use of portable ranging equipment, has been pursued by DSTO.

Small and compact ranging system

A team of researchers and engineers has developed a prototype portable multi-influence range to provide real-time information about the state of a vessel's underwater signatures, and thus, the vessel's vulnerability to various undersea threats.

"The primary focus of the design has been to miniaturise the components into a package that is easy to deploy and recover, yet maintain measurement accuracy, plus have the durability to remain operational for long periods in challenging underwater conditions," explains Bailey.

The procedure for deploying the device, called the Self-recoverable Portable InfluencE Range (SPIER), involves the use of a rigid hull inflatable boat (RHIB) launched from the ship, into which SPIER is loaded by crane at the stern. The RHIB then moves off to a suitable site where SPIER is lowered to the seabed, with the position accurately noted using GPS and acoustic measuring tools.

Once in position, shipboard communications with SPIER are conducted via underwater acoustic modems to turn the system on and check that all components are operational. The ship then carries out a number of runs along a straight course in the vicinity, during which signature data are recorded. When the survey process is completed, the system is instructed to surface for recovery by the RHIB and return to the ship.

TTCP trials

In collaboration with the New Zealand Defence Technology Agency under The Technical Cooperation Program (TTCP) study arrangements, DSTO recently put SPIER to the test in wide-ranging conditions in Australian and New Zealand waters.

The trial objectives were to test the efficacy of a portable range for use as a self-ranging capability, and in particular, to investigate how the magnetisation of a steel-hulled vessel changes during a voyage crossing various latitudes. "The change in magnetisation over time due to stresses experienced by the hull at various latitudes is a very complex problem, one of considerable interest to TTCP member countries," says Bailey.

During the five-week voyage, measurements of the magnetic signature of HMNZS *Resolution*, the NZ Navy's primary survey and acoustic research ship, were taken at Auckland, Dunedin, Sydney and Brisbane, with a final ranging carried out again in Auckland.

The variation in the Earth's magnetic field over the whole voyage was approximately 11,000 nanoTesla in the vertical and 9,000 nano Tesla in the horizontal components. Ocean conditions for the trial, impacting on the stress levels experienced by the vessel and thus the magnetism induced, varied from a calm Sea State 1 up to a very rough Sea State 8.

On the outcomes arrived at, Bailey says, "Initial results show that SPIER will very likely serve a useful role in the quest to reduce underwater signatures. Once familiarity with deployment and recovery of the system had been gained, these processes only took about 30 minutes." Ω

Opposite page: SPIER being hoisted over stern of HMNZS* Resolution *for deployment by RHIB.

Top: RHIB being launched from HMNZS* Resolution *during SPIER trials.

Inset: The SPIER device loaded onto RHIB for deployment.

Getting a feel for life behind the wheel

DSTO has undertaken studies to assist Defence with the acquisition of its new fleet of medium-to-heavyweight land mobility trucks.

The truck replacement venture is currently the largest funded land project in the Defence Capability Plan, and has been under way for several years now with DSTO support. A recent review of Defence procurement and sustainment led to the requirement that new equipment being considered for acquisition be put under much greater scrutiny than before.

Under guidance by the Australian Defence Test & Evaluation Office, a team of DSTO researchers assisted Capability Development Group over a period of about four months to arrive at assessments of the functionality of the various vehicle types as part of the medium-to-heavyweight truck tender evaluation process. A total of 24 vehicles was provided by the tendering manufacturers.

Most of the human factors studies undertaken were to assess how suitable Army drivers found the vehicles for the conduct of their work. DSTO's role was to give advice to Defence on appropriate test and evaluation methods, to provide experimental support, and to analyse quantitative and qualitative data in a manner that sound findings could be derived.

'Hitting the road' in the name of science

Several of the DSTO team served as embedded researchers by going on field trials and road trips with the Army drivers to see and experience their work directly.

Two researchers were assigned to travel with a driver at all times. This involved conducting after-action reviews of the work just completed, and also sharing the after-hours aspects of life on the road – eating, relaxing and overnight stays.

According to DSTO researcher Axel Bender, "Better quality results were achieved, including frank and honest opinions, by having the researchers share the full experience. While we had to cope with some very long days, the effort was worth it."

This approach to the research involved collecting observations of 64 Army drivers who tried the vehicles out on test tracks at Puckapunyal in Victoria, and the Townsville High Range in Far North Queensland, plus road journeys on Australia's highways from Puckapunyal to Townsville.

Informing Defence

DSTO's work identified a range of human factors issues, particularly, difficulties with cabin ingress and egress.

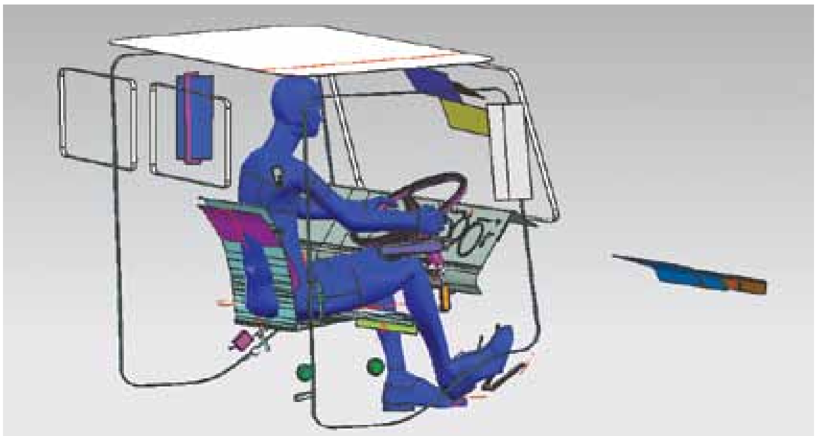
One interesting proposal was that trucks should be fitted with a stereo sound system to combat driver fatigue on long

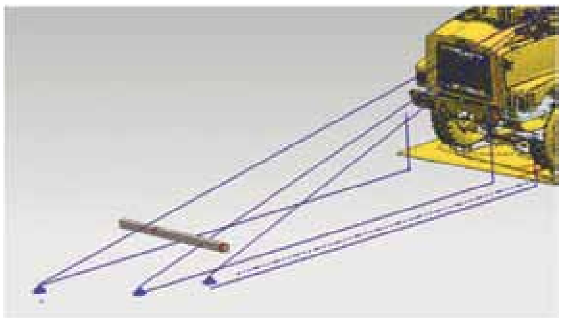
Right: Mercedes Benz and Mack trucks currently in service with Army, used for comparison in the truck replacement studies.

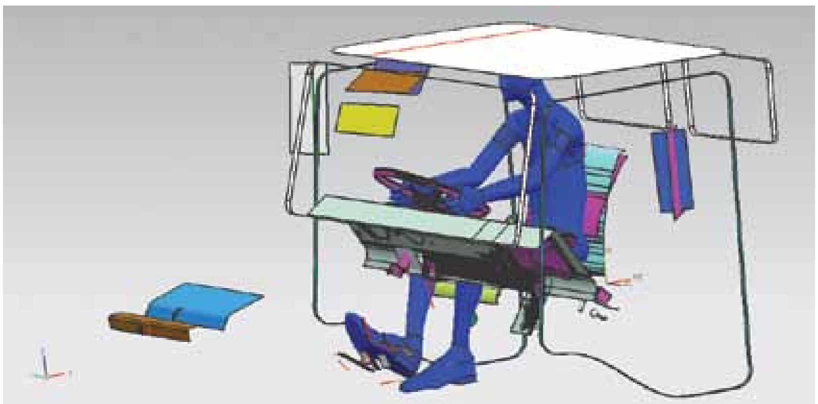
haul trips. If not fitted, drivers often bring their own MP3 players, an eventuality that could diminish operational capabilities.

These issues have been reported to Defence stakeholders for their consideration and possible use in the tender evaluation process, and will also serve as background for future DSTO research work, including collaborations with the Royal Melbourne Institute of Technology and the Monash University Accident Research Centre. Two more trials are planned for 2011.

Also during the course of recent work, the team gathered measurements of some truck cabin interiors in order to study integration issues for the battle management system to be added, with the DSTO team having already made various suggestions in this regard. Ω







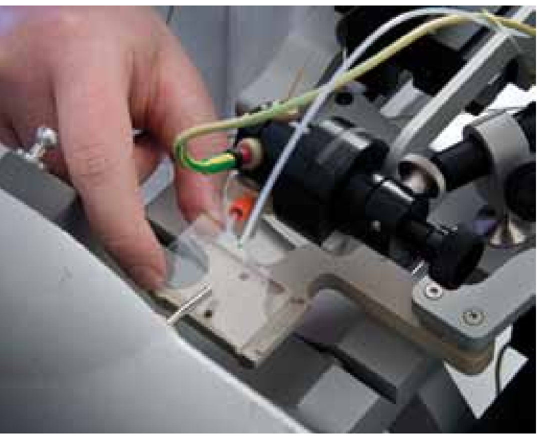
Top: DSTO researcher carrying out data entry while on the road during vehicle testing.

Left top and bottom: Graphics of truck cabin created for ergonomics studies.

Above right: Graphic for study of driver's sight lines from behind the wheel.

Sniffing out what's suspect – an easier alternative

DSTO has evaluated the potential of a technology called ambient mass spectrometry to provide Defence with a readily portable field detection capability for use by non-specialist operators.



This technology, a specialised form of mass spectrometry, enables a search to be conducted for chemical traces on the surfaces of glass, plastics, leather, paper, plant material and human skin in open air and under ambient conditions with little or no sample preparation.

One kind of ambient mass spectrometry system seen to hold particular promise is termed desorption electrospray ionisation (DESI).

"The DESI technique is highly sensitive with an almost instantaneous response, making it suitable for a range of applications in the laboratory and, potentially, in the field for security screening and incident first-responders," says DSTO researcher Dr Andrew McAnoy.

Numerous applications of the technology have already established its ability to detect a wide range of compounds, including drugs and explosives, within materials as complex as biological tissue, blood and urine.

The issue of size

The major drawback for its implementation in a field-portable context, however, is the size of apparatus.

"A miniaturised mass spectrometer with an atmospheric pressure interface is at the prototype stage, but requires further development to realise the full potential of DESI as a portable and deployable field capability," explains Dr McAnoy.

"While the DESI process occurs at atmospheric pressure, the mass analysis process still requires vacuum conditions, posing a significant challenge for the miniaturisation of mass analysers."

Other challenges for field-based application include provision of an adequate supply of scientific grade solvents and gases to be expended during the assay process, electrical power needs and cost of the unit.

Mindful of these challenges, other ambient mass spectrometry technologies are being considered. One such is known as a low-temperature probe that offers the advantage of being able to perform desorption ionisation analysis using just air, thereby obviating the need for scientific grade solvents and gases.

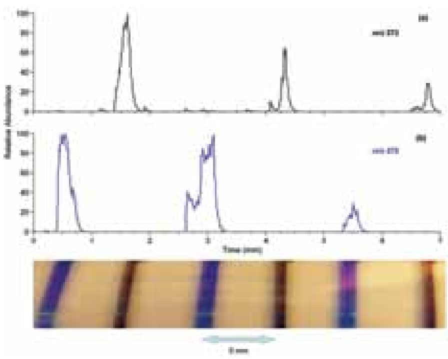
Testing DESI's sensitivity

Meanwhile, the DSTO team has undertaken studies in the laboratory to gather further information about DESI's abilities to detect and identify various compounds.

One study involved Texta pen lines drawn on paper, with a first set in black ink and a second in blue ink. The ink provides a ready visualisation where chemical substances (dyes) are bound to the paper. The DESI apparatus was easily able to identify the presence of the dyes, differentiate between the black and blue dyes, and to generate a chemical map of the surface that correlated with the visual image of the paper.

Other studies were conducted for detecting traces of explosives, herbicides and other compounds, with positive indications also being given for these.

Dr McAnoy's research was carried out under the DSTO Fellowship program. Ω



Left: Dr Andrew McEnoy with DESI apparatus.
Above: Chromatograms obtained by DESI analysis of blue and black Texta lines drawn on a glass surface.

Briefs

Net Warrior moves on understandings for future warfare

DSTO recently conducted a war game exercise involving an airborne attack on the Australian mainland. Throughout the exercise real mission computers were fed information from real-world and simulated systems and their responses monitored.

The purpose of the exercise was to showcase developments in the integration of network centric warfare (NCW) technologies to senior Defence personnel.

Known as the Net Warrior Demonstration event for 2010, this drew on target tracking data obtained by the real Wedgetail Airborne Early Warning and Control (AEW&C) mission system along with intelligence data obtained by the Australian Defence ISR Integration Backbone (ADIIB).

The AEW&C information was presented for command purposes in DSTO's Future Operations Centre Analysis Laboratory in three-dimensional geospatial form on a 'real time' basis, supported with ADIIB contextual information that included imagery and full motion video.

Following the 'learning by doing' approach adopted by Defence for implementing NCW, new capabilities and system integration technologies were being put to the test, with the main interest focusing on performance and capabilities of a middleware-based service orientated architecture for integrating tactical systems with tactical data links.

As well as various findings on the technologies arising from the experiment, it also delivered outcomes in the form of advice to Defence about the need to consider and implement particular NCW concepts and technologies.

Future plans include adding elements from the land and maritime domain. Ω

Defence Science Institute launched

A new research collaboration between DSTO and the University of Melbourne was announced recently by the Minister for Defence Science and Personnel, Warren Snowdon.

Known as the Defence Science Institute (DSI), this partnership is aimed at undertaking research to advance Defence capability.

Research topics to be investigated initially include biological systems, human protection and performance, signature management, energy and propulsion systems, micro-radar technologies and intelligent information systems.

Other research areas of interest are improved detection of concealed targets, and advanced control systems for future land and sea-based electro-mechanic propulsion systems.

DSI is also expected to provide an important training ground for PhD students in these fields of study.

Funding for the DSI is being shared by DSTO and the university with additional support provided by the Victorian government. Ω

Carbon honeycomb solution to shipboard transmission problem

DSTO was recently asked to investigate ways of preventing interference between two types of radio systems fitted to ANZAC-class frigates.

This problem arises because the antenna for Centaur electronic support measures (ESM), critical to the detection of distant threats, is in proximity to the M-ASTIS satellite communications system antenna.

An initial approach for a solution – a physical barrier between the two antennae – had been considered but rejected as unworkable. However, after DSTO computer modelling showed that this form of shielding was likely to be effective, a prototype structure was developed.

The DSTO-designed radio emission shield (surfboard shape, centre of picture) fitted to HMAS Stuart.

To minimise weight, it was constructed from carbon fibre with a honeycomb core in the manner of aircraft structures. This was then covered in DSTO-designed coatings for absorption of the various radio emissions.

A position for the structure on the ESM mast was chosen projecting aft, so that it shielded the high-band radio transmission array from the M-ASTIS antenna. The shape and size of the shield was optimised in order not to obscure the ESM system from desired views of the horizon as the ship's masts swung through various pitch and roll motions.

Trials were carried out with the shield fitted to an ANZAC frigate, showing that the interference problem had largely been mitigated, and that the performance of the ESM system meanwhile was unaffected by the shield's presence.

The time taken to progress from concept to fully tested prototype was just six months. Further work to be undertaken includes fabrication of additional shields, and detailing of shield certification and installation procedures. Ω

Calendar

5 - 7 Apr 2011

Off-shore Patrol Vessels Asia-Pacific 2011

An international forum bringing together the naval community to examine the increasing significance of the OPV sector in the Asia-Pacific region and recent technological developments in this field.

Grand Hyatt
Singapore
http://www.australiandefence.com.au/events/offshore-patrol-vessels-asia-pacific-2011

28 - 30 Jun 2011

Defence + Industry 2011

The largest Defence and industry event in Australia for the year.

Adelaide Convention Centre
Adelaide
http://www.defenceandindustry.gov.au/

5 - 6 Sept 2011

***ADM's* Defence Skilling Summit 2011**

A major forum for exploring the issues of training and maintaining a skilled workforce for Australia's defence industry.

Stamford Plaza
Brisbane
http://www.australiandefence.com.au/events/adm-s-defence-skilling-summit-2011

12 - 13 Oct 2011

Joint Warfare Conference

An event hosted by the Australian Department of Defence for local and overseas attendees with a focus on the development of joint capability against the backdrop of current operations.

Canberra
http://www.australiandefence.com.au/events/joint-warfare-conference

31 Jan - 3 Feb 2012

Pacific 2012 International Maritime Exposition

The commercial maritime and naval defence showcase for the Asia Pacific.

Sydney Convention and Exhibition Centre
Sydney
http://www.pacific2012.com.au/content-exposition/index.html

31 Jan - 3 Feb 2012

Royal Australian Navy Sea Power Conference 2012

The seventh biennial RAN Sea Power Conference, to be held in association with Pacific 2012.

Sydney Convention and Exhibition Centre
Sydney
http://www.pacific2012.com.au/content-exposition/index.html