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Social network analysis in the ops room

Helicopter flotation device

Electromagnetic effects testing for F-35 JSF

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, Dr Alex Zelinsky, and employs about 2500 staff, the majority of whom are scientists and engineers. It is one of the two largest research and development organisations in Australia.

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Cover image: DSTO researchers with full-scale model of F-35 Joint Strike Fighter fuselage for environmental electromagnetic effects testing.

Practice torpedo studies for safer trial outcomes

DSTO is investigating the damage that practice torpedos can do to a target vessel should impact accidentally occur.

To hone the attack skills of Navy submarine crews, exercises are conducted at sea in which practice torpedos are fired at other Navy vessels in simulated engagement scenarios.

These torpedos are not fitted with an explosive warhead and are not intended to hit the target. However, if an impact should occur, the target vessel could nevertheless sustain substantial damage.

“The type of structures and equipment that may be impacted include control surfaces, inlets and outlets, valves, ballast tanks, frame mounted equipment and, of course, the hull,” explains DSTO researcher Paul van der Schaaf.

Real-world experiments for numerical predictions

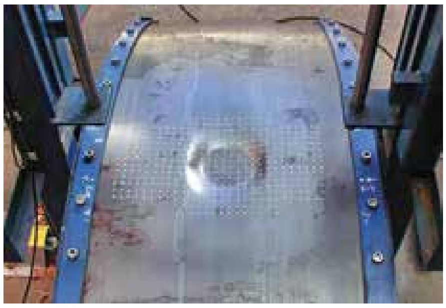
In order to study the damage that could result from practice torpedo impact, DSTO has sought to develop a numerical prediction approach, this being a much more cost-effective way of obtaining results compared to full-scale testing.

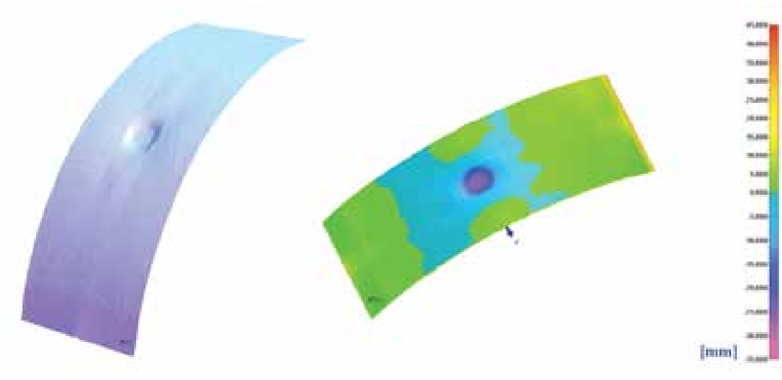
The application of such an approach requires the availability of results obtained through real-world experiments to serve as ‘benchmark’ reference points. DSTO accordingly carried out a series of tests that simulated the dynamics of a practice torpedo impacting the pressure hull of a submarine.

These experiments were undertaken with the use of a small-scale drop tower, which enabled torpedo nose cones to be dropped onto pressure hull sections of varying strength with different levels of impact force and energy.

Experimental apparatus

The drop tower allowed for a drop height of just over two metres, and was designed with guide rails that directed the drop carriage onto the model hull sections. The mass of the drop carriage could be increased by adding up to six ballast blocks each weighing 16 kilograms, making possible a maximum carriage mass of 140 kilograms.





The practice torpedo noses were made of aluminium alloy sheet formed into a hemisphere by a cold-work metal spinning process. Three variants of hull plate in circular arc form were produced for the experiments: steel plate with stiffening ribs and steel plate and aluminium plate both without ribs.

Five experiments were conducted using stiffened steel plate, while two were conducted with unstiffened steel plate and three with unstiffened aluminium plate. The drop events were conducted at three different heights to produce different impact velocities and forces.

Observations and outcomes

Each drop event was captured on high speed video camera in order to determine the speed of carriage fall.

The video footage also showed the impact and rebound phases of movement, from which the impact elastic properties of the plate materials could be determined. The footage revealed that although the carriage bounced on impact, all of the deformation damage to the practice torpedo nose and the hull plate was done on initial impact, thus simulating what would occur in an actual impact.

The shape and the size of the dents arising from the drop tests were measured in each case and noted in tables of results for each set of experimental variables.

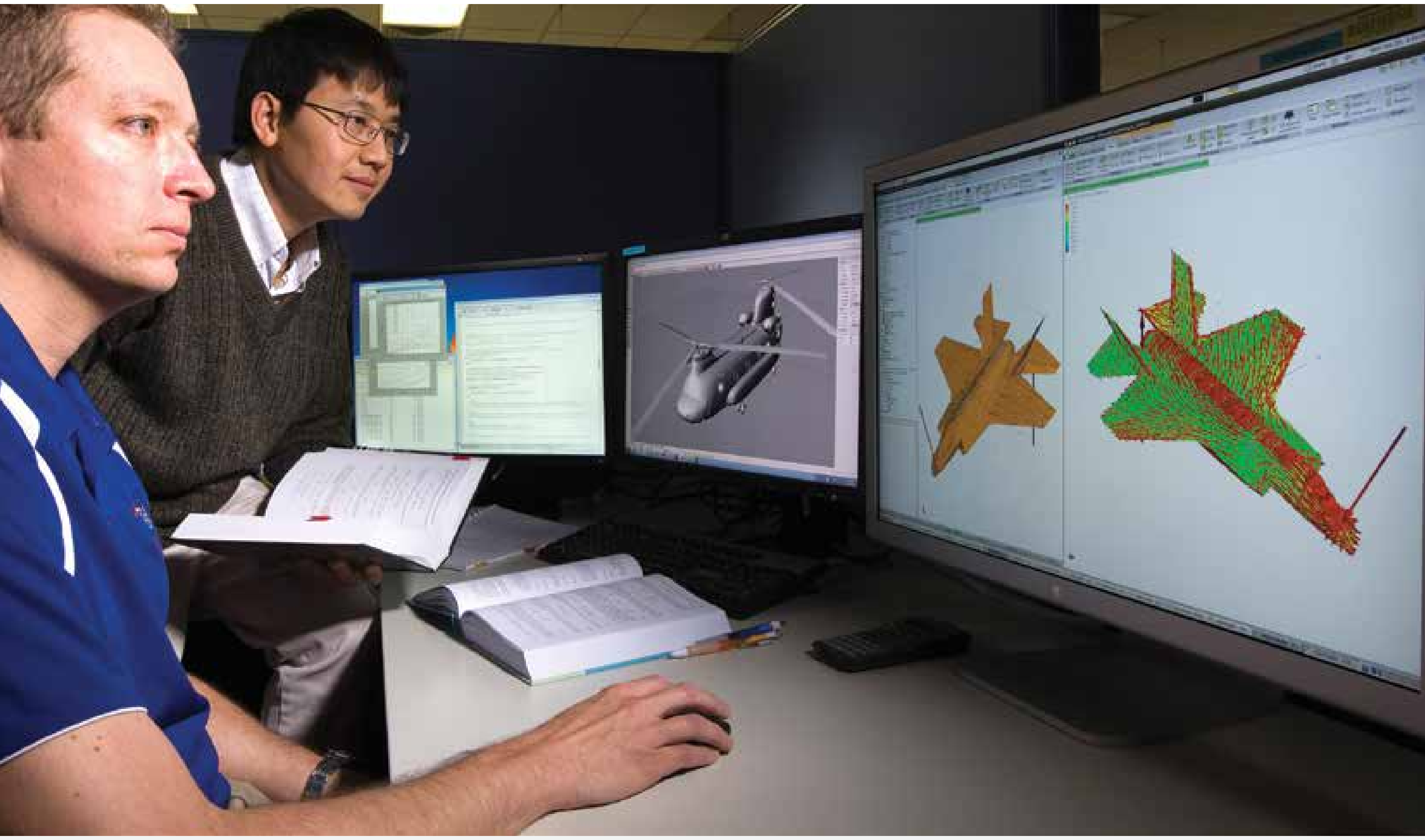
The findings overall were that stiffeners tended to limit the extent of the dent produced. Aluminium plate was seen to have a greater elastic response than steel plate, stiffened and unstiffened. The effect on the torpedo nose, meanwhile, was for flattening to occur on impact with steel plate and dimpling when striking aluminium plate.

The data obtained from these experiments is being used to validate numerical impact models. The models are then used to investigate and predict the damage from a range of possible impact scenarios.

Top left: The DSTO drop tower showing torpedo nose cone and ballast blocks and test hull plate pre-impact.
Top right: The test hull plate post-impact.
Below: Surface scan (left) and contour map (right) of the test hull plate post-impact.

F-35 model flies through electronic maelstrom

The impact of environmental radio frequency emissions on the electronic systems of the soon-to-be-acquired F-35 Joint Strike Fighter is being examined by DSTO with a full-scale model called Iron Bird.



All aircraft in flight are exposed to electromagnetic radiation arising from natural and human produced origins. Natural sources include lightning and static discharge. Human-produced sources currently include telecommunication transmissions and radar, with the possibility of a further source – radio frequency directed-energy weapons – coming into play in the future.

When an aircraft is closely exposed to such emission sources, these can interfere with aircraft communications and sensor systems, cockpit displays and even flight control functions with the effect that their performance is degraded or malfunctions.

Above: DSTO researchers with graphic of computer modelling that predicts the currents induced in the JSF's skin under a certain set of electromagnetic conditions.

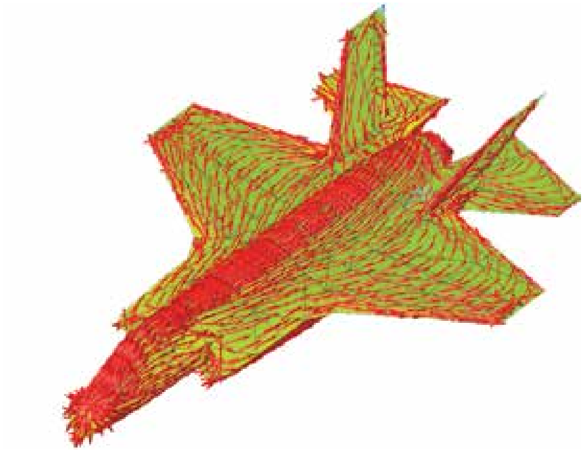
"For military aircraft, the consequences are that the aircraft's capability is impaired and the safety of aircrew and aircraft is compromised," explains DSTO researcher Dr Andrew Walters. "An extreme possible case includes the unintended firing of weapons and disruption to flight computers causing the aircraft to crash."

The problem of interference is growing worse year by year as new civilian transmitters come on air and military sources of radio frequency emissions are more prevalent and stronger in nature. Aircraft systems, meanwhile, are being rendered more vulnerable due to computer processor usage of finer power and voltage tolerances, further exacerbating the problem.

Electromagnetic effects research

To ensure aircraft electronics systems are capable of withstanding these effects, both the individual and integrated systems are tested on the ground under simulated electromagnetic conditions.

DSTO has a well-established team and facilities for electromagnetic effects investigations, which have been applied extensively in support of several Australian Defence Force aircraft over the past two



decades. The knowledge gained has been used to solve potential problems with electronics system design, installation and modification.

Several years ago, DSTO was asked by the Joint Strike Fighter Program Office to assist with electromagnetic effect investigations on the F-35 Joint Strike Fighter. Being a 'fifth generation' technology aircraft, the Joint Strike Fighter's design includes a suite of highly advanced airborne sensors, avionics and weapons with unprecedented levels of integration and reliance on electronic systems.

DSTO's work on the F-35 has involved the development of novel computer modelling that enables the impact of electromagnetic effects on electronic systems to be studied in a very cost-effective way. This modelling tool will assist with airworthiness work being done to bring the aircraft into service and with through-life support.

To verify and fine-tune the computer model, DSTO required data of real-world electromagnetic exposures experienced by the aircraft. This was obtained through experiments using a purpose-built full-scale model of the F-35 aircraft.

Iron Bird

Named 'Iron Bird' by the researchers, the scale model comprises a steel framework clad in a traditional metal skin. While the framework material is not authentic, the skin geometry – critical for capturing the resonant electromagnetic effect characteristics of an aircraft – is.

The experiment involves surrounding the model with an aircraft-shaped mesh antenna that bathes it in electromagnetic radiation from all sides. Electrical leads attached to various points on the model's skin enable readings of currents induced in the skin to be taken.

This set-up can be used to obtain data for various environmental electromagnetic exposure scenarios, replicating the range of those the aircraft is likely to face in actuality.

By inputting these findings into computer modelling, an accurate basis for digital investigations is provided.

Looking ahead to F-35 design changes

The researchers intend to use Iron Bird for investigations into how future changes in F-35 design will vary the impact of electromagnetic emissions on systems.

This will involve making design changes on the F-35 full-scale model and then running emission exposure tests.

Australia has currently agreed to purchase fourteen F-35A aircraft. The first two are in now production by Lockheed Martin Aeronautics in the United States, with delivery due in 2014-15 for commencement of RAAF pilot and maintainer training. Ω

Above: The F-35 Joint Strike Fighter.
Middle and Below: Iron Bird in final stages of construction, with close-up showing the arrays of stand-off spikes installed to facilitate measurement of the induced currents.

In-vehicle work loads study for performance optimisation

DSTO is investigating how different vehicle crew configurations and the technologies they use impact on crew performance in preparation for Army's new vehicle acquisitions.

The changes entailed by the arrival of the new vehicles involve increases in Army vehicle crew size and the application of a range of new skills, knowledge and capabilities.

The challenges this poses for implementation is to understand what effects these changes will have on the workloads of individuals and crew jointly and on their performance.

"We need to know the potential problems involved in operating the platform, and the ways workflows can be designed within the vehicle to accommodate the demands of different roles," says DSTO researcher Justin Fidock.

"This understanding is required in advance of the arrival of the new vehicles so that we can determine what training to provide in preparation."

Vehicle workload study capability

In support of the work, DSTO has established a facility called the Human In-Vehicle Integration Capability (HIVIC) to study the effect of different crew configurations and technologies on human performance by immersion in realistic virtual battle spaces.

The HIVIC facility replicates the cabin environment of a vehicle, with seating and controls as appropriate for up to three personnel. The crew looks out at moving scenery depicted on large screens that simulate the view from the vehicle's windows. The view changes according to where the driver directs the vehicle in this virtual environment.

The terrain depicted can vary according to the type of mission tasks the crew needs to be put through, such as those in urban and desert settings. In addition to showing the natural and built environments, the simulations also feature the movement of civilian persons and vehicles, thus adding the element of distracting detail that crews would face in real life.

Inside the vehicle simulator, the setup includes map displays for crew to use for navigation during a mission as well as communications equipment.

Recent trials

The work done by DSTO has been assisted by psychology students from the University of Adelaide, with a series of ongoing experiments beginning in 2008 being carried out on crew workloads and performance in protected mobility vehicles.

The first trials established that the vehicle workload was too high when undertaken by just one person, with a significant reduction in performance occurring under such conditions. Further studies then showed that there was little significant difference in performance levels for workloads shared by two or three crew.

However, the degree of complexity of the simulated environment for these experiments was later judged to be insufficient to tease out potential differences in performance levels.

To achieve the required fidelity in experimental conditions, several mission scenarios were scripted and combined with a commercial roadmap simulation of Kandahar, the second largest city in Afghanistan.

Virtual missions in downtown Kandahar

The conduct of these virtual missions involved crew being set the task of monitoring the Kandahar streets for certain activities while performing other in-vehicle tasks such as using the communications system to report back to headquarters.

In preparation for these trials, volunteers for the position of mission commander were sought from among the DSTO research community, and were given training for the exercise. They then commanded missions in the vehicle simulator with a crew firstly of two and then three personnel, themselves included.

Assessment of crew workloads was undertaken using subjective workload measurement techniques including instantaneous self-assessment and accuracy (how many objects were spotted) and latency (how long it took to spot objects) measures.

LAMP illumination for in-vehicle studies

DSTO's in-vehicle research capabilities are being further enhanced by the development of another facility called the Land Motion Platform (LAMP).

Designed and constructed by DSTO, LAMP features a similar setup to HIVIC of vehicle controls and crew workstations surrounded by screens depicting outside view, but now contained within a closed cabin and mounted on a moving base. A further advance over the HIVIC setup is that LAMP has seating for up to four crew.

Like aircraft simulators, the entire LAMP cabin moves on electric powered actuators to simulate the twisting jolting forces experienced by cabin occupants during travel. LAMP will be programmable to simulate different kinds of travel roughness. The program data is obtained by taking a real-world vehicle fitted with accelerometers on journeys of varying roughness typical of the range experienced by personnel on missions.

"The development of a closed cabin simulator with motion replication capabilities will further enhance the realism of workload and performance studies," says Fidock. ◘

Top left: DSTO personnel with equipment used to operate the Land Motion Platform simulator.

Top right: interior view of Land Motion Platform cabin.

Above: Work station for driving the Land Motion Platform to ensure its motions correspond to vision showing on screen, done in preparation for studies undertaken with personnel in the cabin.

Opposite page: The Land Motion Platform cabin.

Social networking analysis for better command and control

An innovative social networking analysis tool developed by DSTO is leading to enhanced work practices in operations rooms.

The role of the commander is to establish what military objectives are to be achieved and how best to achieve them, given the resources available and circumstances pertaining. This work, despite the advent of various information technology aids, remains fundamentally a human-centred process dependent on networks of personnel working together.

The Combat Operations Division in the Air and Space Operations Centre (AOC) is one such Defence headquarters where command and control work is undertaken. Here personnel engage in dynamic targeting, the most time-critical and high pressured type of activity. They are required to process large volumes of data, make decisions, take action and communicate with one another in response to scenarios that may be rapidly changing. Most of their work is focused on delivering accurate and timely decisions to commanders about whether to attack a target, and if so, provide a carefully developed plan on how to do so.

"The development of a targeting solution is contingent on efficient team interaction to facilitate communication of information and development of shared situational awareness," explains DSTO researcher Dr Ed Lo.

Studying the patterns of interactions between personnel as they engage in dynamic targeting can deliver important insights that enable improvements to be made.

Analytical framework

The study of social networks emerged as an interdisciplinary venture in the fields of social psychology, sociology, statistics and graph theory over the course of the last century. In recent decades, the development of social network analysis (SNA) has been embraced by researchers in a number of fields as a rigorous way to describe and analyse the underlying network structure of a group of participants.

This it does by depicting in graph form the interactions of the group as a set of communication links in which the participants are the nodal points between links. A node may be connected to some, many or all other nodes, and the volume of traffic passing between the nodes is depicted graphically by the thickness of the link line.

Properties of nodes can be described mathematically in terms of two key features: centrality and sociometric status.

Centrality measures how well connected a node is in a network. This can be calculated variously on the basis of node access to information or the resources of another node, the 'between-ness' centrality of a node or the closeness of a node to others.

Sociometric status quantifies the contribution a given node makes to the amount of communication in a network. This is calculated on the basis of the number of communication events it receives and produces as a proportion of the overall number of nodes and communication events.

The data inputs used to calculate these include speech events between personnel, radio communications, computer chat room exchanges, use of software applications, action progress indicators (red = stationary, yellow = in progress, green = approved) and comments noted by observers. Records for such inputs are gathered for each node in a network.

Analytical enhancements

Dr Lo and colleagues saw that this analytical capability could be made even more useful by making some refinements, arriving at a tool they named SNA of Command and Control (C2), or SNAC2 in acronym form.

These developments arose out of work they did with the AOC during various major joint military exercises to assess alternative ways to implement dynamic targeting. In one exercise, some fifty hours of observations were captured in the Combat Operations Division.

Enhancements to the methodology they recognised to be important were the inclusion of speech utterances and comments by individuals, annotated with associated timings and contextual data inputs by observers about what was said.

By introducing such innovations, a rich view of interactions in the operations room was attained, and playback was now possible of interactions at any given time in a session with contextual data on show. Also now enabled was an ability to study post-event how interactions evolve over the course of an operations room session.

SNAC2 thus offers a much-expanded range of capabilities for exploratory analysis of command and control events. It provides a multi-perspective view of the data and enables the analyst to interact with, tag and categorise the observations.

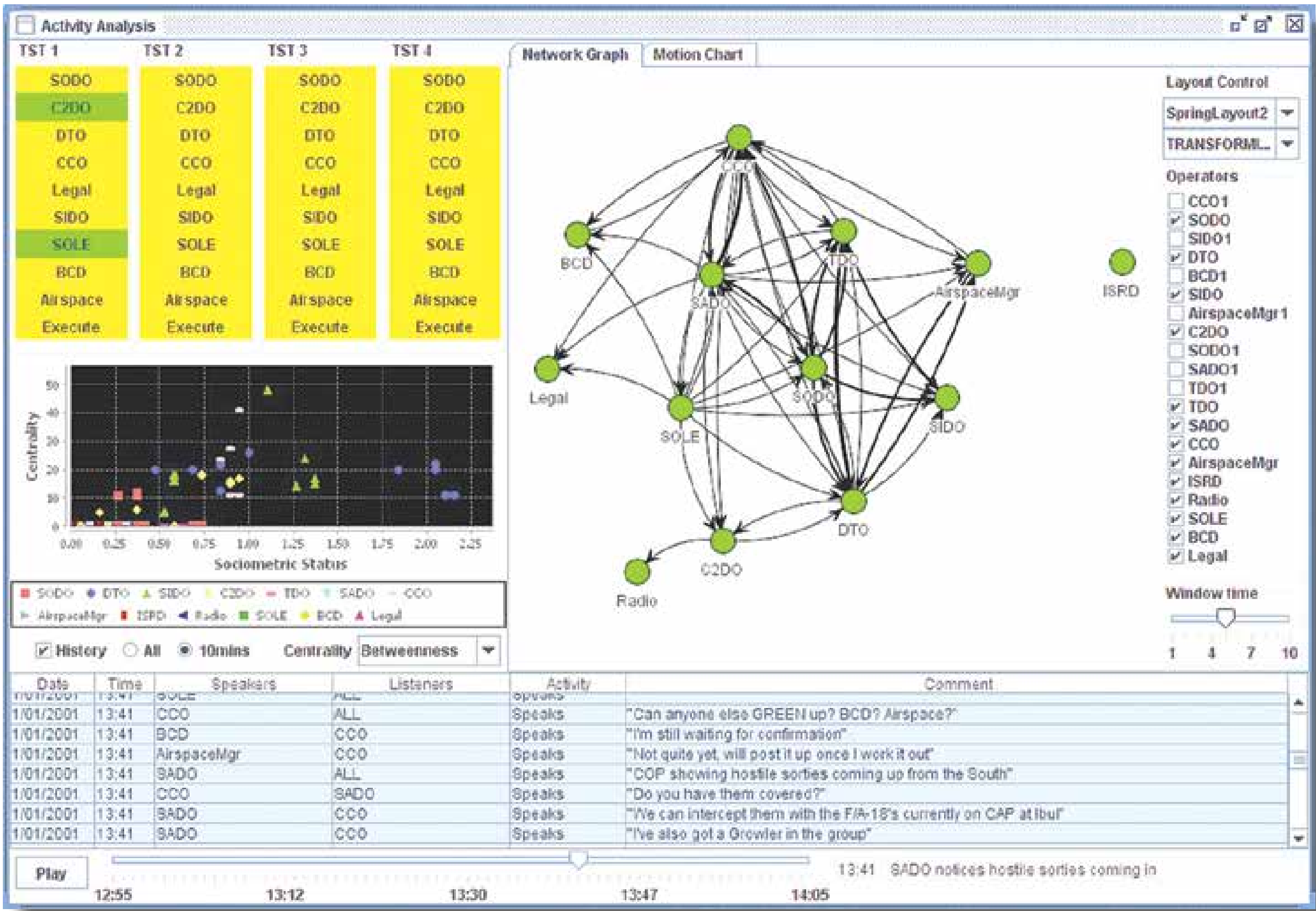
The plot of changing levels of centrality and sociometric status over time, for example, helps to identify operators who suddenly become busy and the times when this occurs. As the analyst steps through the events, relevant discussions are displayed while traffic light indicators show the progress made in the current activities. Standard SNA approaches, by comparison, simply aggregate all interactions collected over a period into a single plot.

A better analytical tool

The range of analytical features SNAC2 delivers includes the ability to capture and represent actual work practices used by operators (which may differ from established guidelines and procedures), replay captured events in detail, mark-up and separate the data into different phases, automate the computation of metrics, study the social interactions in each phase and to capture and analyse unexpected events.

The use of SNAC2's post-event analysis capabilities has helped identify how human errors arise and propagate within the decision-making process, thus enabling risks to be mitigated through improvements to processes and systems.

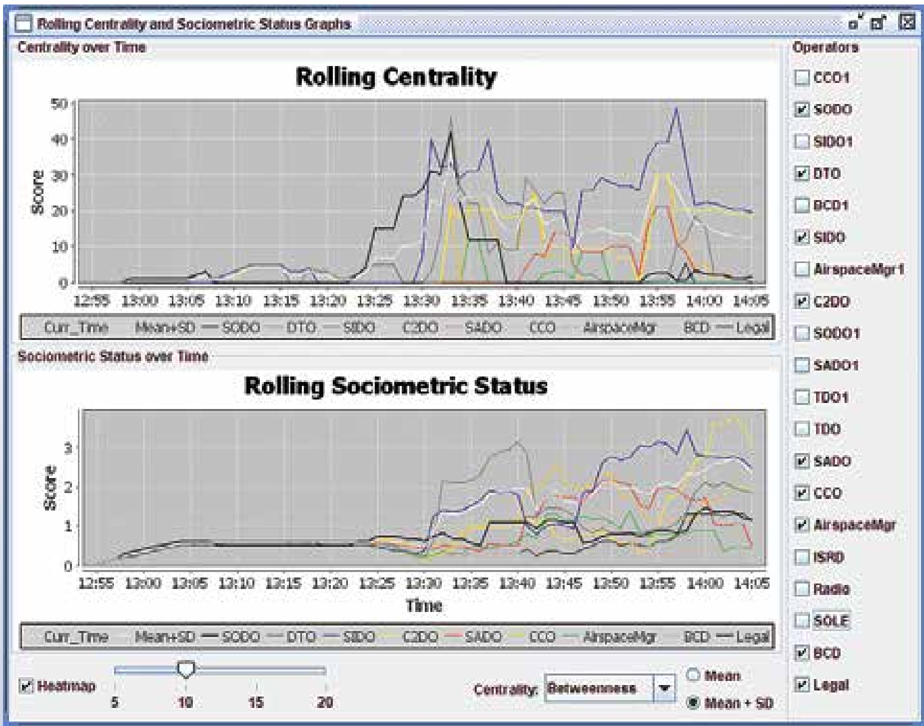
SNAC2 also allows for rapid recognition of patterns in the data. As a result of the richness of data captured, it can reveal operation



room chokepoints (indicated by operators undertaking very high workloads), inefficient work practices (indicated by comparing results with other team outcomes) and workspace design that hinders information exchange (indicated by separation of operators with high information exchange needs).

"The study of recorded data using SNAC2 has, moreover, helped to identify operations room applications and methods that most accurately convey information, maximise shared situational awareness and ensure accurate dispatching of orders," says Dr Lo.

Further work to improve the tool includes studying other highly dynamic command and control environments to glean insights, supplementing observational data with automatic feed sources and use of video and audio capture to help reduce the risk of missing important events. The researchers also intend to explore other ways to innovatively display dynamic datasets to improve the quality of analysis attainable and apply the tool to data collected in other command and control nodes.



Top: DSTO's SNAC2 display showing traffic flows between participants at a particular time, with the progress status of four tasks depicted in top left-hand side and contextual information logged along the bottom.

Bottom: Graphs depicting the changing levels of centrality and sociometric status for each participant during a time period.

Winged horse to the rescue in helicopter emergencies

A new technology, called Pegasus, has been developed to assist personnel survival and aircraft recovery when ditching at sea occurs.

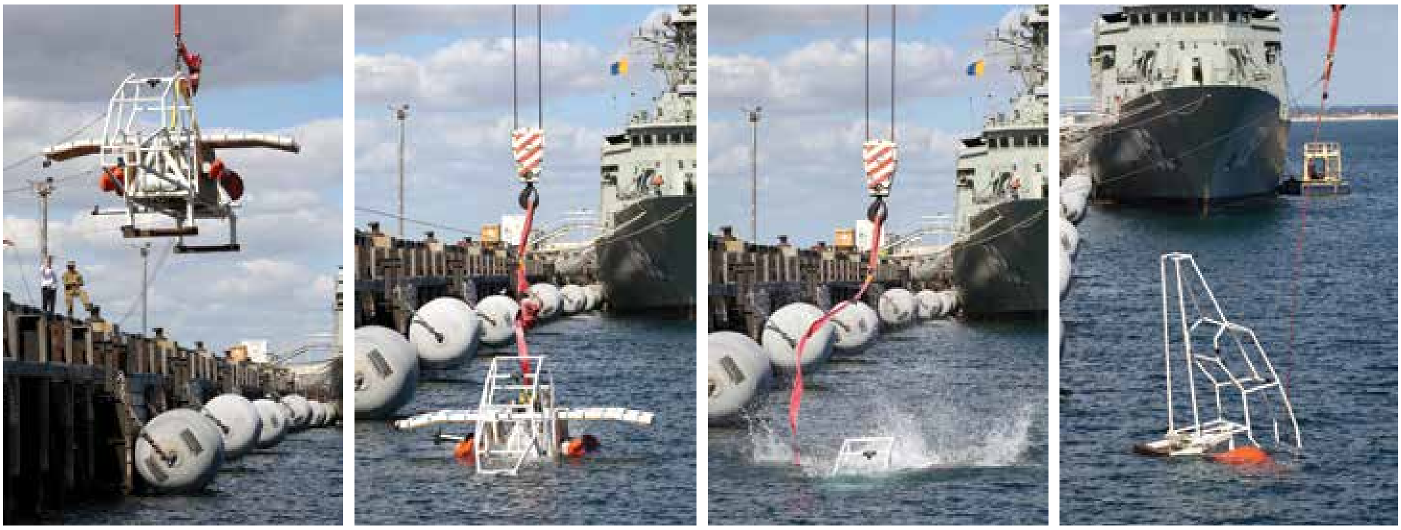
With Army soon to be operating its helicopters from the Landing Helicopter Dock ships currently being acquired by Defence, the need arises for all of its helicopters to be fitted with floatation devices that are deployable in emergencies.

Such devices are already fitted as permanent systems on some medium to large helicopters including the Black Hawk and Chinook. However, these devices are heavy, impacting on aircraft performance, range and carrying capacity. Furthermore, they are designed for use in controlled landings on water and require pilot activation prior to landing. The Tiger Armed Reconnaissance Helicopter (ARH), meanwhile, has no floatation system, resulting in restrictions being placed on the operations it can be used for over water.

The Pegasus Aircraft Buoyancy System, produced by One Atmosphere Pty Ltd with support from L-3 Oceania, offers a lighter alternative design to suit all of Army's helicopters. The technology was invented by One Atmosphere's Managing Director, Tim Lyons, formerly a Royal Australian Navy Clearance Diver. It has since been developed through the Department of Defence Capability and Technology Demonstrator (CTD) Program managed by DSTO.

The Pegasus System has been developed to avoid the devastating consequences associated with military aircraft crashes at sea, as occurred with the tragic crash of a Black Hawk helicopter into the flight deck of HMAS *Kanimbla* near Fiji in 2006. "Developing this system provides a way

Above: The Pegasus system with buoyancy floatation modules inflated.



to make Defence helicopters safer when operating in the maritime environment," explains Lyons.

Bolt-on automatic rescue aid

Pegasus is a post-crash buoyancy system that automatically deploys once a crash into water has been detected. While it can be used to assist the rescue process after crashes into fresh water, its primary purpose is to improve safety at sea.

It is designed to be easily and quickly fitted with bolt attachments or airframe cargo attachment mechanisms such as the bomb rack units fitted to the stub wings of the Tiger ARH. It can similarly be easily and quickly removed if circumstances require.

The system features two buoyancy floatation modules, one on each side, that rapidly inflate to maximum volume upon activation. These are capable of lifting an aircraft weighing ten tonnes to the surface from a depth of ten metres.

For the Tiger ARH, Pegasus lifts the cockpit above the surface of the water to allow the canopy to be explosively ejected as required by design for crash emergency egress. For other helicopter types (non-attack helicopter airframes) Pegasus is designed to keep the aircraft afloat at the surface post-crash while maintaining the cabin air supply, thus supporting a vital need of the occupants while they plan and execute their escape.

The system weighs less than 50 kilograms, has no wired connection to the aircraft, and can operate automatically or under pilot control. Automatic activation occurs if a combination of sensor inputs is detected: the presence of sea water, a sudden increase in pressure due to immersion in water and accelerometer readings of roll and deceleration that typically only occur during helicopter ditchings. Upon receiving such inputs, the system will either activate immediately or wait for further inputs based on the programmed parameters set for a crash event, thus ensuring that activation cannot pose a threat to safety in normal flight.

To deliver rapid module inflation, Pegasus is equipped with a multiple inflation system comprising a number of gas inputs from different mediums. These are activated to provide the required volume of gas against increasing ambient sea pressures as the airframe descends through the water column.

Pegasus put on show

The system was demonstrated at HMAS *Stirling* in March this year.

The demonstration involved the use of an airframe replicating the size, buoyancy and centre of gravity of a Tiger ARH. Suspended from a crane, the test apparatus was dropped into the sea from a height to simulate a ditching emergency.

Upon immersion, the Pegasus system self-activated, slowing the rate of sinking and then brought the airframe to the surface. The technology was shown to be capable of meeting the Defence requirement for floatation support enduring for up to four hours. This requirement was stipulated to ensure the safe egress of crew and personnel and also to allow adequate time for recovery of the aircraft if sea state conditions are amenable.

"Pegasus has the potential to reduce the weight burden for aircraft already fitted with a floatation aid, and to increase the safety for smaller helicopters not fitted with one when undertaking training and operations over water," explains CTD Deputy Director Duncan Watson. "By providing Army's smaller helicopters with a means of staying afloat after ditching, it addresses a significant capability gap for Defence."

The system is seen to have potential use worldwide on a range of helicopter airframes as a means of increasing occupant survivability.

Above: Photo sequence taken during the Pegasus system technology demonstration at HMAS Stirling.

Cognition measurement to make better commanders

A tool for measuring the kinds of cognition (thinking processes) that military commanders engage in holds the promise of improving the way they act militarily.

Explaining the need for the work, DSTO researcher Dr Glen Smith makes reference to the challenge posed by people-based issues that commonly arise in the course of missions.

"While the burden of understanding and managing political complexity is borne by all in today's networked world, successfully finding a way through it still requires particular kinds of military intellect and outlook," Dr Smith says.

DSTO in collaboration with the University of Melbourne has undertaken a long-term study of the modes of thought that lead to success, and has arrived at a scientifically-rigorous means of measuring the degree to which these modes are present in an individual.

This research is being done in conjunction with staff and course members at the Australian Command and Staff College (ACSC). Its purpose is to make individuals aware of their personal style, thus allowing them to seek out ways to change or to develop it further as appropriate for their future command roles.

The tool enables analysis to be conducted in terms of four kinds of thought: meta-cognition, cognition, reasoning and intuition.

Thought modes

Metacognition is the process of working out what approach to use to tackle a problem and monitoring how well the process works. The cognition process involves applying the selected problem-solving approach to the actual options available. Both the processes of metacognition and cognition can be tackled either rationally or intuitively.

As an example, Dr Smith proposes the task of buying a camera.

"First, in metacognitive thought mode, you decide what process you will use in order to choose the camera. This could be to listen to what your friends say, do a Google search, see what's available at the local camera shop, or list desired and undesired attributes of the camera you want.

"One way of deciding on process may be to choose whichever one feels OK at the time, as in the manner of impulse buying: this is intuitive metacognition. Another way of deciding is to think about how you made similar purchases in the past, remember what worked well, and use that process: this is rational metacognition.

"Moving on now to the cognition process in which the chosen process of deciding is applied to the available range of camera choices, there are two ways this can happen also.

Above: DSTO researchers evaluating the questionnaire responses of Australian Command and Staff College course participants.

"You could look at the cameras and go with the one that feels right: this is intuitive cognition. Or you could gather the data to assess each camera by each criterion and apply the combination rule and choose the camera with the best outcome: this is rational cognition."

Ancient heroes at war today

Taking their analysis further, the researchers identified two main military styles of thought that commanders should aspire to; the 'Achilles' type who intuitively decides the best path to a solution but checks action plans logically, and the 'Priam' type who makes rational decisions with intuitive out-of-the-box strategies. These classifications were developed by Dr Smith's research colleague, John Hansen.

The names, those of key characters in the Trojan war saga *The Illiad* by the ancient Greek poet Homer, were chosen because they were both outstanding warriors with different strengths and weaknesses. Concerning weaknesses, the Greek warrior Achilles was famously vulnerable in his heel region, and the Trojan King Priam had an excessive fondness for horses that made the wooden horse ploy by the Greeks feasible.

In the DSTO schema, Achilles types excel in rational metacognitive prowess, thus having reasoned and conscious control over how cognitive processes are chosen. They are also good at intuitive cognition, having automatic well-trained decision-making processes. They are thus model fighters who can deliberatively work out how to change when change is required.

Priam types, meanwhile, excel at implicit metacognition whereby decisions on how to decide come readily 'out of the blue'. Their other mental strength is rational cognition, with which they rigorously check the soundness of decision-making. This makes for a strong strategist with sound tactics.

Dr Smith says, "The key to success as a commander is knowing your mind's strengths and weaknesses and knowing how to use metacognition to control and monitor them, all of which will turn you into a better tactician and strategist. This is where use of the tool comes in."

Shaping the minds of tomorrow's commanders

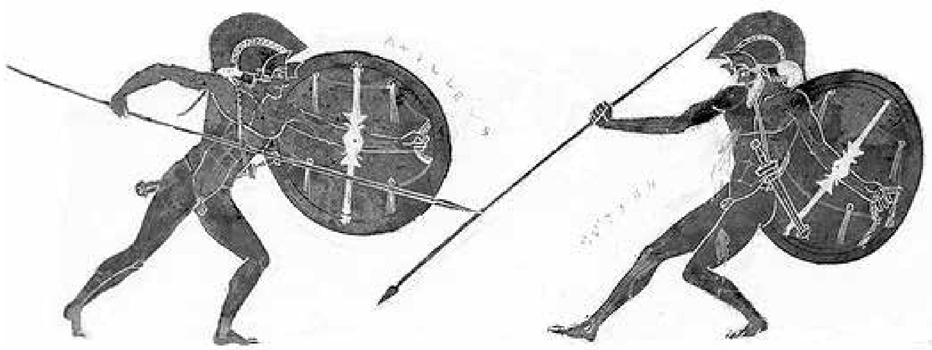
Applying the tool involves a questionnaire process in which a person is asked to focus on a past decision-making activity and then answer questions on how he or she went about it. Their answers are combined to provide measures of the four types of thought. These measures can then be presented as quadrants in a schema, which depicts the dynamic balance of a person's thinking.

The tool has been used for training ACSC course participants to enable them to get the most from their military education. This work took the form of conducting tests on the thought processes of ACSC course members before and after the course, with similarities and differences in results noted.

The researchers aggregated these results to arrive at a set of figures that they presented to Defence College staff to demonstrate the level of educational gains being achieved.

In the next phase of work, the researchers intend to tackle a common human foible – the inability to see weaknesses in oneself. Individually tailored simulation will be provided so that commanders can see the consequences of their actions and thus contemplate change. Ω

Above: ACSC course participants attending a field day at RAAF Base Amberley (photo not related to the DSTO study).



Underwater imaging on trial

DSTO recently evaluated the picture provided by a new kind of sonar.

As part of a program to investigate advanced sonar technologies, DSTO acquired a Kraken Sonar Systems AquaPix synthetic aperture sonar (SAS) system. With the help of Kraken engineers and Navy personnel at HMAS *Waterhen*, the system was integrated with a REMUS 600 autonomous underwater vehicle (AUV) operated by DSTO for testing various undersea technologies.

The primary uses for synthetic aperture sonar by Navy are to survey the seafloor along major shipping routes and to conduct sea mine countermeasure operations. Mine hunting operations, including mine detection and classification, are necessary whenever ship movements are to be undertaken in contested waters.

SAS technology benefits

The advantages of SAS technology over conventional side-scan sonar are the superior image resolution it delivers and the higher rate of area coverage.

"Higher resolution images ensure mine-like objects in cluttered backgrounds are more likely to be spotted," explains DSTO researcher Dr David Battle.

"Furthermore, SAS enables high rates of coverage by insonifying large areas with wide swaths of sound – unlike side-scan sonar, which transmits beams that are highly focused in the azimuth dimension. Whereas side-scan adopts a 'brute force' approach to produce high resolution images, SAS technology employs smart signal processing to focus the images. This approach enables the use of lower frequencies that propagate out to longer ranges, thereby giving higher coverage rates.

"The significance of higher coverage rates is that they lessen the delay before shipping movements can proceed in an area with confidence."

Sea trials

Sea trials of the AquaPix SAS were conducted in Jervis Bay last April to study the performance of this specific system as well as the limitations of the technology generally. A REMUS 100 vehicle with side-scan sonar was also deployed over the same trial area to enable comparisons to be made between the two technologies.

The DSTO researchers also wanted to examine the conditions of SAS data capture under which image reconstruction could fail during post-mission data processing. One such concern related to SAS operations in shallow water.

The issue here is that sonar signals transmitted by the system may reflect multiple times between the seabed and the surface, causing high levels of interference with the signal reflecting directly from the seafloor to the receiver. To counter the problem, a technique known as multi-path mitigation is applied. This involves the transmission of high and low frequency signals at short and long ranges respectively, with the respective signal returns received by arrays oriented at different angles. Since the multi-path signals interfering with direct returns tend to arrive at steeper angles, they are easily identified by their higher frequency and can thus be filtered out. In this way, the system is desensitised to this kind of interference.

Trial results

Post-trial data analysis revealed that the stability of the Remus AUV was more than adequate to allow for high quality SAS imaging, except when the AUV was undertaking turns – as had been expected by the researchers.

For the version of the AquaPix SAS trialled by DSTO, the swath was found to extend in excess of one hundred metres either side of the vehicle, with a uniform resolution of better than five centimetres being achieved.

"Although the sonar was not specifically configured for imaging highly reflective targets, such as the all-metal Firefly aircraft wreck in Jervis Bay, fairly detailed images of this were obtained," says Dr Battle. "Some image artefacts were visible, however, and these may illustrate the limits to multi-path mitigation in very shallow water."

Concerning power use, even though the REMUS 600 test vehicle had just half of its normal battery capacity available due to the modifications required to fit the SAS, only about six per cent of capacity per hour was consumed while travelling at three knots with the SAS transmitting at full power.

Conclusions

Overall, the AquaPix SAS was found to meet all expectations, with the image quality and range being particularly impressive.

Further work may be done by DSTO in association with Kraken to permit on-board processing of the sonar data during a mission. This opens up the possibility of conducting very long duration missions using the REMUS 600, with the vehicle making autonomous decisions as to which objects can be ignored and which may be sea mines that pose a threat to shipping. Ω

Above: Image of the Jervis Bay seafloor produced by data collected with the AquaPix synthetic aperture sonar.

Left: DSTO's Remus 600 testbed AUV fitted with the AquaPix synthetic aperture sonar.

Briefs

Three-way collaboration results in new food research centre

The launch of the Centre for Food Innovation (CFI) in Launceston in April this year has greatly advanced the cause of food research in Australia by bringing together the expertise of scientists and technologists from DSTO, the University of Tasmania and the CSIRO.

A collaborative agreement signed by the partners has enabled them to initiate joint research projects and link into national food research networks.

Work to be undertaken at the centre of specific interest to Defence will include research into new food processing and packing technologies that will extend the shelf-life of fresh produce, and the development of key technologies to make and test specialised foods that support high-performance activity.

The CFI is seen to provide a setting in which knowledge about Defence food and nutrition needs can be combined with knowledge about commercial food products, and, working with industry, new and innovative products developed. The focus will be on dual-use products suitable for inclusion in Defence combat ration packs as well as commercially marketed.

In addition to broadening and extending DSTO's food research base by combining the three research efforts, the advent of the centre is expected to boost local agricultural activity while also encouraging local food processer involvement in the production of Defence ration pack components.

A further benefit the collaboration offers is that it will enable DSTO to extend its existing capabilities in food science and technology at DSTO Scottsdale.

Signing of the collaborative food research agreement by CSIRO Chief of Animal, Food and Health Sciences Professor Martin Cole, University of Tasmania Vice-Chancellor Professor Peter Rathjen and Chief Defence Scientist Dr Alex Zelinsky.

ISR system research framework for closer ties with Coalition partners

DSTO has recently completed the development of a framework for research into intelligence surveillance and reconnaissance (ISR) system software and hardware, named the Evolutionary Layered ISR Integration Exemplar Architecture (ELIIXAR).

ELIIXAR will enable DSTO to understand how best to link together various ISR data sources and ISR exploitation and analysis tools onto a common integration backbone. Furthermore, it will facilitate improved discovery, integration, and sharing of information with other Defence and Coalition partner forces; a goal that is core to Defence's future warfighting concepts.

This new research capability is now supporting the majority of DSTO's research into future integrated ISR solutions for Defence.

Investigations are being undertaken into ways that the ELIIXAR environment can be linked to similar frameworks developed overseas. By conducting experiments on how these systems interact, DSTO will be able to inform Defence on how it can remain interoperable with other Defence Forces in the years ahead.

Media and communication products analysis tool

DSTO has developed a software tool for analysing media and communications products. Its purpose is to assist studies on the ways that themes, images, colour, allusions to cultural sensitivities and language are used to influence a target audience.

This manner of work is part of the psychological operations field (known as psyops) in which social intervention strategies and communications techniques are used to win the 'hearts and minds' of a target group or population, or to influence their morale.

Development of the tool was undertaken as part of a collaboration with DSTO's equivalent in the United Kingdom, the Defence Science and Technology Laboratory (Dstl) to develop intelligence processing and analysis technologies.

Dstl recently carried out a series of trials and evaluations of the tool, and the results of this evaluation are expected to benefit DSTO's research program.

DSTO has also entered into a collaboration with Dstl to produce a technology that combines a UK-developed tool for processing structured data with a DSTO tool suite for processing unstructured data. The resultant capability will be accessible to both nations.

Recently published DSTO Scientific Reports

DSTO publishes the outputs of its research in a series of Science and Technology Reports. Below is a list of recent public release reports. For a pdf copy of any of these reports email Libreportofficer@dsto.defence.gov.au

Load Carriage Capacity of the Dismounted Combatant – A Commander's Guide

There is a universal requirement for military personnel to carry an external load. When undertaking mission planning it is important for commanders to consider the factors influencing load carriage capacity and identify the likely burden. This planning is critical to the maintenance of dismounted personnel's operational effectiveness, battlefield performance and ultimately mission success.

A Comparison of Civil and Military, European and United States Regulations and Standards for the Certification of Helicopter Structure

A comparison of a range of civil and military, United States and European regulations and structural certification standards for the fatigue substantiation of rotary wing aircraft structure was conducted. The result of the comparison activity was a thorough, updateable, user-friendly, interpretive and current comparison product.

Establishment of VISAR Measurement System for Material Model Validation in DSTO

This report describes the establishment of VISAR, a velocity interferometer measurement system in DSTO for recording high-temporal resolution velocity data in high-velocity impact experiments. This data is critical for model validation, material and warhead performance characterisation and effects studies.

Development of Photon Doppler Velocimeter for Explosives Research

A Photon Doppler Velocimeter (PDV) was built for explosives research. The measurement limitations of the PDV system are determined, applications for explosives research are discussed, and the upgrade pathway is recommended.

Calm Water Resistance of a 1:25 Scale Model of the Armidale Class Patrol Boat

DSTO has undertaken a series of calm water resistance scaled model tests on the Armidale Class Patrol Boat. This report presents the data from the experimental test series.