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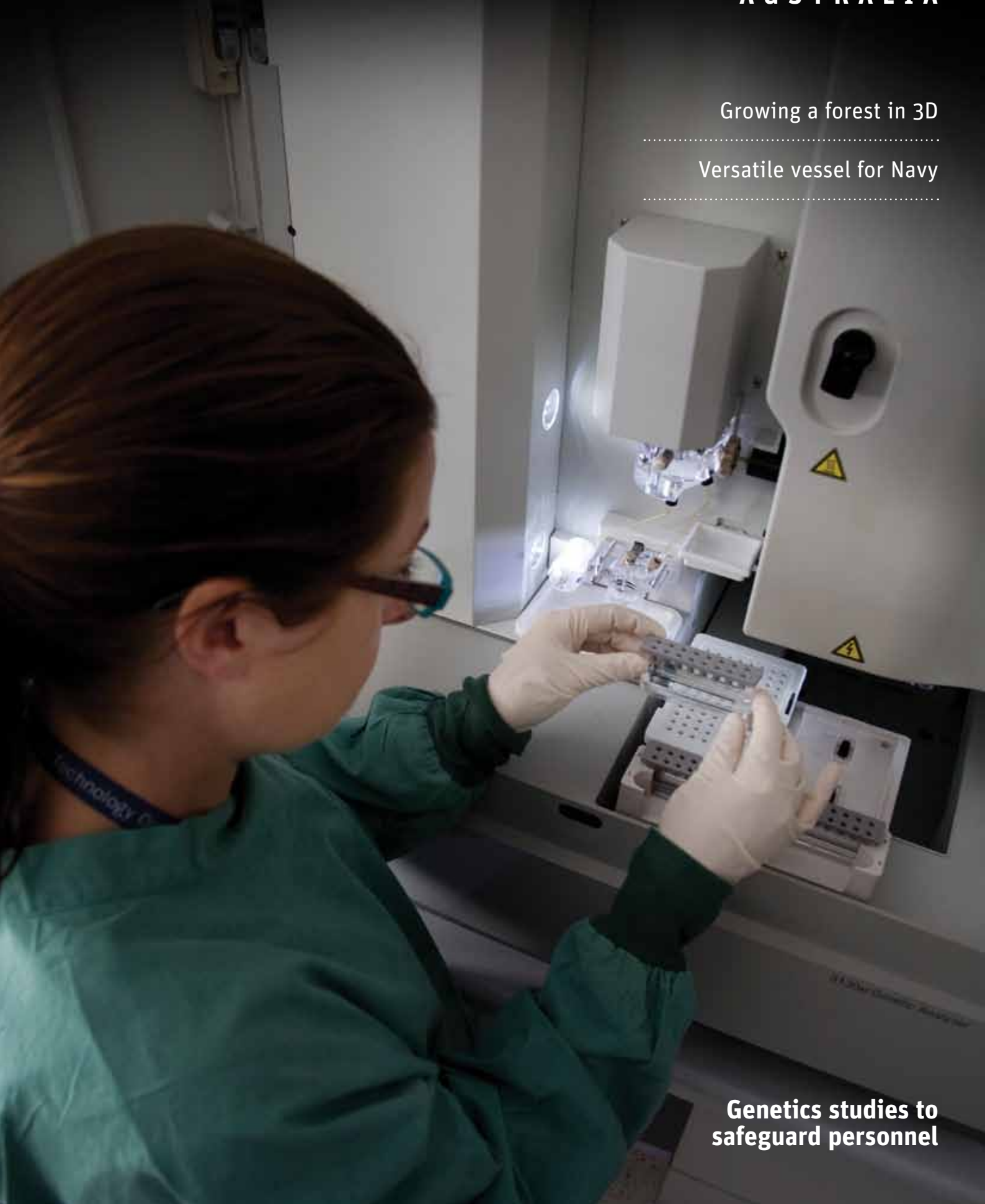
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A U S T R A L I A

Growing a forest in 3D

Versatile vessel for Navy

Genetics studies to
safeguard personnel





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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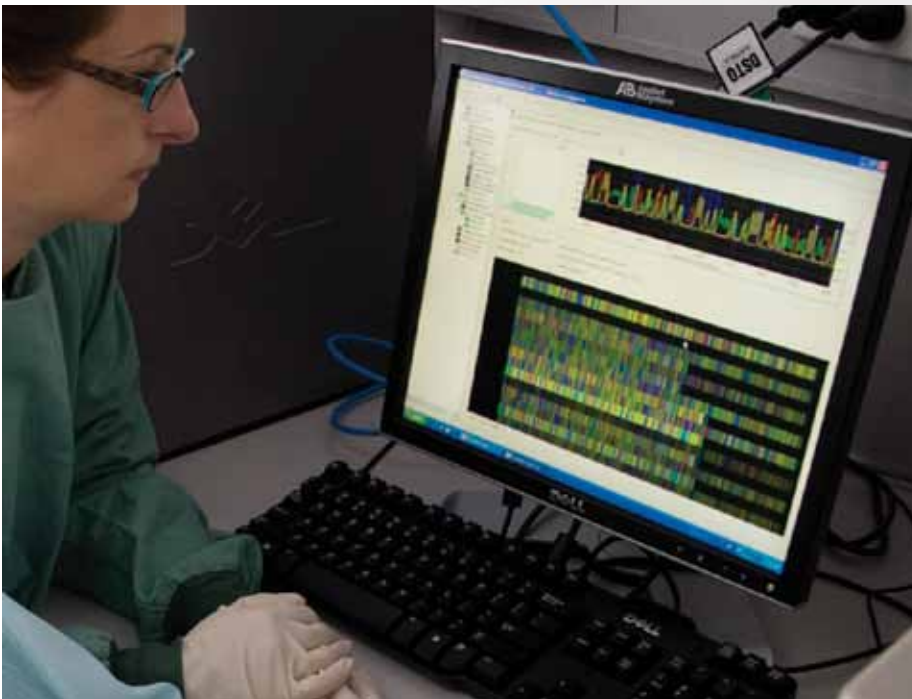
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Cover image: DSTO researcher loading DNA samples into fluorescence-based capillary electrophoresis gene sequencer.

Exploring predisposition to substance effects

DSTO is investigating the genetics of an enzyme that may make a person more sensitive to pharmacologically active agents in order to better inform Defence about the susceptibilities of personnel to various forms of exposure.



The enzyme under study, a naturally occurring part of blood, is known as butyrylcholinesterase (BCHE).

“Genetic variations in BCHE affect the response of the body to various xenobiotic agents,” explains DSTO researcher Kate Shields.

“Mutations in BCHE are responsible for the majority of cases of prolonged apnea – cessation of breathing – following administration of a drug called succinylcholine, a muscle relaxant commonly used in emergency medical interventions.

“In addition, genetic variation in BCHE is linked to sensitivity to both organophosphate and carbamate compounds, including the drugs pyridostigmine, physostigmine, heptyl physostigmine and SDZ-ENZ 713. These drugs can be given to personnel before or after deployment to conflict zones to counter the effects of chemical warfare agents.”

Getting a picture of genetic variations

The work carried out by a team of researchers at DSTO has involved analysing the genetic makeup of the BCHE enzyme for 51 Australian Defence Force (ADF) personnel.

“Our study has successfully screened the four coding regions and surrounding intronic regions of BCHE for both known and new forms of genetic makeup,” says Shields.

The study methods applied included use of a technology called High Resolution Melt, which is particularly suited to the detection of mutations in double stranded DNA samples. The technique is fast and simple to apply for genotyping of large numbers of samples, making it a very cost-effective study tool.

Another tool applied was that of a fluorescence-based capillary electrophoresis gene sequencer. The Applied Biosystem 3130 apparatus in operation at DSTO has the ability to analyse several hundred samples in a single run.

Study outcomes to date

Of the 51 samples of BCHE from individuals tested, twelve were found to be substantially different genetically (known as polymorphisms) while 35 were shown to have at least one genetic variation.

Eight of these polymorphisms were previously known, two of which were found in individuals known to be sensitive to succinylcholine and pyridostigmine.

Included in the four new kinds of polymorphisms identified, two are thought to cause a change in an amino acid that forms part of BCHE. With these latter cases, future studies will be undertaken to see if the genetic variation alters amino acid levels or its activity in the individuals concerned.

The overall findings to emerge from the study for Defence purposes are to demonstrate that unique and important functional genetic variations in BCHE between individuals can be identified, with some variations known to cause enhanced sensitivity to succinylcholine as well as organophosphate and carbamate compounds in a small subset of individuals.

Potential drug therapy advances

“Through this work, we see the possibility of one day delivering a capability to tailor drug therapies according to a particular patient’s abilities to metabolise, eliminate and respond to specific drugs,” says Shields.

“Such therapy could be applied very beneficially, for example, when giving frontline personnel treatment for chemical agent exposure before and after the event.” ¹



Top: Onscreen results of DNA sample analysis and (above) DNA samples ready for analysis.

Rotor visibility problem under study



Helicopter pilots in flight sometimes have difficulty gauging distance from the main rotor blade tips to nearby objects, which can lead to mishaps. DSTO has studied a solution involving rotor tip markings and under-rotor illumination.

The root problem is that pilots may underestimate the length of rotor blade extent, meaning that the tips are actually further away than perceived, or judge other objects to be further away than they really are – or some combination of both.

These errors most commonly occur when the pilot is faced with a lack of depth cues.

“When, for example, a helicopter hovers in front of a cliff-face or descends close to a forest clearing, there are few linear perspective cues, and the main cue to distance is the texture of those objects,” explains DSTO researcher Dr Geoff Stuart. “If the texture of these is finer than usually encountered, the pilot may assume the distance to object is further than it actually is.

“The problem may also in part be attributable to the difficulty of seeing the edge of the spinning rotors, and of estimating

the distance to this barely-visible nearly horizontal edge, due to lack of contrast between the rotor tips and the background.

“With binocular visual systems based on horizontal separation of eyes, we rely on vertical or oblique contour cues in a scene to judge distances, which may be largely or entirely lacking for helicopter pilots much of the time.”

Investigations of possible solution

The task DSTO undertook to research, therefore, is whether an improvement in contrast between sky and rotor tips can be achieved, and if so, whether it will improve the accuracy of distance estimation by pilots.

One source of naturally occurring contrast is that between the dark underside of the rotor and the overhead illumination of the sky, with the silhouetted rotors being

visible as just an area of barely perceptible greyness in the upper field of view.

A proposed approach for enhancing rotor tip visibility was to paint the underside of the rotors with a bright saturated colour that contrasts with the sky. However, analysis showed that in order to discern the added colour in silhouette, it would be necessary to illuminate the rotors from below with a bright source such as a searchlight.

“Unfortunately, increasing the rotor tip visibility in this way leads to even lower luminance contrast between the underside of rotor and the sky – a classic ‘trade-off’ situation that required experimental investigation,” says Dr Stuart.

In preparation for the trials, the researchers first sought to measure real-world lighting conditions to establish appropriate in-laboratory lighting levels.



Experimental simulation of pilot's view of helicopter main rotor disk. The rotor tip undersides are painted fluorescent orange-red, but the rotor disk is visible only indistinctly at top of screen when lit just from overhead with natural daylight. The pointer at bottom of image is to be placed by test subjects at estimated edge of rotor tips.



The same scene but with rotor tip undersides illuminated by spotlight. This level of contrast, devised as a control condition for experimental purposes, was not attainable under real-world daylight conditions. Despite the artificially high-level contrast, test subjects performed even worse at judging distance to rotor tips than under lower contrast conditions.

This they did by measuring the luminance given off by the sky and of a fluorescent orange-red painted card attached to the wing of an aircraft outdoors, with a ratio between the two luminance levels arrived at.

Test subjects and setup indoors

The experimental apparatus consisted of a model-size helicopter main rotor 45 centimetres in diameter, with tip undersides painted fluorescent orange-red.

Six volunteers from the DSTO research community, none with helicopter flight crew experience, served as test subjects, having firstly been checked for visual acuity and colour perception.

The test subject view of the spinning rotor was set by having each person look through an aperture with head fixed in a mounting that limited their gaze to just one position.

Following a procedure designed to minimise experimental errors known as 'starting point effects', each test subject was required to position a computer-controlled pointer using a joystick control at the distance they thought indicated the outer edge of the rotor circle.

Three kinds of test conditions were studied.

One, termed the 'control condition', involved a blue sky background with the rotor underside illuminated to make the orange-red tips visible – these being conditions not representative of the real-world, but used to establish if high contrast levels would lead to better distance judgment.

The other two conditions were those of rotor against a bright white sky with underside illumination, and the same sky conditions without underside illumination.

Test outcomes

The results demonstrated, somewhat contrary to expectation, that participants' ability to accurately and consistently judge the distance of the tips of a model rotor blade did not depend on the degree of visual contrast of rotor tips with the background.

"The condition with the highest contrast, the control condition, in fact resulted in the most degraded performance," comments Stuart.

"Meanwhile, the use of the searchlight to illuminate the rotor underside resulted in only a slight reduction in variance of distance settings that the test subjects settled upon.

"This means that any technical intervention to provide illumination of painted rotor tips from below is unlikely to overcome the impoverishment of visual depth cues that makes judgment of distances under these circumstances so difficult."

The reasons for such an outcome are seen to stem from the lack of salient depth cues appropriate to human horizontally-oriented binocular vision in these conditions.

While the research outcomes did not confirm the suitability of a solution, they did establish that the proposed under-rotor illumination approach would not be helpful, and thus, that an effective solution will necessarily take some other form, such as a proximity warning system. [4](#)



Sounding out a hidden maritime threat



A technology for mine sweeping using acoustic waves, called the Infrasonic Advanced Acoustic Generator (IAAG), has gone on trial with DSTO as part of the Capability and Technology Demonstrator (CTD) program.

The threat in question is that of sea mines designed to detonate upon detection of acoustic signals emitted by vessels. Not only can these mines target vessels in this way, they can also differentiate between targets since larger ships emit lower frequency signatures.

Thales Australia has developed minesweeping technology that neutralises the mine problem by creating an acoustic signal that emulates the emitted acoustic signature of vessels and thus triggers mine detonation.

The Advanced Acoustic Generator (AAG) is one such device, now in service with the US Navy, Royal Australian Navy and two other navies. The AAG is able to emulate the acoustic signature of warships up to destroyer size and merchant ships below 50,000 tonnes.

Further innovation

A further Thales innovation is the IAAG, developed for the US Navy's mine countermeasures fleet, and with nine units now delivered. This addressed a capability requirement for a high-power, low-frequency acoustic generator for sweeping in Target Setting Mode for modern mines targeted against larger naval and merchant ships, and for sweeping in Mine Setting Mode against existing obsolescent acoustic mines.

"Since the IAAG is a mature technology, the main thrusts of CTD investigations were to demonstrate that the IAAG can be integrated into the current Australian Minesweeping System for emulation of large naval and merchant ship acoustic signatures at very low frequencies," explains Anthony Quach, DSTO Technical Lead for the CTD project.

"The broadband frequencies it generates range from infrasonic to lower ultrasonic frequencies with a fundamental frequency range of 5 Hertz to 40 Hertz inclusive. This capability aptly complements that of the AAG with a fundamental frequency range from 5 Hertz up to 250 Hertz."

Self-powering sound generator

The IAAG, just less than four metres in length and weighing 1,210 kilograms in air, is operated by towing it behind a vessel. Typically the depth of deployment is around five metres, but it can also be operated at depths between two and ten metres.

A forward mounted 1,200 millimetre diameter turbine provides hydraulic and electrical power to respectively drive and control the two 'back-to-back' mounted pistons.



The movement of the two acoustic pistons is controlled by on-board electronics to produce the required acoustic signature. Programs for signal generation are downloaded to the IAAG unit immediately prior to deployment, using a handheld device. During a mission these programs can be individually selected over a link.

The two 'back-to-back' pistons of the IAAG have a swept area 12.5 times that of the AAG piston.

This enables it to produce very high sound pressure levels at very low frequencies through displacement of large amounts of water.

"Uniquely for minesweeping technologies, both the IAAG and AAG operate independent of external power or control sources, and are deployable from non-specialist naval ships or civilian vessels as small as fishing boats," says Quach.

The IAAG CTD sea trials

Four sea trials were conducted between June and September last year at HMAS Creswell, Jervis Bay, by Thales Team (comprising

Thales Australia, Resonance Technology and QuickStrike Defence & Aerospace) and DSTO.

The aim was to demonstrate the IAAG's acoustic output and its effectiveness in deployment in different configurations with Navy's Maxi Dyad magnetic influence sweeps, also manufactured by Thales Australia.

An IAAG unit was supplied by Thales Australia to DSTO with recommendations on how it could be deployed and recovered with current Navy minesweeping equipment. The recommended operating arrangements (proposed by Thales) included the use of two generators in a sweep; the AAG amidships, and the IAAG aft to emulate ship propeller blade rate and hull resonances.


The first sea trial established that the IAAG and its float could be successfully and safely deployed from a wharf and later recovered.

The following two trials demonstrated that the IAAG and float could be successfully and safely deployed at sea, towed at the required speeds and recovered after the mission. For the second trial, the IAAG apparatus was connected to the rear of

the Maxi Dyad, and for the third, it was placed between two Maxi Dyads.

The last trial demonstrated that the IAAG and float could be successfully and safely towed in two configurations while producing various acoustic signals as programmed. A portable acoustic underwater range was deployed on the seafloor to record the IAAG signal emissions. Analysis of the range data collected during this trial established that the IAAG's infrasonic emissions could suitably emulate large merchant or naval ships.

Outcomes delivered

"The Thales Team successfully delivered all the CTD outcomes, and professionally managed the CTD within the timeline," says Quach. "Overall, a very good outcome was delivered for Navy, with this cutting edge mine countermeasures technology being shown to enhance the Australian Minesweeping System capability and thus meet Navy's operational requirements." 

Opposite: The Infrasonic Advanced Acoustic Generator readied for sea trials.

Above: The device being deployed.

Growing a forest in 3D

In preparation for studies of airborne Laser Detection and Ranging (LADAR) capabilities to detect objects obscured by tree cover, DSTO developed a virtual, three dimensional (3D) forest of Australian trees.

Information for the tree models was obtained from measurements made in woodlands near RAAF Tindal, Northern Territory, with photos of poplar box (*Eucalyptus populnea*) taken in Central Queensland to inform the depiction of overall appearance.

The tree models were developed using 'Maya', a 3D animation software package. A tool in Maya called 'tubes' has the ability to emulate the creation, growth and behaviour of plant life, controlled by a comprehensive set of parameters that define the shape and growth behaviour of branches, twigs and leaves.

The researchers began by making an example model of a medium-sized birch tree, and modified this to create a set of models of the Australian forest poplar box trees. Using Maya, they were able to directly assemble these tree models into a forest scene, and for the purposes of LADAR studies, the parts of scene captured in a single LADAR snapshot could be highlighted with lighting effects.

While these Maya representations allowed for digital simulations of the image of a target beneath the foliage resulting from a single LADAR 'snapshot', the Maya environment did not allow the researchers to combine multiple results from different viewing angles, nor to conduct additional analysis on the results.

Point cloud modelling for improved analytical capabilities

In response to these limitations, the approach that DSTO researchers Mark Graham and Adam Davies came up with was to develop a customised 3D model using a software application called MATLAB; a programming language which has uses in plotting of mathematical functions and data and graphic display, among others.

MATLAB was applied to create a 3D depiction of trees known as a point cloud model.

"The point cloud model depicts the visible surface of 3D objects through the use of volume units of data for each point, known as 'Volumetric Picture Elements' – 'voxels' in short – very like the way that pixels form



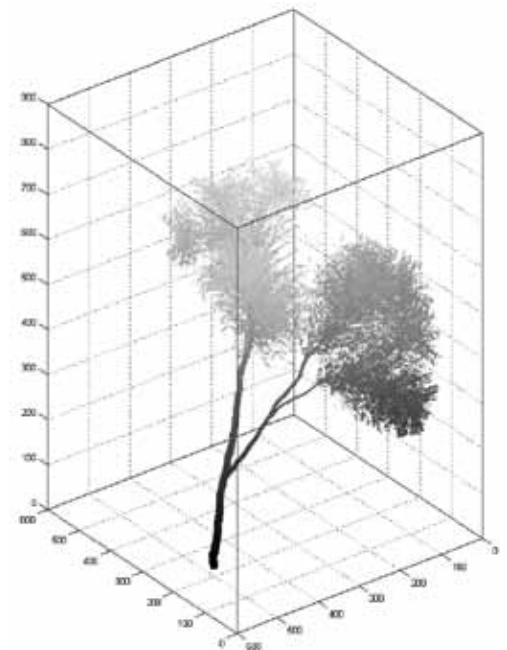
a two-dimensional digital image," explains Mark Graham. "Each voxel represents a value on a regular grid in 3D space."

The voxel form of 3D picture creation is commonly used in medical imaging and games simulations. A particular advantage it has over other kinds of modelling is its ability to depict overhanging phenomena, such as cave rooves, arches in buildings – and tree branches.

To create the point cloud model from the underlying Maya tree models, the researchers exported data from Maya to MATLAB in a series of files that gave depth information for each point in the scene for a particular two-dimensional (2D) view – as if captured by a virtual camera at a particular distance and orientation to the virtual 3D tree.

Given that a single viewpoint was insufficient for the formation of a MATLAB 3D point cloud model, views from four sides and from above were captured and transferred to MATLAB for each model of tree.

"The distance from the virtual camera to the 3D image pivot point, located at the

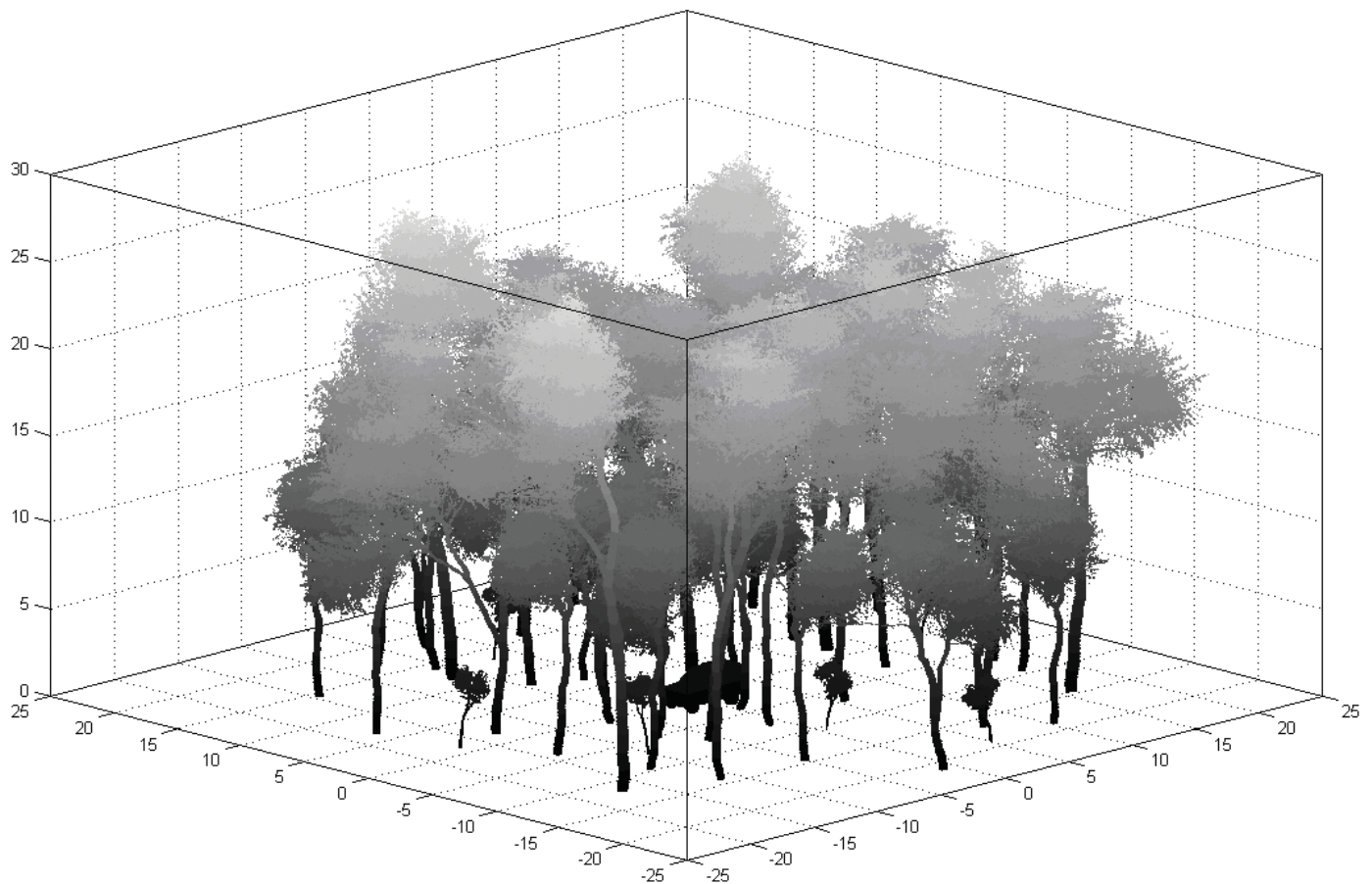


base of the trunk, was the same for all views of each tree, and set to the shortest distance such that the largest tree model was contained in the field of view of the camera. This provided the highest-possible resolution image while maintaining a constant distance between the camera and pivot point for all trees," says Graham.

The process of reconstructing the Maya 3D image in MATLAB as a 3D point cloud model gave rise to a number of translation errors, challenges that the researchers successfully took on.

One such issue was the need to eliminate duplication of voxels, given that significant overlaps arose when the 2D captures of the Maya image were combined. This problem was overcome by applying a filter to remove duplicates.

Other significant problems tackled included the need to remove erroneous voxels, and to interpolate for voxels missing after the transfer of data from Maya to MATLAB.



A virtual forest grows

Several tree models were developed in this way. These were then used to construct a forest scene by placing trees at particular x and y coordinate positions in a virtual terrain.

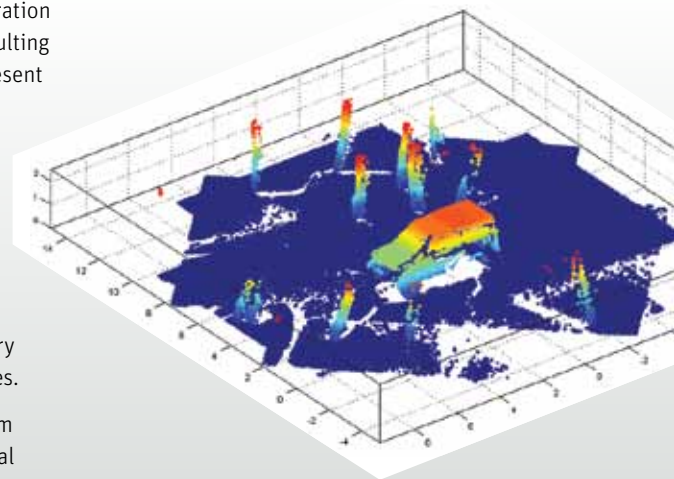
In the course of building the forest, the researchers had to ensure that trees did not overlap. They guarded against this by generating 3D images with each new tree displayed in a different colour to those already present, so that any overlaps would stand out.

By careful attention to the mix and placement of trees, the model forest was given the characteristics of open poplar box forest, as required for the LADAR studies, with foliage cover varying from 30% to 70%. The trees depicted included 18 with height ranges from 20 to 30 metres, 23 from 10 to 20 metres, and eight trees less than five metres, comprising 49 trees in total over an area 50 metres in diameter.

The forest model was digitally tested for veracity by determining light penetration through the canopy foliage. The resulting forest was found to accurately represent real-world conditions.

This model forest, plus a model target vehicle also produced in MATLAB, were applied in simulation studies of the performance of an airborne foliage-penetrating LADAR system, which delivered realistic 3D LADAR imagery for use in operations analysis studies.

The outcomes are expected to inform recommendations for the operational use of such a system. [n](#)



Opposite left: Poplar box woodlands in northern Queensland.

Opposite right: MATLAB-generated 3D point cloud model of simulated poplar box tree.

Top: MATLAB-generated 3D point cloud model of simulated poplar box forest with Land Rover concealed in centre.

Above: LADAR imaging study outcomes obtained using the simulated model forest.

Planning for multirole vessel development

Defence seeks to deploy vessels with the versatility to perform roles currently handled separately by different classes of vessel, and DSTO has arrived at ways to help ensure these capabilities are delivered most effectively.



Due to advances in unmanned vehicle technology in areas ranging from reconnaissance, surveillance and intelligence gathering to mine clearance, the possibility arises for new Navy ships to be given roles that were previously the province of particular class vessels.

When designing such a multirole vessel (MRV), an approach based on modularity can be used in which modules of equipment for performing various tasks are added into a base vessel design.

“The array of functional combinations for the base platform consists of a wide range of common function options, with the particular range of options selected for an MRV having particular impacts on how it will look and perform,” explains DSTO researcher Brett Morris.

“By establishing the common functions required of an MRV, some of the design and cost implications of incorporating them into a base vessel can be explored early on to ensure that the most capable and cost-effective concept design is arrived at.”

Iterative developmental process under study

To this end, DSTO has investigated the usefulness of a proposed process for establishing MRV functionality.

This process involves a series of rounds of consultations with stakeholders, in which feedback from previous rounds informs further refinements. Discussions between stakeholders are then held on the implications of incorporating these common functions into the base MRV platform design.

To determine the validity of the proposed approach, the researchers applied it in the form of a pilot study aimed at developing a hypothetical MRV concept encompassing the current and near-future roles of patrol boat, mine countermeasure and hydrographic survey vessels.

During this study, which included consultations with mock stakeholders for the sake of veracity, preliminary functional analysis identified a total of 75 functions that the MRV needed to perform to deliver the required functionality. The subsequent stakeholder brainstorming, review and final functional analyses steps undertaken within the process uncovered a further 21 functions that the MRV would need to perform.

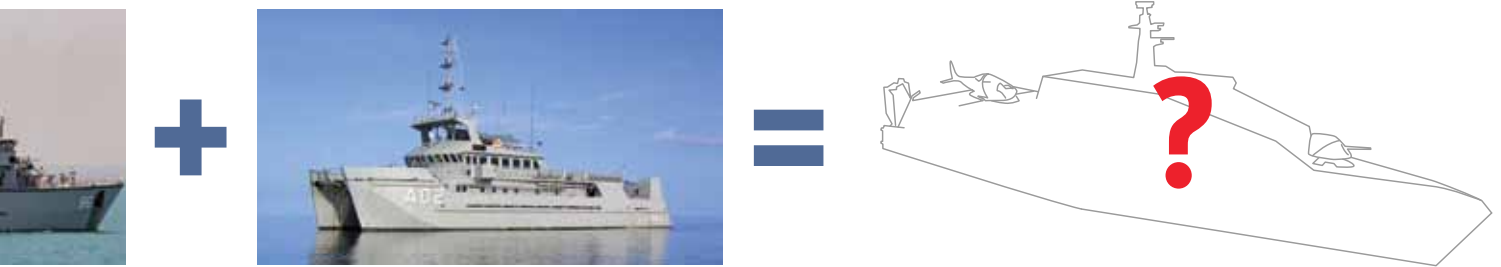
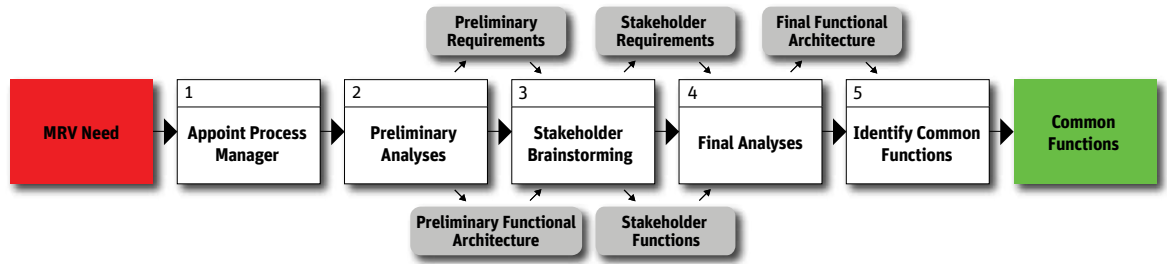
From this, a list of 29 functions was identified common to patrol boat, hydrographic survey and mine countermeasure functions, along with seven further functions that are common to two of these roles.

The 36 functions that were identified include: Accommodation, Auxiliary, Ballast, Ceremonial, Communication, Mission Command, Vessel Command, Deadweight, Environmental Protection, Hotel Services, Heating Ventilating and Air Conditioning, Interoperability, Boats (Launch, recover and stow), Maintenance, Medical, Low Speed Manoeuvrability, Mooring, Navigation, Range, Above Water Sensors, Underwater Sensors, Shallow Water, Seakeeping, Stability, Strength, Transit, Training, Deterrent, Munitions Stowage, Helicopter (Launch, recover and stow) Unmanned Underwater Vehicle (Launch, recover and stow) Unmanned Surface Vehicle (Launch, recover and stow) Unmanned Aerial Vehicle (Launch, recover and stow) Remotely Operated Vehicle (Launch, recover and stow) Survivability and Towing.

Implications of function integration

The pilot study MRV process then moved onto discussion of some of the implications of incorporating these 36 functions into a base MRV platform design.

The main influences the common functions were found to have on base MRV design involved considerations of space and location, with all functions having an influence on the hull mechanical and electrical system design in one form or another.



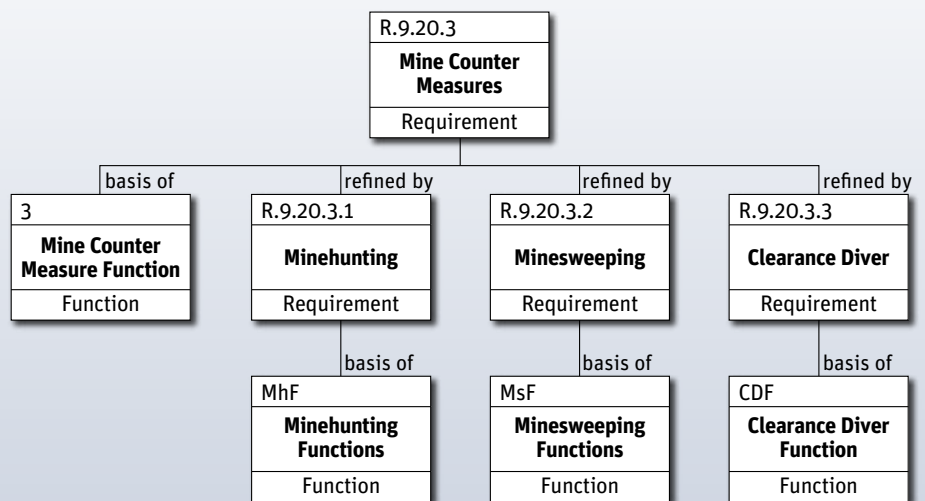
Particular considerations included the need to locate the functions of mission and vessel command in close proximity, as was also the case with the functions of navigation and communication.

Additionally, the capability for boat launch, recovery and stowage needed to be located near the stern according to current designs for such a capability, which significantly impacted on the choice of vessel hullform. Meanwhile, another factor that also had a large bearing on hullform choice was the state of the seas in the proposed area of operations.

Hence, the process commonly involved arriving at a delicate balance between requirements for functions, possibly involving tradeoffs.

One drawback with the approach noted by the researchers in the pilot study was that external systems, such as wharves and dry-docks that the MRV will interface with, were not taken into account.

Overall, the study established that the proposed process was a valid way for identifying the common functions that an MRV will be required to perform, and was valuable also for giving stakeholders insights into the implications of incorporating their requirements into an MRV at the concept design phase. ²



Montage: A representation of different capabilities that may be delivered by an Australian Defence Force multirole vessel; Patrol Boat, Hydrographic Ship, Minehunter Coastal and Survey Motor Launch.

Top: Schematic diagram of process used to identify the common functions of a multirole vessel.

Below: Schematic diagram depicting requirements and functions for the mine countermeasures function to be performed by a multirole vessel.

Makeover of a missile



Software upgrades for the Advanced Short-Range Air-to-Air Missile (ASRAAM) have markedly improved its capabilities, and DSTO has played a key role in delivering this success in an Australian-based research effort.

Within the next few months, Australia's F/A-18 A/B fleet will receive the latest software upgrade for ASRAAM, the leading-edge air-to-air missile that has now been in service for six years.

ASRAAM gives RAAF pilots a decisive air-to-air combat advantage over potential rivals, having excellent speed and range and the ability to be cued to the target from the launch aircraft sensors or via the pilot's helmet mounted sight, or even from coordinates sent by another aircraft.

"ASRAAM is one of a new breed of software-based weapons, where the true capability is embedded in the complex algorithms that control not only the interface between missile and pilot, but also the data processing functions," says DSTO researcher Dr Barnaby Smith. "The ASRAAM computers analyse the infrared image from the seeker and use advanced image processing techniques to enable acquisition and tracking of faint targets, which may be dispensing flares or flying in front of complex background scenes.

"With some of ASRAAM's key capabilities being software-driven, there has been a great opportunity for adaptations and improvements to be made as required. Recent upgrades to ASRAAM software developed within Australia have not only enhanced the robustness of target acquisition and tracking, but pilots also now have much better situational awareness due to the improved tones that they hear from the missile – in fact, performance has been improved across the board."

ASRAAM development for Australian needs

In 1998 when ASRAAM was selected as the preferred missile for the F/A-18, Defence had the foresight to invest in an ongoing capability for in-country software change. The plan was to focus on performance against regional threats, improving and adapting the missile to evolving targets and countermeasures as well as supporting the development of Australian tactics. The UK manufacturer of ASRAAM, MBDA, gave DSTO

researchers full visibility of the missile and development of the weapon progressed as a joint UK-Australian collaboration.

In the years before entry into service when ASRAAM was still under development, DSTO supported over a dozen extended flight trials in which the missile was evaluated and new software tested. "Ten years ago we had a missile which underperformed in some key areas," says Dr Smith. "We worked closely with MBDA and the UK Ministry of Defence during that early development period and used it to learn all we could about the system. We evolved our own techniques for testing the performance in challenging scenarios, and by the time ASRAAM was introduced into service in 2004 we had very high confidence in its capability."

In 2005, the Australian ASRAAM Software Support Capability (AASSC) was commissioned, comprising staff from MBDA and BAE Systems Australia who worked side-by-side with scientists in the DSTO Missile Simulation Centre in Adelaide. The aims of the work were set as a series of prioritised requirements.

DSTO worked closely with AASSC to identify potential changes, undertook the initial research to investigate new algorithms, and tested interim software loads built by the AASSC both in the laboratory and in the air. AASSC was responsible for engineering the final loads and proving performance in their own computer modelling environment. DSTO then undertook confidence testing prior to the RAAF certification process.

Study tools and facilities

To undertake testing of the new software, DSTO developed special-purpose resources to enable computer modelling and hardware-in-the-loop simulation of missile fly-out.

"We've developed unique capabilities in 'real-time' – which is to say, extremely fast – computer generation of synthetic infrared scenes in the form of a software package called VirSuite. We've basically built a 3D model of the world in the infrared, including clouds, aircraft targets and flares, and fly the missile through that environment," says Dr Smith.



The computer-generated infrared scene is projected onto a missile mounted on a hydraulically-driven motion table, activating the in-built motion sensors and enabling the missile to be 'launched' in the laboratory. The quality of infrared image projection is considered exceptional by world standards, another significant achievement by DSTO.

Apart from the laboratory instrumentation, computer models have been used to investigate missile performance against different targets, particularly when they are dispensing flares or flying over sun-lit landscapes and clouds. Such studies play a fundamental role in software development.

A further important resource tool consists of two DSTO-built pods mounted on a Lear jet that then performs tactical manoeuvres against an F/A-18 'target'. One pod carries the forward section of an ASRAAM missile, allowing measurement of acquisition and track performance with different software loads. The other pod is used to acquire high-resolution infrared imagery of the airborne environment for use in modelling and laboratory tests.

DSTO's contributions to the UK-Australian research effort are considered to be invaluable, providing missile study capabilities that exceed those available in the UK. The VirSuite system, meanwhile, has been licensed for use by US agencies for infrared missile research.

A joint approach

The AASSC software development has been overseen by a joint management team comprising the Defence Materiel

Organisation, DSTO, the RAAF's Air Combat Group and the companies MBDA and BAE Systems Australia.

A key feature of the work process adopted was that of joint negotiations and agreement on projects, which allowed MBDA flexibility without requiring it to be conservative in approach.

Elaborating on this, Dr Smith says, "In the early days of contract development, some of the changes eventually implemented would not have been countenanced by MBDA due to the level of risk.

"The partnership approach to the AASSC contract obviously had its own element of risk, but through the close working relationship, this risk was mitigated, and the resulting output was a significant capability edge."

Proof in the air

That capability edge was demonstrated in 2008 when a RAAF F/A-18 fired an ASRAAM at an unmanned drone target simulating a 'chase down' by an enemy fighter. The ASRAAM was fired 'over the shoulder' at the target which was more than five kilometres behind the shooting aircraft. The missile scored a direct hit on the drone.

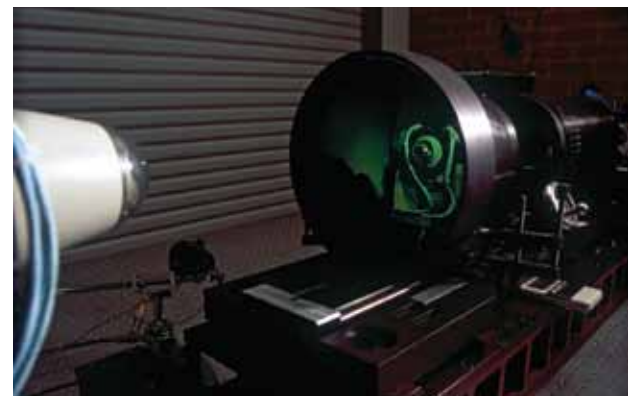
For this firing, the target coordinates had been supplied by a second F/A-18 via a datalink, with four F/A-18 aircraft actually in the sky at the time. DSTO thus had to undertake a thorough risk analysis

beforehand to ensure that the software would work, and that none of the F/A-18 aircraft would be inadvertently targeted.

"The last decade has been really productive," says Dr Smith. "We now know as much about the operational characteristics and performance of ASRAAM as the manufacturer. We have the ability to really get to grips with aspects critical to pilots through feedback they offer, and have made software changes that help give them a clear edge over an enemy."

The AASSC contract expired late last year, but DSTO continues to work on the follow-up software load. Throughout the development period there has been a close collaboration with the UK Ministry of Defence on performance assessments, exchange of test data and sharing of analysis tools.

Craig Hardie, the DSTO senior engineer who has overseen the development of the latest software load, says, "The UK plans to use the latest Australian software for their ASRAAMs on Typhoon and Tornado aircraft. There are also plans for a joint UK-Australian load to be developed over the next three years that would give a step-change in capability." ¹



Opposite: ASRAAM mounted on wingtip of RAAF F/A-18.
Top: DSTO's facilities for 'hardware-in-the-loop' testing of missile performance in simulated flight.
Above: Apparatus to project infrared imagery onto missile seeker device during laboratory testing.
Below: The infrared image of a target as seen by the missile seeker device.

Spray-on nano solution to keep uniforms dry



A technology that renders fabric highly water repellent shows great promise for use in waterproofing uniforms.

The developmental work has been carried out by DSTO in association with the Centre for Material and Fibre Innovation (CMFI) at Deakin University.

Current arrangements for equipping front-line personnel with wet weather protection is through the use of a waterproof poncho fitted over the uniform and gear worn by the person.

This arrangement is far from optimal since getting the poncho on over bulky protective uniforms and equipment is not easy, and access to wearable equipment can also be impaired.

DSTO researcher Jie Ding has been looking at better ways of providing protection against precipitation with a waterproof coating that can be applied directly to uniforms, thus obviating the need for a separate waterproof layer.

Waterproofing with low free energy

“Super water repellent materials, called superhydrophobic surfaces, can be produced by depositing a thin layer of nano particles on the surface of a fabric to create a surface condition known as ‘low free energy’,” says Ding.

“This causes droplets of water falling onto the fabric to just sit on or run over the surface, with no absorption by the fibres occurring as would happen with untreated fabric. Water vapour and moisture, meanwhile, can pass through from the inner side of the fabric, meaning that it has the ability to ‘breathe’ to prevent moisture build-up due to transpiration.”

The major challenge impeding use of the nanoparticle approach was that it required a tedious and difficult multi-step process of chemical application, making it impractical to use on an industrial basis.



The work done by DSTO and CMFI overcame this problem by developing a one-step coating process, whereby the fabric is simply dipped in a solution of chemicals, or this solution is sprayed on. The process can be applied with fabrics including polyester, wool and cotton.

One issue the researchers had to resolve to make the technology effectively usable was ensuring that the nano coat could be applied uniformly. “We had to repeat our experiments many times to arrive at conditions that produced the right results,” says Ding.

The research program was undertaken with preparation and application of the chemicals being mostly done at CMFI, and analysis and microscopic investigation of the results carried out at DSTO facilities.

Trials of coating performance

Following this development work, trials were conducted on the use of a transparent silica nanoparticle coating to waterproof Defence’s Disruptive Pattern Camouflage Uniform fabric.

The results were that the coating successfully gave the garment superhydrophobic water protection without adversely impacting on the visual-range and near-infrared spectrum properties of the uniform fabric. In other words, the capabilities for personnel to conduct stealthy operations were unaffected.

Further work is being carried out on coated fabrics to investigate their breathability and comfort and the durability of coating. [n](#)

Main photo: DSTO researcher Jie Ding working on superhydrophobic coatings.

Top right: Droplet of water sitting on treated Disruptive Pattern Camouflage Uniform fabric.

Below right: Untreated fabric showing wet patches where droplets have been absorbed.

Briefs

DSTO planning for improved national crisis management

The Australian government is seeking to improve interaction and co-operation across government, business, and non-government organisations to deliver more effective, proactive and flexible national crisis management arrangements.

In 2008, a team of DSTO researchers began designing new crisis management arrangements to address the challenges of Australia's future national security environment using a scientifically rigorous evidence-based approach. The work was undertaken by consulting with senior stakeholders in the national security community, and these findings were applied to develop user requirements for the proposed facilities.

The new model provides for coordinated and resourced response options formulated by teams of subject matter experts from a range of agencies.

DSTO's recommended approach has delivered an improved foundation for a whole-of-government approach to crisis management. It has also advised on planning, situation monitoring, and information management issues as well as the organisational structure and work processes to be implemented. A key element of the new arrangements is the capability to share information across individual agencies involved in a response. [n](#)

New facilities for study of luminescence

DSTO will soon have access to world-class facilities for research into the phenomenon of luminescence, to be housed in the Institute for Photonics & Advanced Sensing (IPAS) at the University of Adelaide.

Luminescence is the property of a material to give off light when stimulated by heat or certain wavelengths of light, which indicates the degree to which the material has been exposed to ionising radiation from both naturally and artificially occurring radioactive substances.

Possible uses for the technology include detection of covert activities involving fissile materials as well as ways of establishing baseline measures of background radiation in order to gauge exposure levels to radiation after a radioactive contamination incident. Evidence of radiation exposure in such cases is locked into the crystalline structures of grains of sand, brick, salt, gyprock, concrete and ceramics found in the environments involved, and can thus be detected long after the radiation exposure has ceased.

DSTO researcher, Dr Nigel Spooner, is serving as Adjunct Professor of Luminescence and Head of the IPAS Environmental Luminescence group. The group is conducting world-leading research on new advanced sensing technologies including a Super Science Project focused on developing fibre optic-based sensors for explosives.

Goals of the new facility include delivering deployable capabilities to detect radiation exposure above background levels through sampling a novel range of luminescent materials. [n](#)

Lead-free solder performance

Many technologies developed by Defence often involve commercially developed electronic components and units to keep development costs low.

Traditionally, eutectic tin-lead solder has been widely favoured for its reliability. However, since the introduction of protocols such as the Waste Electrical and Electronic Equipment directive and Restriction of Hazardous Substances directive, lead-free solders are now becoming widespread globally in order to eliminate the toxic heavy metal component.

Certain consequences arise for Defence in terms of the performance and reliability of commercially acquired electronics items, especially given that Defence operational environments may be far more extreme than commercial or domestic environments.



Artist's impression of building under construction to house various IPAS research activities including luminescence studies.

Managing risks

DSTO accordingly has collated a range of data in order to advise on the risks posed by items made with lead-free solder as well as proposed ways to manage these risks. Major issues include the formation of 'tin whiskers' that can cause short circuits, and 'tin pests', a cold weather condition that converts the valuable white form of tin to a non-conductive grey powder-form. To date, no lead-free solders are qualified for use in military environments.

Proposed risk management processes involve sourcing proven long-term reliability data and compatibility data from the suppliers or manufacturers for a given set of conditions for a particular application. An important strategy is also to closely monitor, control and detect lead-free solder as commercial-off-the-shelf items are obtained. Of the several analytical techniques available for identifying lead-free solder, the most convenient and effective has been found to be a hand-held x-ray fluorescence device.

The research also investigated strategies that will assist Defence to move to soldering with lead-free solder. [n](#)

Calendar

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>

27 - 29 Sep 2011

Defence Operations Research Symposium

Annual event conducted by DSTO's Operations Research Hub to discuss new trends in military operations research.

DORS2011 will focus on new techniques for OR and the application of techniques to solve Defence problems.

Australian Defence Force Academy, Canberra

**For further information email DORS2011@dsto.defence.gov.au
Tel (02)6128 7355**

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>

16 - 17 Nov 2011

Defence Human Sciences Symposium

The principal Australian forum for defence-related human science research.

DSTO Melbourne, Fishermans Bend

<http://www.dsto.defence.gov.au/dhss2011/>

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>

22 - 26 Oct 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 Centre, Melbourne

<http://www.dsto.defence.gov.au/lwc2012/>