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AUSTRALIA

Safer evacuation measures at sea

Spray-on coatings for better blast protection

Particle dynamics research into airborne hazard behaviours

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, 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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Cover image: DSTO researchers conducting particle dispersion study in water channel apparatus.

Keener aircraft eyes for spotting incoming fire

Most Australian Defence Force (ADF) aircraft have the ability to warn against missile attack – a capability that DSTO has been working to improve and extend.

The Cassadian AN/AAR-60 missile launch detection system (MILDS) fitted on ADF aircraft warns of attack by detecting ultraviolet light given off by a missile's rocket motor.

The apparatus consists of four to six ultraviolet sensors mounted around the body of the aircraft, giving 360 degree coverage. The system's master sensor analyses and classifies all detections and determines if they are a threat to the aircraft. The AN/AAR-60 MILDS in turn is linked to a variety of missile countermeasures that are activated automatically upon detection of a threat.

The system, mounted on the Tiger Armed Reconnaissance Helicopter as well as the MRH-90 and CH-47 Chinook helicopters plus the Orion AP-3C, provides fast warning and response with a very low false alarm rate. It is particularly useful for detecting infrared-guided missiles including shoulder-launched heat-seeking missiles.

A good system made better

Because the AN/AAR-60 is considered crucial for aircraft protection against surface-to-air missiles, DSTO was recently tasked to assess its performance against specific threats.

This work involved analysis of data recordings from live missile firings and data recorded from operational missions during ADF operations in Afghanistan and the Middle East.

"The findings arrived at by DSTO and the AN/AAR-60 system's maker, Cassadian, were that system performance for detection of specific threats could be improved, and that such improvements could be achieved by devising new signal processing algorithms," says DSTO researcher Dr Sebastien Wong.

"The outcomes of this work were to deliver increased detection performance against all types of missiles, and to simultaneously lower false alarm rates."

A key enabler for the work was the strength of the relationship DSTO and the Defence Materiel Organisation has with Cassadian, a subsidiary of the European Aeronautics Defence and Space Company. This trust allowed the company to share its 'know-how' without fear of loss of intellectual property rights.

Detection capabilities extended

Another major advance that has been pursued subsequently has been to establish ways of adapting the AN/AAR-60 system to provide warning of incoming small arms fire and rocket propelled grenades (RPGs).

The value of doing so can be found in the many anecdotal reports of aircrew serving in conflict zones. These reports tell of aircraft having come under attack from small arms fire, which the crew only learned about after seeing bullet hole damage in their aircraft back at base. The addition of a hostile fire indicator (HFI) warning capability to detect this less lethal but more common threat was thus seen to be highly desirable.

The challenges of delivering the new capability, however, were formidable. These included ensuring non-interference with the primary AN/AAR-60 requirement to detect incoming missiles, and that the impacts on aircraft in terms of additional weight, power and space required were minimal. The latter issue is of particular concern given that all available space in military aircraft is generally in use by design to house vital aircraft equipment or a system or capability of some kind.

HFI technology developed

The new capabilities sought were to detect hostile fire at useful ranges coming from balllistic weapons of varying calibre and RPG launches. The kinds of signals to be detected now included muzzle flash and tracer illumination from weapon firings and RPG emissions.

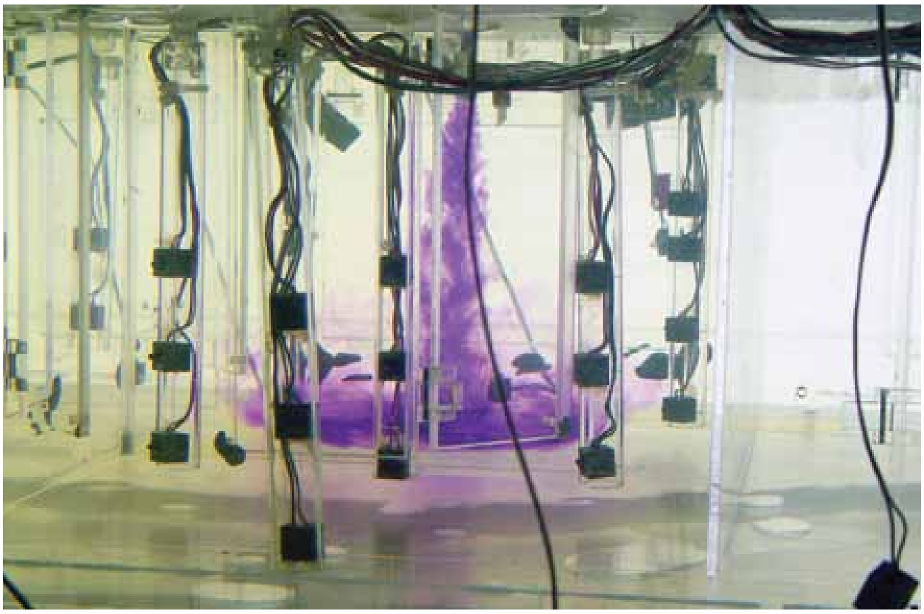
The proposed solution will only require upgrade of sensors with a new hardware version and uploading of some new algorithms into the AN/AAR-60 signal processing system. This will enable the system to detect and track tracer fire, and locate the origin of small arms fire.

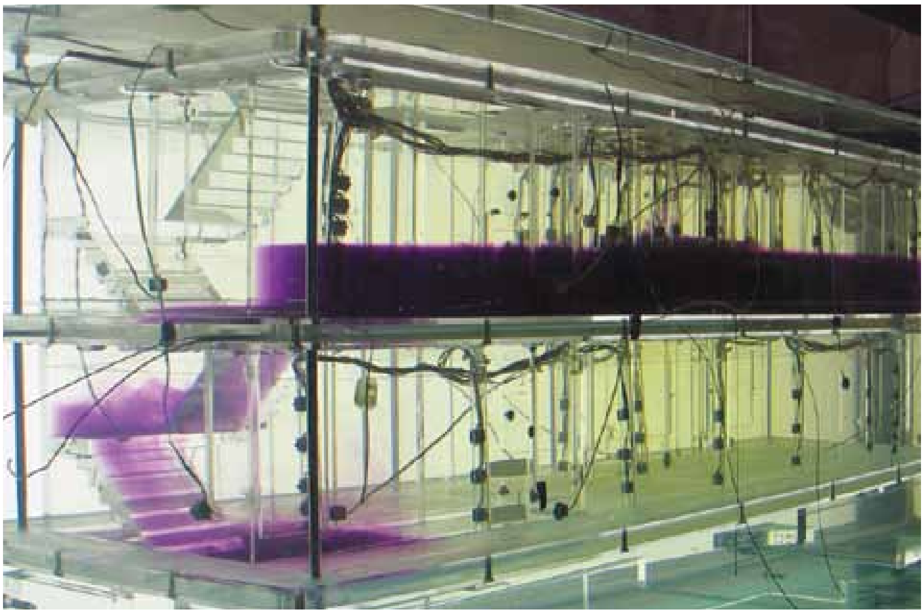
The work on AN/AAR-60 overall is on track to deliver a more complete threat warning solution for ADF aircraft.

***Above left:** Crane-mounted rig used by DSTO to simulate MILDS sensors on a hovering helicopter for threat warning tests.*
***Above right:** A suite of AN/AAR-60 MILDS components, as used on ADF aircraft.*

Better understanding of airborne menace behaviours

DSTO has developed improved ways of predicting the spread of air-released hazards and when and where they are likely to settle.





The type of airborne threats addressed by this work includes chemical, biological and radiological (CBR) warfare agents as well as toxic gases, smoke and aerosols.

The main mechanisms of particle dispersion – random displacement by turbulent fluctuations – have been thoroughly examined theoretically and carefully validated experimentally, with work first being done in this area back in the 1920s.

Much research effort and discussion in the scientific literature since then has been directed towards achieving a better understanding of particle dispersion mechanisms.

"The importance of particle dispersion work arises from the fact that geophysical systems, such as the atmosphere and oceans, can transport particles on a global scale," says DSTO researcher Dr Alex Skvorstov.

"For example, radioactive particles released by the Chernobyl reactor accident in 1986 are still carried in high altitude atmospheric layers, having circled the globe many times already."

New dispersal mechanism identified

DSTO, in collaboration with the Defence Research and Development Canada (DRDC), has recently established a new mechanism of particle dispersion through theoretical and experimental investigations.

"Finding a new particle dispersion mechanism is a very significant achievement, given the large amount of research effort that has been put into the area," says Dr Skvorstov.

"This mechanism is found to be dominant in the atmospheric boundary layer at the long-time evolution of a large-scale cluster of hazardous particles."

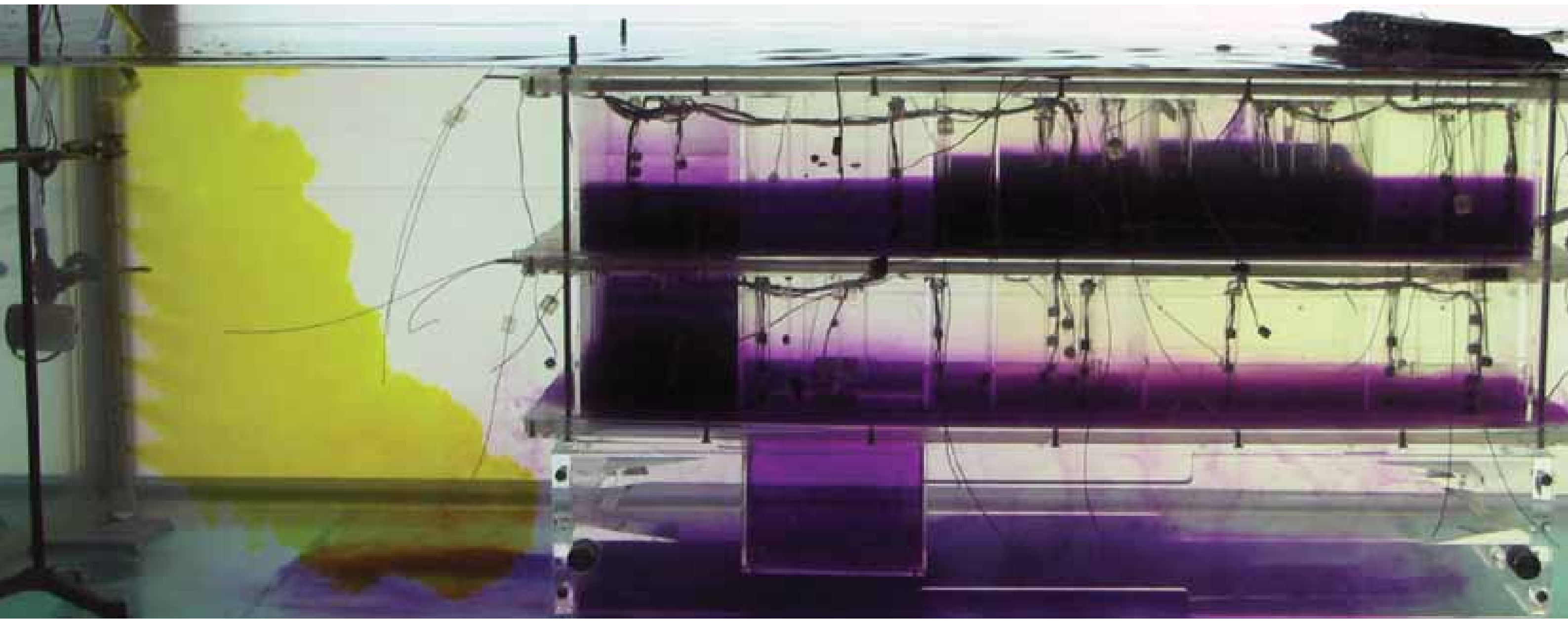
The results of the DSTO-DRDC work, published in the prestigious *Physical Review Journal*, may have significant consequences for technical applications in the defence and national security domains.

The DSTO-DRDC findings were arrived at through research carried out under The Technical Cooperation Program (TTCP).

Towards a better dispersion model

With CBR warfare posing a pronounced threat worldwide, much work has been done on developing computer models of plume behaviour to assist emergency response measures.

Proposed CBR response strategies include the use of wireless networks of sensors that gather real-time point data on meteorological conditions and particle emissions. Feeding this data into a model enables predictions to be made of the likely spread and density of the plume for a given set of environmental conditions. This approach can also be used to establish the site of release by describing plume behaviour in the reverse time direction.



Such modelling takes into account the effect that various obstacles to particle flow have on mixing and dispersal within confined spaces and in the open. The obstacles to flow found within structures are features like walls, ceilings and stairs. In an open setting, salient obstructions are trees and buildings, with the height and density of these affecting plume turbulence and concentration.

Different research efforts have applied various approaches to arrive at a predictive capability, ranging from rigorous theoretical modelling, empirical modelling based on measurements taken during field trials, and the use of computational fluid dynamics modelling.

While the latter form provides the greatest accuracy, it also requires significant amounts of computational power and often very long calculation time.

DSTO-DRDC recently managed to improve on this situation with the development and validation of a new physics-based model of particle flow that both provides good modelling accuracy and reduces the computational effort involved.

This development opens the way to the development of modelling that may be useful for Defence and homeland security agencies on an operational basis.

Validation of model accuracy

The new model, devised by DSTO, was subjected to a validation process to establish its predictive accuracy. This process firstly involved computer-based numerical simulations, followed by experiments carried out by DRDC in an apparatus called a water channel.

A water channel apparatus typically consists of a glass tank in which a structure sits, with water-borne tracer particles emitted around, over or within the structure.

The structure used for the Canadian work was a surface uniformly textured with angular features that caused turbulent flow behaviour, as would occur with the release of airborne particles in an urban setting. The experiment involved releasing tracer particles into the water flow and then observing where they go and how long they take to settle.

Further validation work involved field trials undertaken with TTCP partners.

As a result of this validation work, the Australian-Canadian particle propagation model became the first anywhere globally to have proven modelling accuracy. The model was put to practical use in the lead-up to the 2010 Vancouver Winter Olympics during risk assessment work done on stadiums.

DSTO model research

Water channel research is now being conducted on model-scale complex structures, this time at DSTO. The model currently being used is a two-storey building with a system of interconnected compartments.

The model building, originally built for a different research purpose, was modified to ready it for particle propagation studies, making such studies possible in Australia for the first time.

These studies are expected to enhance understandings of hazardous particle propagation in complex structures such as ships and submarines.

In addition to The Technical Cooperation Program work being conducted, DSTO is also participating in research under a CBR Memorandum of Understanding involving the United States, United Kingdom, Australia and Canada. Ω

Photos this page and previous: Dye inserted into and dispersing through water channel apparatus to simulate airborne particle behaviour.

Roaming radio link delivers extra communications coverage

A DSTO-initiated radio transponder system carried by an unmanned aerial vehicle (UAV) is generating great interest within Defence circles.

Above: DSTO researchers conducting balloon flight studies at the Woomera Test Range.

The system, known as the Airborne Ultra High Frequency Transponder for Radio Relay (AUTRY), was developed by DSTO and Australian industry to enhance Army communications capabilities.

The problem it addresses is the need for ground troops to communicate by radio when out of line-of-sight of each other. Ultra High Frequency (UHF) radio communications, as used by Army, are only reliable if there is no physical barrier between radio units, and obstacles such as mountains, buildings and the earth's curvature present impediments.

One way to overcome the line-of-sight problem is by use of satellite communications. However, demand for Australia's military communications satellite bandwidth has always been high and constantly increasing as new technologies come into use.

Over a decade ago, Dr Weimin Zhang began to investigate surrogate satellite options to ameliorate this pressure. His previous work on troposphere scattering and High Frequency radio communications had led him to understand the limitations of these options, so the solution he sought instead involved a UHF transponder link carried by an airborne platform.

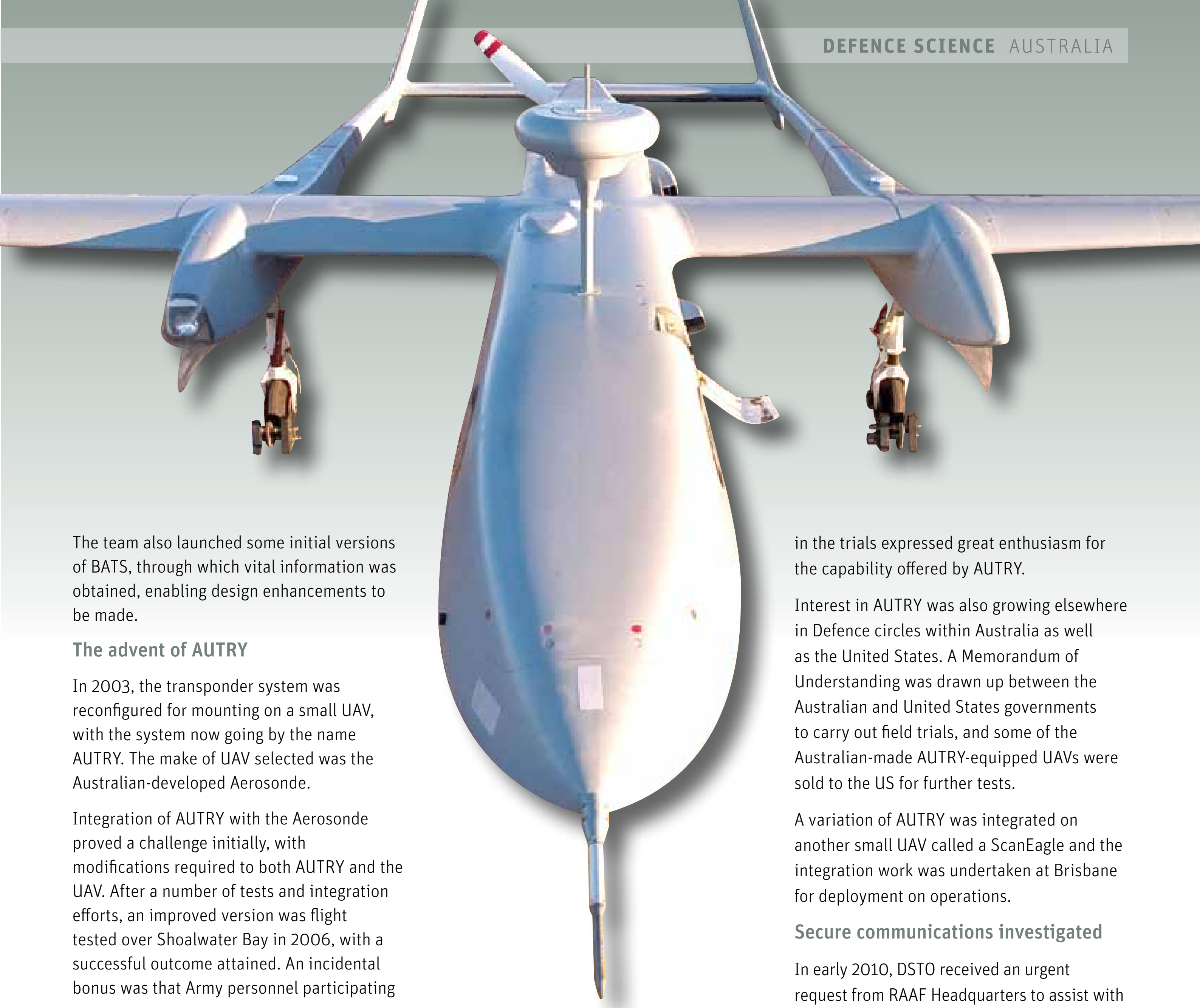
Weather balloon and BATS

The first incarnation of this idea used a helium filled latex balloon as the airborne platform, an approach inspired by weather balloons Dr Zhang saw in use on Navy vessels.

He studied the suitability of such a system by research into balloon ascend and descend rates, wind profile and speed of surface platform movement. Finding this to be viable for his purposes, he set about developing a disposable transponder structure.

With DSTO support and minor capital funding, an Adelaide-based company, Long Distance Technologies (LDT) was contracted to develop the concept apparatus, named Balloons As a Temporary Satellite (BATS).

Working in parallel, Dr Zhang assisted by a small group of researchers undertook balloon flight studies at the Woomera Test Range. Data obtained by tracking the balloon flight paths served to confirm the findings of Dr Zhang's earlier analysis.



The team also launched some initial versions of BATS, through which vital information was obtained, enabling design enhancements to be made.

The advent of AUTRY

In 2003, the transponder system was reconfigured for mounting on a small UAV, with the system now going by the name AUTRY. The make of UAV selected was the Australian-developed Aerosonde.

Integration of AUTRY with the Aerosonde proved a challenge initially, with modifications required to both AUTRY and the UAV. After a number of tests and integration efforts, an improved version was flight tested over Shoalwater Bay in 2006, with a successful outcome attained. An incidental bonus was that Army personnel participating in the trials expressed great enthusiasm for the capability offered by AUTRY.

Interest in AUTRY was also growing elsewhere in Defence circles within Australia as well as the United States. A Memorandum of Understanding was drawn up between the Australian and United States governments to carry out field trials, and some of the Australian-made AUTRY-equipped UAVs were sold to the US for further tests.

A variation of AUTRY was integrated on another small UAV called a ScanEagle and the integration work was undertaken at Brisbane for deployment on operations.

Secure communications investigated

In early 2010, DSTO received an urgent request from RAAF Headquarters to assist with provision of a communications relay capability for deployment. A particular requirement was that cryptographic equipment not be carried on the UAV platform. The platform used here was the Heron UAV.

Delivering this capability involved working with RAAF personnel, the Heron designers and the Defence Materiel Organisation on integration and flight tests.

"The trials were very successful," says Dr Zhang. "They impressively demonstrated to all participants that AUTRY's large coverage footprint can dramatically enhance the radio communications capabilities of deployed forces."

To date, over 30 AUTRY units have been produced by RF Industries in Adelaide. A Department of Defence Capability and Technology Demonstrator project is currently underway with the company to develop an enhanced UHF repeater that will extend radio range capabilities for ground forces.

***Top:** Heron UAV fitted with AUTRY.*
***Above:** DSTO and Army personnel with Aerosonde UAV fitted with AUTRY.*

Getting better prepared for emergencies at sea

Understanding how personnel move around a vessel during emergencies is critical to the development of safe and effective evacuation measures, and DSTO is making important advances in this area.

The Canberra Class Amphibious Assault Ships to be acquired by the Australian Defence Force (ADF) can each carry up to 2,000 personnel, including Navy crew and embarked Army troops – many more than previously possible on a single ADF vessel.

With such large onboard numbers now involved, Defence has to ensure that if evacuation at sea should be necessary, this can be handled optimally and safely.

According to DSTO researcher Michelle Grech, “Currently, there are significant gaps in our understanding of the underlying processes in escape and evacuation events at sea as well as the safety issues involved.”

The value of modelling

One way of studying evacuation events is through the use of computer-based simulations. This approach had indeed been applied for the study of building and aircraft evacuation, with some 40 simulation tools having been developed for those purposes.

Modelling was first applied also to the study of shipboard evacuation processes following some major failures in passenger ship evacuation. The approaches to modelling being adopted, however, took a variety of forms. This led the International Maritime Organisation (IMO) to lay down guidelines for modelling, setting out standards on how evacuation modelling should be conducted for certification purposes of merchant shipping operations.

As a result of IMO recognition that modelling could deliver greater shipboard safety, more sophisticated models for maritime use were developed. These are now capable of representing human movement as populations of interacting individuals as well as simulating the complexities of the spaces in which they interact.

While such tools have proved very suitable for the needs of passenger and merchant shipping operations, for naval operations, another need remained to be addressed – the ability




to simulate ship recoverability processes.

Ship recoverability is the capability to restore operational capacity after sustaining damage, which involves the tasks of damage control as well as repair and restoration of ship systems.

DSTO set about filling the gap here in modelling capability by seeking to build on available resources.

A realistic model for Australia's Navy

One of the more popular tools for modelling human movement on naval ships in many countries is a software package called maritime *EXODUS*, which is capable of simulating behaviour and movement in large complex spaces. DSTO investigations into its capabilities, however, revealed a number of limitations from the point of view of Australian Defence Force operations.

One critical deficiency identified was the lack of data on personnel performance and behaviour for Australia's Navy population. Another was that the maritime *EXODUS* evacuation scenarios were not appropriately representative, being based on the assumption that the vessel maintains even heel and trim throughout.

To overcome these shortfalls, DSTO set up a two-phase research program. The first phase, now completed, involved a pilot study with DSTO volunteers. The second phase, to be conducted soon, will involve full-scale ship trials to capture data on Navy personnel performance in the course of escape and evacuation events that incorporate damage control activities.

The aims of the work overall are to deliver a capability for Navy to evaluate, assess and improve naval ship recoverability operations for current and proposed vessels as well as to develop and improve relevant damage control guidelines and processes. It will also enable incorporation of modelling outputs into the Integrated Survivability Assessment Simulation Tool being developed by DSTO. These outcomes are expected to contribute ultimately to better naval ship design and safety.

Pilot study

The pilot study was undertaken at HMAS *Cerberus* in November last year.

Preparations for the study included the use of two structures replicating the upper decks of a ship. Both have identical passageway and cabin layouts with one key difference – the decks of one are inclined at seven degrees to the horizontal plane (simulating a permanent vessel heel of seven degrees) while the other structure sits flat.

Twenty participants were recruited for the study from within DSTO, the criteria for selection specifying that the person had to be relatively fit and under the age of 40. The participants were then surveyed by questionnaires to gather demographic data on gender, age, height and weight for the study population.

The conduct of the study required participants to get from a position in the structure to a designated evacuation mustering station, with increasing levels of task difficulty imposed over the course of four runs.

The first run required participants just to get from their position in the structure to the mustering station. In the subsequent three runs, participants had to transit one closed watertight door, then two, and lastly, to collect and don a lifejacket before carrying out the other steps.

These four runs were carried out firstly in the flat configured structure, then in the one with simulated seven degree heel.

To collect data on participant performance, each was required to wear an infrared sensor tag. These were triggered to record data about time and place when the wearer passed through each of six beam of infrared light emitted by beacons placed along the routes. The participants also wore 'actiwatches' to detect and log movement intensity and duration, and half the participants were additionally fitted with monitors to collect data on movement orientation changes.

As a cross-check for the infrared tag data, video camera recordings were captured at six points along the route so that participants' progress could be studied via time-code analysis of the footage, and study observers also logged participant arrival times using stopwatch and timesheet methodology.

The analysis process

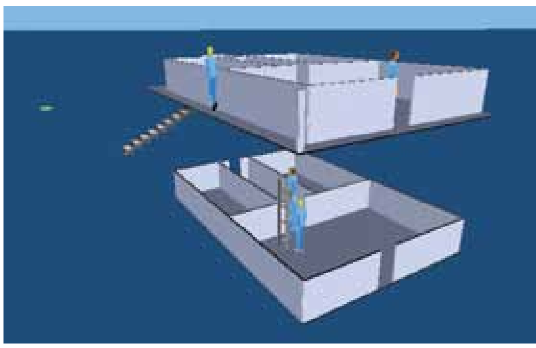
After completion of the evacuation trials, data extraction was undertaken to arrive at findings on a range of performance aspects.

These included individual response times to sounding of alarm, average individual travel speeds, identification of congestion points, time to travel between key location points such as up and down ladders, time taken to arrive at the mustering station, time taken to open and close the watertight doors, and time taken to collect lifejackets.

This data will be used to prepare for the full-scale studies with Navy personnel by providing a measure of the performance and accuracy of personnel tracking equipment, and informing the development and refinement of study methodologies.

Another use for the pilot study data is to assist with validation of the maritime *EXODUS* escape and evacuation simulation tool. This will involve compiling data into a coherent input data set that can be reliably applied for the validation process.

Maritime *EXODUS* will then be tasked to simulate the pilot study runs for each phase, with its findings checked against those of the pilot trial to establish reliability and consistency in simulation results output.



Main photo opposite: DSTO's maritime evacuation research facility.

Photo montage: Evacuation experiments conducted using structures simulating ship upper decks in level-heel mode and with seven-degree heel.

Graphic above: Computer modelling for ship survivability studies.

Spray-on polymer offers added blast protection

DSTO research has shown that a coating of polymer on steel plating enhances the steel's resistance to blast deformation forces.

In response to the growing threat of terrorism, defence research organisations around the world have sought to increase the blast resistance of metal panels in vehicles and structures.

While items yet to be manufactured can be readily made more blast-resistant through the use of stronger steel plating, the challenge has been to find cost-effective and time-efficient ways of doing so for items already produced.

An approach that shows great potential here is the use of polymer coatings applied to the side of the metal plate facing away from the direction of potential blast effects. These materials are manufactured as liquid-form products suitable for spray-painting onto a surface.

"Many polymer products can be relatively easily applied to existing vehicles and structures, making them well suited to battlefield protection upgrades," says DSTO researcher Kate Ackland.

Testing DSTO's polymer effectiveness

DSTO undertook a first lot of tests on a polyurea product made in-house.

Two grades of steel were used in testing; D36 ship steel, and X80, a low-cost high-performance steel designed for manufacture of high pressure gas lines.

Three one-metre square samples of each steel were prepared for testing. One had polyurea coating applied on the back surface to a depth of 10 millimetres, and another was similarly coated to a depth of 19 millimetres. The third, given no coating, was included for testing to establish a baseline measure of coating effectiveness.

The plates were then exposed to blast force loading at an outdoor test range. The blast effect the researchers chose to create was produced by detonating a spherical half-kilogram charge of pentolite centrally suspended 20 millimetres from the steel plate. This experimental setup was established through trials as a way to produce plate deformation without rupture.

To ensure a consistent level of blast force was being applied on all tests, pressure gauges were set up to measure the outcomes of detonation. A timing apparatus was also used to measure the rate of plate deformation.

The findings for the D36 steel were that the 10 millimetre coating reduced deformation by 6 per cent and the 19 millimetre coating reduced it by 24 per cent, compared to the deformation the uncoated plate sustained.

For the X80 steel, meanwhile, the results were 29 per cent and 43 per cent deformation reduction respectively compared to the uncoated sample of this steel, showing that the coating had a much greater protective effect on the stronger steel.

Testing the commercially available range

Another series of experiments was undertaken on the performance of three commercially available products, including a polyurea product and two polyurea-polyurethane blends.

These coatings were applied to four millimetre-thick mild steel plates. A five millimetre steel plate with no coating was used to compare the effects of the same blast loading on a higher strength steel.

The results were that similar levels of deformation occurred for both coated and uncoated plates, meaning that coatings delivered a significant protective effect for the thinner, lower strength steel.

Modelling validation

The test results from the first set of experiments was used to validate the outcomes of modelling simulations conducted with a software program called *AUTODYN*.

For plates made of D36 steel, there was close agreement between the real-world data and the modelling data, with modelling results for maximum permanent deformation found to be within 10 per cent of the experimental results.

The correlation between models and experiment, however, was not as close for X80 steel plates, with deviations of up to 18 per cent between the two sets of results. The conclusion thus drawn is that modelling for the X80 material may need to be refined.

Modelling application

The numerical models were used to investigate the effectiveness of different coating configurations by varying the coating thickness, density and location – front of plate, back of plate or between two plates.

As found in the first set of experiments, protective performance increased with coating thickness. However, the researchers recognise that increasing coating thickness to deliver higher blast protection may not always be an option due to space restrictions on a platform.

Another finding was that protective performance increased with density, suggesting that a heavier material dispersed within the polyurea, such as metallic particles, may enhance its blast protection without adding to thickness.

When the location of coating was varied in the digital models, blast protection was slightly higher if applied on the back face of the steel. A sandwich configuration was also explored, where the coating was sandwiched between two steel plates. This configuration gave similar results to the coatings on the back face.

Protective approach with potential

DSTO's research overall has shown that polyurea coatings may be suitable for protection upgrades of steel structures when applied to the back face.

Suggested further work includes investigation of whether polymer coatings can be used to prevent fracture of a steel plate, and if so, what properties and thickness of coatings are optimal for preventing fractures. This work will be conducted via experiments as well as use of modelling.

Opposite page: DSTO researchers setting up apparatus to test blast protectiveness of a polymer coating.
Above: The test apparatus before detonation and after.

Analytical assistance for undersea decision-makers

In the highly complex world of submarine operations, arriving at optimal decisions is far from easy, and DSTO analysis is improving outcomes here.

The work of submarine commanders is made very difficult by the large number of operational factors that need to be tracked, and the very variable nature of operational scenarios.

Supporting their work is a hierarchical organisation of control room personnel and systems known as the Action Information Organisation (AIO). During high-tempo phases of operations when speed is particularly of the essence for decision-making, mission success depends on the capabilities of the AIO to deliver timely and relevant information to the commander.

The enormous complexity of the submarine operations domain also poses problems for design of the system-operator interfaces used by AIO personnel – a process where qualities of optimal usability and effectiveness are sought.

“Traditional methodologies used for the development of interface designs depend on the ability of subject matter experts and designers to predict the full range of situations that the submarine may find itself in,” explains DSTO researcher Dr Peter Henley.

“Where this cannot be done because of domain complexity, there may be operational situations in which the decision-support offered by the operator interfaces is at best ineffective or, at worst, downright dangerous.”

He and his colleagues have therefore sought to develop another way around the problem.

A new approach

The solution they propose is to establish interface designs that make the constraints to safe and effective decision-making obvious to those using them.

This approach allows for what is termed ‘context-conditioned variability of response’ from users that will enable them to deal successfully with unforeseen situations and circumstances.

"The intention is to help them define the limits to the solution-space, and they then rely on their expertise and training to devise the most appropriate response to their current situation," says Dr Henley.

"Limits on the solution-space can take many forms, from Rules of Engagement and Standing Orders to knowledge of the water depths expected on the current course, or the predicted change in probability of detection caused by a change of 'own-ship' course or speed."

Methodology applied

The methodology adopted by DSTO to discover these constraints and their associated knowledge-support and decision-support information is known as cognitive work analysis (CWA).

This is a theoretically complex analytical methodology developed in the 1980s, which the DSTO researchers recently adapted into a practically applicable 'analysis-to-design' tool.

It provides five distinct analytical 'lenses' – work domain, task, socio-organisational, activity and strategies – through which to view and capture the computer-based work of individual operators together with control room work patterns and information flows.

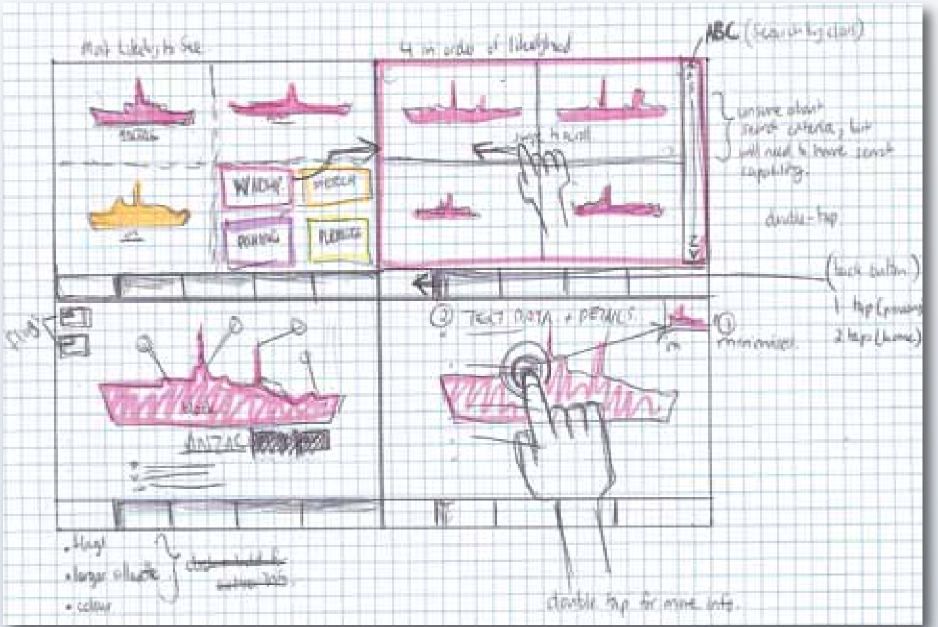
Applying the CWA approach has involved information gathering through interviews conducted with control room personnel as well as by observing command team training in a shore-based simulator.

Testing the methodology

Having successfully adapted and applied the CWA methodology, the researchers then undertook to test the efficacy of this approach by attempting to design two operator interfaces; one for use by the submarine watch leader and another for the periscope operator.

These designs were developed and implemented to the concept demonstrator stage, and initial end-user feedback has been positive. The DSTO researchers are now working towards full implementation and testing of the interfaces.

"As a result of our recent work, we possess a high degree of confidence that we have a practical method for deriving the knowledge-support and decision-support required by any member of the submarine AIO, and structuring it in such a way as to define both the form and content of the resulting user interface," says Dr Henley.



"This approach should have broad application for decision-making support in any kind of highly complex operational domain, including those outside Defence."

Further work

The DSTO researchers have also embarked on socio-organisational research that will deliver an understanding of how operators work together to achieve the overall goals and priorities of the AIO.

The work will involve a holistic social network analysis coupled with a link analysis of information sources, flows and sinks. Further individual operator analyses will also be undertaken, and the knowledge thus obtained will be applied to inform the design of future submarine control room layouts, the interfaces that they will contain, and the crewing structure that will make use of them.

The researchers are also working to develop operationally focused metrics that enable quantitative measures to be made of control room performance at both individual and team levels. These will be applied in scenario-based, operator-in-the-loop testing to ensure that any proposed changes made will, in fact, deliver system performance improvements.

While the DSTO work is providing support for current submarine fleet operations, it will also inform decisions on control room crewing and work processes for Australia's next-generation submarine.

Opposite and top: DSTO's Periscope Operator Interface design.

Above: A sketch diagram produced by the DSTO researchers of the functionality of the Periscope Operator Interface, including details of how information is to be accessed by tapping the screen.

Finding the right measure of soldier fitness

Recent research done by DSTO has established better indicators of fitness predictors.

DSTO is currently undertaking research on physical employment standards (PES) for Defence to provide a way to objectively assess the physical capacity of Australian Defence Force soldiers, irrespective of age, gender, height or weight.

Part of this work has involved ascertaining appropriate means for testing physical suitability for certain tasks.

Previous test methods required recruits to undergo an exercise regime that involved running, push-ups and sit-ups. This, however, poorly predicted physical fitness for muscular strength-based operational tasks; consequently DSTO undertook to investigate other possible fitness predictor techniques.

(A more detailed account of the background to PES research work is provided in the article, 'A fitter approach to personnel physical readiness,' published in *Australian Defence Science* Vol 17 No 1 2009.)

Box lift study

A study was recently conducted by DSTO to compare the results obtained using the approach, detailed in the above referenced article, with a new approach involving a 'box lift and place' assessment. This study was carried out using a test population of around 150 soldiers.

The 'box lift and place' assessment required participants to lift a weighted box from the ground, step forward, and place it onto the back of a truck, very much like the manner that such work would be performed in the field.

A mix of other potential strength assessments were tested including repetitive box lift and place, lift-carry-lift, repetitive lift-carry-lift, lifts to anatomical heights, and more.

Participants were then asked to undertake six employment category specific strength tasks: loading ammunition onto a tank, repetitively loading an artillery gun, dragging an injured soldier, extracting an injured soldier from an ASLAV, building a bridge, and lifting a field pack onto the tray of a truck.

Results

After analysing the study data, the researchers found there were very different levels of correlation between the two fitness testing approaches and fitness to do strength-based tasks.

"If participants were successful with the 'box lift and place', they were also likely to succeed in five of the six strength-based tasks," explained DSTO researcher Greg Carstairs.

"Meanwhile, success with current fitness testing methods indicated fitness for only one of the six strength-based tasks, namely bridge building."

"A repetitive box carry and place assessment was the only test that related to repetitively loading an artillery gun."

The conclusion drawn was that assessments directly relevant to specific tasks give a better indication of a person's ability to perform tasks in an employment category effectively and with a potentially reduced risk of injury.

"What we found is that the box lift assessment is a far superior predictor of job performance to those currently used and those used in the past," says Carstairs.

"It is also as good a measure, if not better, in five of the six tasks to the other potential strength assessments while being easier and quicker to administer."

Similar testing will be undertaken on forced march, fire-and-movement and lift-and-carry activities to enable quantification of soldiers' aerobic power, anaerobic power and muscular endurance capacities respectively.

This work is being undertaken at a time when all Defence force roles, including those of frontline combat, will soon be open to female personnel. The expectation is that better PES criteria will improve ADF abilities to recruit, train, and retain capable personnel.

Above: Soldier carrying out a strength-based task that simulates the exertion of dragging an injured colleague to safety.

Briefs

New Chief Defence Scientist takes the helm

Dr Alex Zelinsky was recently appointed Chief Defence Scientist and head of DSTO following the departure of Professor Robert Clark from this position in 2011. Dr Zelinsky takes up his new role in March 2012.

Dr Zelinsky, an internationally recognised scientist in the field of information sciences, distinguished himself while Professor of Systems Engineering at the Australian National University with his pioneering development of new human-machine interaction technologies.

Previous work in the field of robotics and computer vision had been undertaken with the AIST Electrotechnical Laboratory in Japan. His ANU work led to the creation of a spin-off company for the development of computer vision technologies, Seeing Machines.

Joining CSIRO in 2004 to lead its Information and Communications Technologies Centre, Dr Zelinsky was appointed Group Executive, Information Sciences Group in 2007. A focus of his work there was building research capabilities to address national challenges in the energy, health, agriculture, mining and environment sectors.

He has also worked with private and public sector organisations at the senior executive level, and is widely recognised for the outstanding contributions he has made in a leadership role.

One project of particular note that Dr Zelinksy is overseeing is the Australian Square Kilometre Array Pathfinder radio telescope and the associated high performance computational facility, the Pawsey Centre in Western Australia. Ω

Dr Alex Zelinsky.

Hypersonics program wins international award

DSTO has been working for the past six years in a collaborative research program with the US Air Force Research Laboratory and the University of Queensland in order to further fundamental scientific understandings of hypersonic flight.

The Hypersonics International Flight Research Experimentation (HIFiRE) program has undertaken to study hypersonic aircraft design, including related technologies in propulsion, materials, control, sensors and guidance in the course of nine flight trials.

The first flight, HF1, successfully launched in 2010, satisfied mission goals by reaching a speed of 8,000 kilometres per hour (Mach 7.5). In the process, 4GB of data were gathered, and subsequent processing and analysis has delivered valuable design data on aspects of airflow behaviour at hypersonic speeds.

The quantity and sensitivity of the data collected represented a break-through in hypersonic flight test evaluation. As a result, the principal players involved in the HIFiRE research program and representing DSTO, the US Air Force and the University of Queensland are to receive the International Council for Aeronautical Sciences (ICAS) 2012 von Karman Award for International Cooperation in Aeronautics.

This honour, commemorating the work of Hungarian-American scientist, Theodore von Kármán, to establish a global hypersonics research effort in the mid-twentieth century, is given for outstanding advances achieved through international collaborations. The award will be presented to the HIFiRE team at the 28th ICAS Congress in Brisbane in September 2012. Ω

New printer delivers in 3D

DSTO recently installed a 3D printer that enables quick production of prototype components in-house, meaning that researchers and clients can now readily access an actual version of a design for tactile examination of form, fit and function.

Previously, the options for component development were to examine component designs on screen by turning a computer model with use of computer controls. If a 'hard copy' version was required, this took possibly several hundred hours of computer numerical control (CNC) machining to produce at a considerable associated cost.

DSTO's 3D printer is capable of producing multiple components with a build table size of 350mm x 350mm x 200mm. Designs larger than this can be managed by printing them in parts for later assembly or by reducing the scale of model.

The process involves heating engineering-grade polymer resin to liquid form which is then spray-printed through jet nozzles in a particular planar shape corresponding to a very thin slice of the 3D model. The polymer is hardened by exposure to ultraviolet light during the printing process as successive layers are built up.

In fast mode, the printer produces polymer layers 30 microns thick, and in high quality mode, the layers are just 16 microns thick. It can print designs with an accuracy of plus or minus 0.1 millimetres, and nine different kinds of polymer can be used, ranging in stiffness from elastic to non-elastic.

The technology is capable of producing designs that are not possible with CNC methods, such as a sphere with spikes and machinery drive chain with fully functioning links. Ω

Machinery drive chain modelled by DSTO's 3D printer.

Calendar

16 Apr – 17 Apr 2012 **Association of Old Crows Conference and AGM**

The only combined electronic warfare, information operations and cyber operations convention in Australia, held every two years.

Adelaide Hilton Hotel
Adelaide
http://www.australiandefence.com.au/event/association-of-old-crows-conference-and-agm

23 – 24 May 2012 **Heli and UV Pacific**

A key event for the military and parapublic rotorcraft and the unmanned systems communities to network, discuss and demonstrate their products and experiences in the Australasian region.

Queensland RACV Royal Pines Resort
Gold Coast
http://www.shephardmedia.com/events/heli-uv-pacific-2012-69/

31 May 2012 **DTC Annual Defence Industry Dinner and Awards Ceremony 2012**

A prestigious event for the South Australian defence industry sector, involving more than 400 local and interstate attendees from defence industry, Defence, and State and Federal Governments, providing a valuable opportunity for industry and policy makers to network.

Adelaide Entertainment Centre
Adelaide
http://mybookingmanager.com/dtcdinner2012

31 May – 1 Jun 2012 **2nd Annual Cyber Security Summit**

A forum for senior Defence, National Security and Industry executives to consider ways for countering the real, evolving cyber threat to Australia's national security establishment.

Hotel Realm
Canberra
http://www.admevents.com.au/cybersecurity

18 Jun – 21 Jun 2012 **Simtect 2012**

An event that brings together educators, analysts and developers from Defence, resources and infrastructure, emergency management, transport, education, public sector and simulation industries around the theme: simulation – integrated solutions.

Adelaide Convention Centre
Adelaide
http://www.australiandefence.com.au/event/simtect-2012

29 Oct – 2 Nov 2012 **Land Warfare Conference**

A major event for users, providers, academics, designers and manufacturers to meet, present, share and exchange new and visionary ideas on Land Systems.

Melbourne Convention and Exhibition Centre
Melbourne
http://www.dsto.defence.gov.au/lwc2012/