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# DEFENCE SCIENCE



**World leading research in active sensing radar**

**Dealing with invisible forces that mess with aircraft**

**North West Shelf surveillance trial a high-flying success**

**Easing crew fatigue at sea**

**Taking a better look at Australia's remote boundaries**

# Report Documentation Page

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**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 Roger Lough, and employs about 2100 staff, including some 1300 researchers and engineers. It is one of the two largest research and development organisations in Australia.

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# Wet-end diagnostic system for submarine sonar

Wet Nurse submarine sonar diagnostics system.



DSTO has developed a diagnostic system for Collins class submarines to keep tabs on the performance of external parts of sonar systems while submerged.

The system, known as 'Wet Nurse', provides the crew with the ability to identify defective sonar array sensors while at sea and to take remedial action. It also provides the command team with an estimate of the associated performance degradation caused by the defective sensors.

The application is based on commercial-off-the-shelf (COTS) processing hardware and a generic open architecture developed by the UK Defence Science and Technology Laboratory (Dstl) and UK defence contractor, QinetiQ.

According to DSTO researcher Stephen Hoefs, "The use of an open architecture computing design enabled the Wet Nurse concept to be developed in a very short period of time."

## Advantages of open architecture

Giving the background to the advantages of open architecture (OA) approaches, Hoefs explains, "Military acquisitions usually have a long delivery time, and over the course of delivery, customer requirements often move on. However, modifications can become unaffordable when a supplier has 'lock-in' status as the equipment provider. This lock-in also generally extends to in-service support strategies and technology obsolescence."

"Also, the pace of technology advancement in COTS computing is so fast that some means of isolating the software processing from the underlying hardware is required. Otherwise, the software processing would need to be rewritten every time a new host central processing unit is used, or the operating system is upgraded, or new device drivers applied. This isolation layer is generally called 'middleware'."

The use of open architecture is intended to overcome both these problems by adopting widely accepted industry standards and technologies for key hardware and software interfaces and middleware.

"When combined with open business practices and component decomposition into suitable functional sizes," elaborates Hoefs, "the acquisition process can be made much more competitive, evolvable and with significantly shorter delivery times. Open architecture is an essential enabler for through-life capability management."

## The Wet Nurse trial

The Wet Nurse sonar diagnostic system was successfully tested on HMAS Dechaineux last year, with DSTO personnel Damien Killeen and Leon Wende on board.

During the trial, Wet Nurse enabled the identification of defective sensors that the crew otherwise would not have known about. Remedial action was taken at sea to rectify the problem.

In addition, the command team in the control room were kept informed of the health of the arrays via hard copy printouts in the form of a sensor health summary report that included array performance degradation estimates. This helped the command team to understand their day-to-day sonar performance and therefore how to employ it with confidence in operational missions.

The ship's crew were unanimous in their positive comments and general encouragement for the Wet Nurse system. While a number of problems were encountered during the trial, overall the system performed very well. The RAN's Submarine Force Element Group has subsequently requested that the system be fitted on all boats.

The Wet Nurse diagnostics system was recently moved to HMAS Rankin and a second trial system fitted to HMAS Farncomb.



HMAS Rankin.

# Dealing with invisible forces that mess with aircraft



DSTO has developed a cutting-edge technology to test the ability of Defence aircraft to fly safely through strong electromagnetic fields.

Commercial passengers are reminded with monotonous regularity of the hazards that electromagnetic radiation pose to aircraft communication and navigation equipment. Military aircraft can be similarly prone to disturbance when flying near powerful external sources of electromagnetic emissions, such as broadcast transmission towers or power lines.

Naval aircraft, especially helicopters, that take off and land near powerful shipboard communications and radar antennas, are particularly severely exposed.

The conventional way of testing an aircraft's ability to cope with low-frequency electromagnetic interference requires getting access to the many bundles of cables snaking throughout its cavities.

However, as aircraft design has grown in sophistication, different system components are being assembled with greater integration, and more extensive use is

being made of metal shielding mesh around the cable bundles to protect the aircraft against external electromagnetic influences.

As a result, the process of testing for electromagnetic effects by working with the wiring directly has become increasingly difficult due to diminishing accessibility.

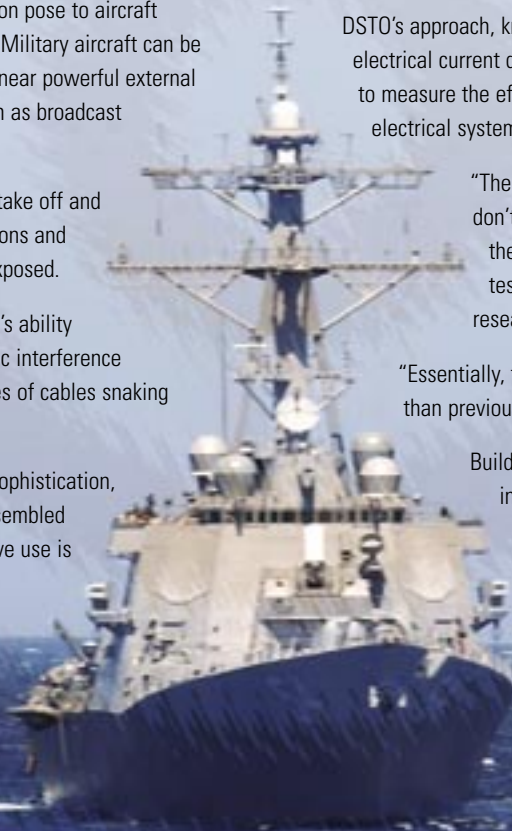
## Direct current injection

DSTO's approach, known as direct current injection, is to introduce an electrical current directly onto the surface skin of the aircraft in order to measure the effect of an electromagnetic field on the aircraft's electrical systems.

"The advantages of direct current injection are that we don't need to get to the cable bundles, and we can test the whole aircraft in one go rather than having to test each individual bundle of cables," explains DSTO researcher Dr Chris Leat.

"Essentially, the process is both more efficient and more accurate than previously," he says.

Building on experimental study of the direct current injection approach overseas, the innovation DSTO has brought to the field is the use of a mathematical model that compactly depicts the levels of radio

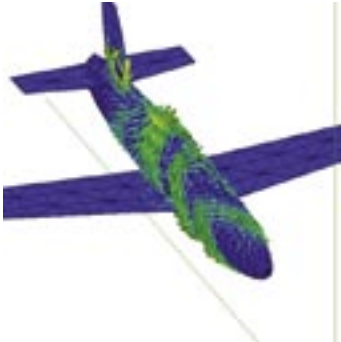




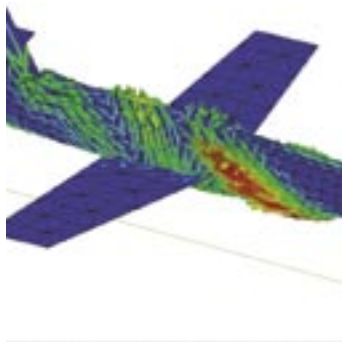
Aircraft being tested for electromagnetic effects using direct current injection techniques.



Aircraft cable bundles.



3-D computer model of radio frequency skin currents.



Aircraft operating close to powerful shipboard transmission antennae are exposed to high levels of electromagnetic radiation.

frequency skin currents on every part of an aircraft over a range of frequencies created by external sources of electromagnetism.

Validation of this mathematical model for each type of aircraft being tested is carried out by exposing the aircraft to an artificially induced electromagnetic field and taking low-level measurements of aircraft skin currents with a number of current measuring probes.

The model then tells researchers how much radio frequency power should be applied at each frequency to an aircraft during testing in order to simulate the effect that different types of external electromagnetic emitters will have on the aircraft avionics during flight – all without having to touch a single cable bundle.

Conventional methods of testing for electromagnetic interference are subsequently used to monitor the performance of the avionics. Aircraft instrument readings for flight, such as altitude and air speed, are simulated by inputs, and these are observed for any deviations arising.

When problems of electromagnetic interference are indicated by the test process, further diagnostic work is carried out to identify the path that electromagnetic energy is using to enter the aircraft's avionics. Possible solutions that can be applied include braided metallic sheathing of wires, repair of broken earth connections, and the use of fibre-optic links instead of copper.

### A further innovation

While the process of conducting low-frequency testing has generally been undertaken in an open space, this could well change as a result of recent developments at DSTO.

Researchers are investigating the possibility of carrying out low-frequency testing in an electromagnetic reverberation chamber, a facility usually only suitable for high-frequency electromagnetic testing. By fitting the reverberation chamber with a device known as a septum, testing

can be undertaken over a range of frequencies down to 1MHz. The combined facility is known as a hybrid reverberation chamber-transverse electromagnetic cell.

The significance of this work is that an aircraft will no longer have to be moved from one location to another for high and low frequency testing, offering more gains in efficiency for the process.

Furthermore, the process of testing indoors using such a hybrid facility avoids the problem of interfering with other radio spectrum users. This is a significant issue for outdoor testing, given that virtually every available frequency of the radio spectrum is in use by civilian and military operators, and interference can have dire consequences for them. The hybrid facility can be made to ensure that no electromagnetic waves escape, thus allowing testing at any frequency.

Transverse electromagnetic cells are already used for testing small items such as individual avionics boxes. However, a number of challenges arise when combining it with a reverberation chamber and making this suitable for testing an entire aircraft.

One such problem is the undesirable radio frequency resonances that a transverse electromagnetic cell gives rise to. The present technique for eliminating these resonances is to use absorber materials. A drawback of this approach is that the absorbent material – commonly a delicate foam that can be easily damaged by handling – must be removed and reinstalled for each test, which poses significant issues of practicability for testing operations.

To overcome the problem, DSTO is developing a technique of active resonance cancellation that will quash the unwelcome resonances, thereby obviating the need for absorbing materials.

“The testing we have carried out has been very successful so far, and the results are looking very promising,” says Dr Leat.

If proven, the advent of this new technology will represent a world-first.

# World leading research in active sensing radar

DSTO is participating with local and US partners in the development of a new kind of radar system, and the outcomes have gathered accolades internationally.



*Dr Stephen Howard, Prof. Bill Moran and Dr Andrew Shaw in anechoic chamber for radar research.*



*ADF naval platforms of the future may eventually be fitted with the new kind of radar.*

Three Australian-US research projects are being carried out: two under the Waveforms for Active Sensing (WAS) Program mounted by the US Defense Advanced Research Projects Agency (DARPA), and one as a Multidisciplinary University Research Initiative (MURI) 'Waveforms for Full Spectrum Dominance' funded by the US Air Force Office of Scientific Research (AFOSR).

The principal partners include DSTO and the University of Melbourne, and in the United States, Princeton University, the University of Illinois, Washington University, Arizona State University, Colorado State University, Rensselaer Polytechnic Institute, the University of Maryland and the Naval Postgraduate School, plus defence corporations Raytheon Company Missile Systems and Science Applications International Corporation.

Participating US Department of Defense facilities include the Naval Research Laboratory (NRL) in Washington DC, and the Air Force Research Laboratory (AFRL) in Rome, New York State.

The general aim of these research projects is to enable a radar system to adapt its performance to environmental conditions in order to improve detection and target tracking capabilities. The research will have impact on future airborne and surface based radars including large phased array radars for naval platforms, ballistic missile defence and airborne early warning and control systems.

## Active Sensing Radar

DSTO researcher Dr Stephen Howard explains, "The concept of Active Sensing Radar (ASR) is relatively new, and provides a basis for future adaptive radar systems."

"To describe how ASR works, we can begin by saying that radars obtain information about the environment by illuminating it with radio frequency waveforms and then analyse the reflected returns. The radar system uses simple statistical descriptions of background reflections, known as clutter, to reduce the effects of such 'noise' on the received signal, which enables the system to discriminate objects of interest with greater fidelity."

"In a refinement of that basic system, applied on what are known as phased array radars, a clearer radar picture is facilitated by conventional processing of the received signal using statistics gathered from the environment over previous 'looks'. This form of processing, referred to as 'space-time adaptive processing', has been around for many years."

"The ASR system currently in development has the advantage of adapting on both the transmit and receive stages. The radar modifies its configuration in response to the information it has already acquired from the environment, such as clutter and multi-path effects."

"The radar illumination parameters that can be varied are the transmit waveform, beam-pattern, polarisation, and pulse repetition interval. In addition, the 'receive' processing is enhanced to accommodate both transmission and environmental information using highly sophisticated statistical tools," he says.

### Waveforms for Active Sensing (WAS) program

One of the WAS projects for development of ASR is being undertaken with the NRL Advanced Multifunction RF Concept (AMRFC) radar facility on Chesapeake Bay. The goal of this project is to obtain quantifiable improvements in the detection of small targets in sea clutter.

According to Dr Howard, the AMRFC facility, established at a cost of \$US100 million, "offers unique opportunities for the study of advanced illumination and radar processing techniques, having an ability to coherently transmit on four sub-arrays independently with dual polarisation on each."

"The techniques under development by Australia and the US include advanced waveforms, sophisticated statistical clutter modelling, scheduling algorithms, waveform library design principles, and a novel technique for instantaneous radar polarimetry developed by the DSTO-Melbourne-Princeton team. The testing of the polarimetry technique is a key component of the experimental program being undertaken by the AMRFC radar," he says.

The second WAS project is focused on fully adaptive radar techniques for detection and tracking of vehicles in an urban environment, where multiple reflections of signals off buildings seriously degrade conventional radar performance.

The work program is built around a test facility at the AFRL's Rome facility, with delivery of quantifiable improvements over existing methods expected.

Both of the DARPA-funded efforts are 15-month contracts, which, if successful in delivering on the goals, will lead to further funding as part of a Phase II program.

### Future directions for Active Sensing Radar

Looking ahead, Dr Howard foresees that "radars will have considerably more flexibility in the transmit waveforms, the processing of returns and in antenna geometry, arising from advances in hardware design, new materials and hardware manufacture, which are being driven by the demands of the commercial telecommunications industry."

"New radar systems will have multiple transmit and receive antenna elements capable of working independently. Mode-switchable and configurable radars will be able to greatly reduce time to detection by extracting operating parameters from sensor data in real-time. This will enable control over the sensor front-end for selection of an illumination mode, giving better differentiation of targets from the evolving background clutter. All this promises to significantly improve radar performance," he says.

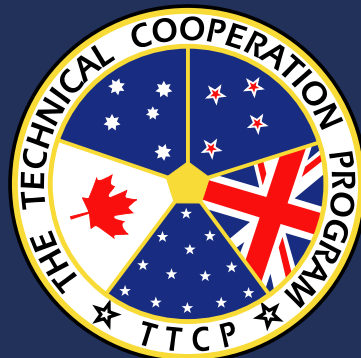
### DSTO's expertise with this work

*DSTO was invited to participate in the three research projects on adaptive radar because of its long-term effort in the area of sensor management with Melbourne University under the Centre of Expertise in Networked Decision Sensor Systems (CENDSS).*

*A team of about 9 DSTO and Melbourne University researchers, led by DSTO researcher Dr Stephen Howard and the Centre's Research Director, Professor Bill Moran, has been working at the forefront of radar research internationally. This team, in collaboration with another at Princeton University led by Professor Robert Calderbank, is the only group to be chosen as participants in all three projects.*

*One area of DSTO research, headed by Dr Howard, is studying advanced illumination and radar processing techniques. Another area, led by Dr Andrew Shaw, who also leads DSTO's Microwave Radar Major Science and Technology Capability (MSTC), examines the technology of multi-function phased-array radars. Dr Dan Madurasinghe heads a further research effort on space-time adaptive processing in which DSTO maintains a strong global lead.*

*Total US funding for the two WAS projects and the MURI is around \$US8 million. Australia has provided about \$AUS1 million in funding from various sources including the Australian Research Council, Department of Education Science and Training, and DSTO. The work of Australian contributors is managed under the auspices of The Technical Cooperation Program (TTCP).*



# North West Shelf surveillance trial a high-flying success

Surveillance images taken by Mariner Demonstrator during the North West Shelf UAS Trial.



DSTO has led the planning and conduct of a major Defence trial to test the ability of unmanned aerial systems (UAS) to carry out maritime surveillance over the strategically important energy-producing fields of Australia's North West Shelf.

The North West Shelf UAS Trial was conducted to assess the potential of Unmanned Aerial Vehicles (UAVs) to operate as part of a joint integrated surveillance capability, and to operate along with RAN Patrol Boats to provide an additional layer of security in Australia's northern maritime approaches.

Long-range unmanned aircraft, such as Global Hawk and Mariner, ordinarily operate at high altitudes with a flight endurance of up to 30 hours, and when fitted with advanced radar and electro-optical sensors, are eminently suited to providing sustained surveillance over vast areas like that of the North West Shelf.

The recent North West Shelf Trial involved a Mariner Demonstrator UAV working with a Royal Australian Navy Armidale Class Patrol Boat HMAS Pirie, the Border Protection Command (BPC), a BPC aircraft and the Pilbara Regiment to conduct surveillance and response missions.

The Mariner Demonstrator aircraft, together with its ground control elements and other technical support, was provided for the trial by US company, General Atomics Aeronautical Systems Inc.

## A complex multi-agency venture

Preparations for the trial and its conduct involved the work of a 100-plus member team over nearly two years.

DSTO led the trial effort with input from a range of its research capabilities, including intelligence, surveillance and reconnaissance, satellite and computer communications, electronic warfare, radar, air operations, air vehicles, scientific and engineering services and information systems.

In addition, DSTO undertook the formidable task of managing and coordinating the work of the many and various Defence organisations involved, under the direction of DSTO's Deputy Chief Defence Scientist (Platform and Human Systems), Dr Ian Sare, who served as Trial Executive Authority.

Participating Australian Defence Force organisations included Army, Navy and Air Force, the Capability Development Executive, the Intelligence and Security Group, the Defence Materiel Organisation, the Chief Information Officer Group, the Defence Support Group and the Border Protection Command (a partnership between Defence and Customs, formerly known as the Joint Offshore Protection Command).

## Some preliminary difficulties

One challenge in the lead-up to the trial was to mount a fully integrated maritime surveillance radar onboard the Mariner Demonstrator.

General Atomics had selected a radar developed by Israeli defence contractor, Elta Systems Ltd, (similar to those used on Australian Defence Force (ADF) AP-3C Orion patrol aircraft), to be carried by the Mariner, but this had never been done before. Rising to this challenge, General Atomics and Elta Systems worked intensively together to achieve a successful integration of the Elta radar onto the Mariner.

Another challenge the team faced, says Dr Sare, "was to assemble the broader mission support systems that interfaced with the General Atomics Ground Control Element, controlling what the UAV would do during the trial sorties, and disseminating the information captured by its sensors. To arrive at a workable system, DSTO had to work very closely with General Atomics, some other Defence industry players and parts of Defence."



*Mariner UAV in flight over Kangaroo Island, South Australia.*



### The trial in progress

The trial was conducted over 29 days during late August and September 2006, commencing with two test flights out of RAAF Edinburgh near Adelaide, followed by four missions undertaken in a two-week period from RAAF Learmonth on the far north-west coast of Western Australia.

The UAV was launched from RAAF Learmonth by a local Launch and Recovery team, but once airborne, control was transferred to operators located in a building at RAAF Edinburgh – the facility designated as the North West Shelf Australian Ground Environment (NWS AGE) during the trial. Communications between the UAV and NWS AGE were enabled by satellite link.

Sorties lasted from two to over twenty two hours. During these sorties, the UAS was employed to detect, track and identify vessels passing through the surveillance area. Data collected by the UAV's sensors were transmitted by satellite link to RAAF Edinburgh for analysis. Successful direct downlink of imagery was also demonstrated from the UAV to HMAS Pirie and elements of the Pilbara Regiment, which had been equipped with Remote Video Terminal devices.

The crew at RAAF Edinburgh coordinated the UAV operations with the patrol boat to assess how well the two could operate together to provide an effective maritime surveillance and response capability.

### Virtual UAS trial

Following on from the real-world North West Shelf UAS Trial, a modelling and simulation exercise was undertaken by Northrop Grumman in its Cyber Warfare Integration Network (CWIN) facility in San Diego, California, USA.

The purpose of this virtual trial was to investigate the performance of a representative RQ-4B Global Hawk UAS fitted with a sensor package optimised for conducting maritime surveillance in the North West Shelf environment, and to look into further situations or conditions not encountered in the actual flight trials, including different weather conditions and night operations.

A Global Hawk platform was not available to participate in a real world NWS trial because of the high operational demand for these platforms.

During the CWIN demonstration, the simulated Global Hawk UAS 'flew' similar maritime surveillance missions to those in the real-world trial. A sequence of simulation runs (missions) were conducted over a two-week period in October 2006. RAAF 92 Wing operators were included as human players within the virtual simulation environment, where they were able to perform mission command and sensor operation functions in a real-time fashion as the simulated mission activity was played out. DSTO provided a number of analysts to assist with the conduct of the simulations, and data capture.

The results of the CWIN activity will complement the findings from the real-world flight trials and contribute to the overall assessment of employing unmanned aerial systems for a maritime surveillance function.

### A successful venture

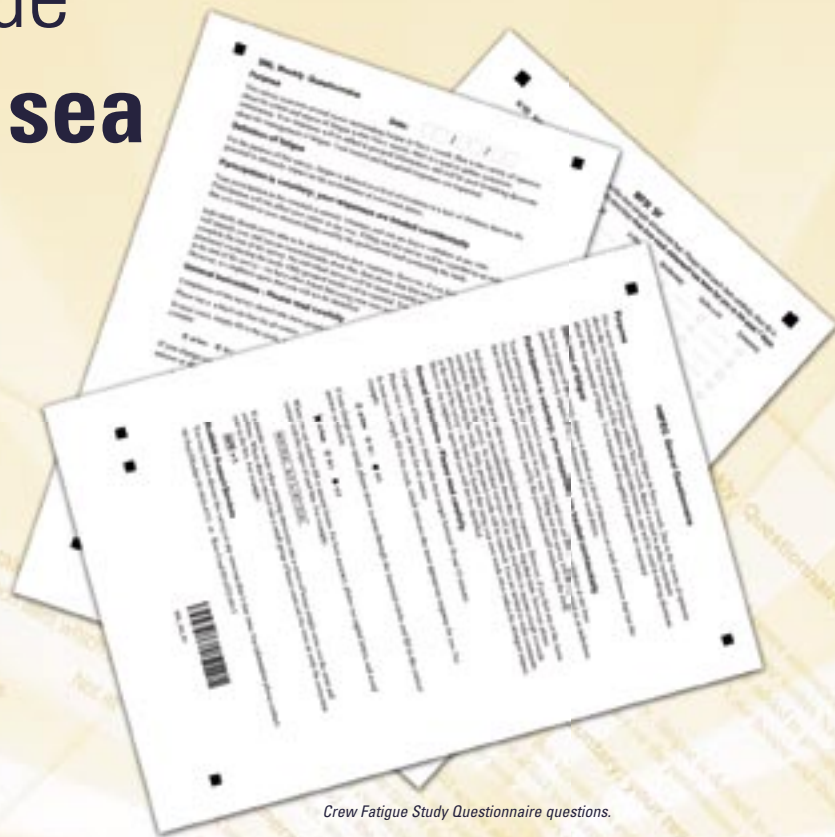
According to Dr Sare, "The outcome of the North West Shelf UAS trial, which required a tremendous cooperative effort from a large number of people across DSTO, and more widely across Defence, was a resounding success."

The trial is expected to provide useful data that will assist Defence to develop its requirements for acquisition of a long-endurance, multi-mission UAS under Project AIR 7000 Phase 1, and assist the Border Protection Command, Immigration, Fisheries and Quarantine services to assess the value of using UAVs for coastal surveillance and border protection.

The trial will also provide an assessment of the procedures and practices for sharing surveillance information among government agencies to develop a whole-of-government response to Australia's national security needs.

It is anticipated that UAS capabilities could contribute to a range of security aspects in Australia's remote northern approaches by providing improved surveillance on illegal fishing, drug running and people smuggling activities.

# Easing crew fatigue at sea



Crew Fatigue Study Questionnaire questions.

HMAS Benalla.



## DSTO studies factors affecting quality of life at sea.

Quality of life at sea is a serious issue for Navy. It has an impact on recruitment and retention. DSTO recently undertook a major study of some of the factors that affect this challenge for the RAN.

The DSTO study was conducted over a three-month period early this year onboard two RAN vessels, HMAS Benalla and HMAS Shepparton, during planned operations north of Cairns. The operations were conducted in three phases of about one-month duration each, with intervening periods for crew respite and provisioning at Cairns or Weipa.

DSTO researcher Paul Elischer says, "The aim of the study was to identify and quantify the major contributors to fatigue in the maritime environment, and the ramifications of fatigue on crew, operational performance and safety."

One DSTO researcher was assigned to each vessel for each phase of the operation, with a total of five different researchers experiencing time at sea for the duration of the operations to observe at first-hand the operational and personal requirements of shipboard life on crew.

Researchers acquired both subjective data, via questionnaires, and objective data, via a range of instrumentation techniques. They also undertook one-on-one observations to assess energy expenditure of crew undertaking their normal day-to-day duties. After collecting and collating the data, some preliminary analysis was conducted.



HMAS Benalla and HMAS Shepparton.

### A range of study tools

The questionnaires inquired into crew perceptions of nutrition (dietary habits), workload (time on duty and watch-keeping schedules), fatigue, sleepiness, sleep-wake cycles, effects of motion and general well-being.

Data gained from objective measures included the likelihood of seasickness, obtained by using instrumentation to record ship motion; sleep-wake cycles, recorded by use of a wristwatch device worn by volunteers to distinguish active and non active periods; general well-being obtained by anthropometry measures; cognitive performance and skill; and habitability parameters such as temperature, humidity and noise.

“Objective techniques, being less obtrusive, are the preferred approach for acquiring crew performance data,” says Elischer, “but they first need to be validated against the statistical results from questionnaires. This subjective information is of paramount importance since all crew are different in their abilities to tolerate various stresses, and the individual is the only one who knows exactly how he or she feels.”

### Research on tools of research

The project also provided the opportunity to evaluate two forms of instrumentation used by DSTO for this kind of research.

One such tool, developed by DSTO, predicts the likelihood and incidence of seasickness by measuring the vertical acceleration of the vessel under prevailing conditions. This device, a standalone unit that can record the required data for extended periods, incorporates algorithms developed by overseas researchers that calculate a figure for the probability of seasickness onset.

The other instrument that was examined is a recently acquired piece of hardware – a head, gaze and fatigue analysis tool – designed for assessing fatigue levels of crew involved in prolonged computer-machine interactions. Miniature cameras controlled by a software package are used to record facial characteristics, including measurement of the blink rate and the extent and frequency of eye closure.

### Research outcomes

A significant amount of data was acquired during the three-month study period. The surveys and results have been collated and processed, ready for analysis to be carried out by the researchers using various statistical techniques.

The work has evaluated the impact of factors including duty schedules, sleep-wake cycles, workload, tasking, ship motion, nutrition and habitability issues such as noise, temperature and humidity on fatigue and performance and general well-being.

The outcome of the study, according to Elischer, “will allow Navy to develop strategies to minimise fatigue and performance issues that can be applied without compromising operational performance.”

“These strategies could include risk management systems, educational and training programs, policy guidelines for the management of fatigue and operational performance, and the development of decision-making tools for optimum deployment of crew,” he says.

# Taking a better look at Australia's remote boundaries

New generation high-altitude persistent surveillance systems can provide more extensive and sustained coverage of the nation's distant northern approaches, but there are technology issues to address first.

In recent times, concerns have been heightened about incursions by foreign craft into Australian waters for illegal fishing and people smuggling, undertaken in small hard-to-detect wooden vessels.

Maritime surveillance to date has primarily involved aircraft flying at low altitudes with their sensor systems looking out towards the horizon at low angles. Governments worldwide are now looking to take advantage of longer flying high-altitude systems, such as unmanned aerial vehicles (UAVs), new higher flying manned aircraft and even satellites, that will enable larger swathes of ocean to be searched at a time.

However, the higher operating altitude of these surveillance platforms involves a higher radar 'grazing angle' – a more vertical radar view – and the ability of radars under these conditions to detect vessels and, in particular smaller craft, is not well understood.

"To measure and understand radar performance," says DSTO researcher Rod Smith, "we need to characterise both the clutter or background environment as seen by radar, and the radar signature of the object we're interested in."

## Radar grazing angles and sea clutter

In May this year, DSTO undertook a maritime surveillance trial off the Northern Territory coast to investigate the performance of radars operating at high grazing angles.

During the 12-day trial, radar and video images were collected of confiscated illegal fishing vessels being towed or at anchor in Darwin and Gove Harbours. Radar sea clutter data were also obtained from several locations ranging from close to shore to further out in the Timor Sea.

The trial was carried out using the DSTO-developed Ingara multi-mode imaging radar, mounted on DSTO's Intelligence Surveillance and Reconnaissance Test Bed (ISRTB) aircraft along with the recently acquired L-3/Wescam MX-20 electro-optic video sensor.

"The Ingara multi-mode radar is a very capable and flexible system," says Smith, "allowing us to collect 360° high-resolution, fully polarimetric X-band radar data from a variety of grazing angles in a relatively short space of time. This is a unique Australian research capability."

DSTO personnel worked onboard the ISRTB aircraft to collect radar and MX-20 video data throughout the trial, amassing some 50 flying hours. At the same time, other members of the DSTO team worked on the target fishing vessels to gather ground-truth data complementing the airborne data being collected.

The ISRTB aircraft was operated by Raytheon Australia with Raytheon and Army pilots flying the aircraft.

Sea clutter statistics were gathered by DSTO on a hired fishing boat, taken at a number of sites over several days to measure the influence of variables such as radar frequency, grazing and azimuth angles, radar polarisation, resolution, wind vector and sea state.

The process involved the deployment of a wave buoy and associated radar calibration equipment at each of the sea clutter measurement sites. The multiple measurements obtained provided the widest possible data set on sea state conditions.

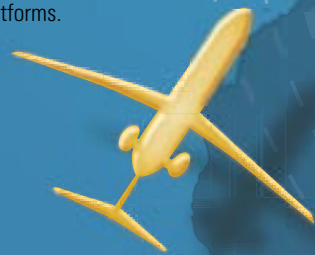
## Future developments

According to Smith, the trial was a major development in terms of the comprehensive nature of the data gathered. "It's the first time we've collected information about illegal fishing vessels to this degree of fidelity," he says.

The findings will be used for developing techniques and tools that can more accurately predict the ability of future radar systems, operating at higher grazing angles, to detect objects in various sea conditions.

Further investigations over the coming year will examine a wide range of issues associated with the detection of small vessels in the maritime environment.

The results will be presented to the Australian Defence Force (ADF) to inform its plans for future acquisitions. The work may be eventually applied on unmanned aerial vehicles, which are being considered as future maritime surveillance platforms.





*Confiscated illegal fishing boat at anchor in Darwin Harbour.*



*Radar target on board confiscated illegal fishing boat.*



*Wave rider buoy being loaded aboard vessel for deployment during radar surveillance trial.*

# Health check for tail rotor cables in helicopters

The life of a helicopter crew can hang from a cable and DSTO is working to ensure the cables remain in fine fettle.

The tail rotor control cables of a helicopter form an integral part of the aircraft's flight control mechanism, linking the pilot to the tail rotor blades. If the control cables fail during flight, the pilot no longer has directional control of the aircraft, with possibly catastrophic consequences for both the aircraft and crew.

The Navy Aviation Systems Program Office (NASPO) recently requested DSTO to conduct a review of the Royal Australian Navy's (RAN's) inspection procedures and allowable wear limits for the tail rotor cables used in their rotary wing aircraft.

This request was made to ascertain whether the cables are being maintained in accordance with the Original Equipment Manufacturer's (OEM's) specifications, as a follow-up to the recent identification of several unserviceable cables in operational aircraft.

NASPO is concerned that in-service cables may be suffering damage sufficient to render them unserviceable, but which cannot be detected by current visually-based inspection techniques.

## Study goals

The work being conducted has two primary goals, according to DSTO researcher Chris Dore.

"Firstly, the load-bearing ability of cables in various stages of wear is to be determined to provide further insight into the OEM-specified allowable wear criteria," he says. "A thorough understanding of cable capabilities will enable judgments to be made on the seriousness of the damage suffered by the cables."

"Secondly, the current inspection procedures used by the RAN will be assessed to identify where improvements can be implemented, and whether new techniques may assist in more accurately determining the physical condition of an in-service cable."

## Static strength testing

Addressing the first primary goal, a series of static strength tests are being conducted using a 100 kilo-newton tensile test machine located at DSTO's Fishermans Bend site.

The main objective of the testing is to determine the actual breaking strengths of cables in different states of wear, using the wear limits prescribed by the OEM as a baseline.

The data gained from the testing will be compared to the specified minimum breaking strength for the control cables. This will provide an understanding of the sensitivity of cable strength to wear and will identify the degree of conservatism incorporated into the cable wear limits by the OEM.

## Non-destructive testing

A series of non-destructive inspection tests is also being conducted by DSTO.

The technique used exploits a phenomenon known as the thermo-elastic effect, which involves subjecting a material to cyclic loading and capturing the thermal response with sensitive thermo-graphic equipment. This thermal response, determined by the particular properties and geometry of each specimen, provides a unique signature for that specimen.

The testing procedure is being developed using a commercially available infrared camera coupled with software developed at DSTO.

If variations can be detected in the thermal response of worn cables when compared to a pristine section, thus indicating damage, it may be possible to incorporate the technique into the inspection of in-service control cables.

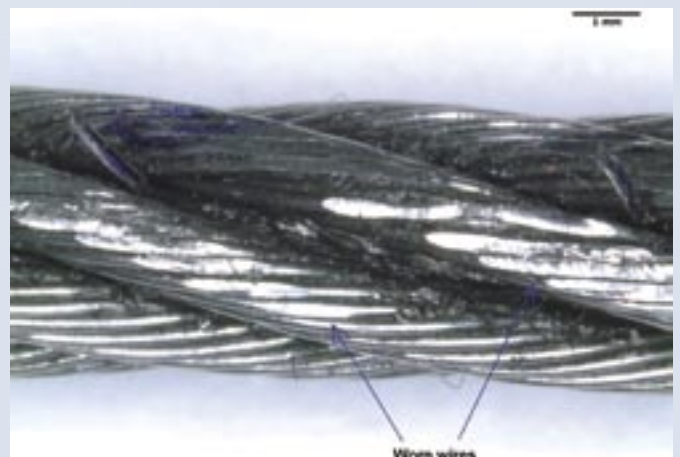
One of the potential advantages to be gained from applying this technique is the ability to identify worn and broken wires within the core of the cable. Such damage is undetectable by current procedures.

In addition to this testing, other techniques are being investigated to determine their applicability to the assessment of the structural condition of the tail rotor control cables.

## The end result

The work has received significant input and funding from the Rotary Wing Section of the Directorate General of Technical Airworthiness and the Naval Aviation Systems Program Office.

The testing overall will enable better management of these flight critical components through a greater understanding of the operational limits of the cables, and recommendations for improving current inspection techniques.



Close-up of tail rotor control cables showing damage.

### DSTO and ANSTO to collaborate on national security research



Roger Lough with David Cohen from ANSTO's Institute for Environmental Research

DSTO and the Australian Nuclear Science & Technology Organisation (ANSTO) have signed a Memorandum of Understanding (MOU) establishing a framework for collaborative activities in the fields of national security and defence. Chief Defence Scientist Dr Roger Lough and ANSTO Executive Director Mr Ian Smith signed the agreement in Sydney on 29 August.

ANSTO is the lead Commonwealth agency responsible for nuclear research and development, and the centre of Australian nuclear expertise. The MOU will span five years and allow both organisations to combine their skills and knowledge in fostering a long-term collaborative research program.

Initial cooperative activities covered by the MOU include the development of a national chemical, biological and radiological (CBR) training program, a miniature robotic platform with a compact sensor to detect radiological isotopes, a modelling system to forecast the extent of radiation exposure, and the detection of gamma-ray signatures that are unique to nuclear materials.

### Extended range for Joint Direct Attack Munition

DSTO, in conjunction with Hawker de Havilland of The Boeing Company, recently conducted successful initial testing of a smart bomb known as the Joint Direct Attack Munition Extended Range (JDAM-ER).

The JDAM-ER is a guided gliding bomb based on the Mk 82 500lb General Purpose munition, fitted with the Boeing GBU-38 JDAM global positioning system-aided tail kit. It also has a wing kit developed by Hawker de Havilland, using the Kerkanya gliding bomb technology developed by DSTO in the 1980s.

The tests were conducted at Woomera, South Australia, in mid August this year, to demonstrate the range and accuracy capabilities of the new JDAM-ER when deployed with the F/A-18 aircraft.

The development activity was conducted under the Capability & Technology Demonstrator (CTD) Program managed by DSTO. The trial proved that major range enhancements can be provided to existing JDAM Global Positioning System (GPS) Guided Bombs.

Consideration will now be given to further develop the wing kits to bring them to commercial production. If the wing kits prove to be commercially viable, there is likely to be significant Australian industry input in the required manufacturing activities.

### Missile Approach Warning System updates for ADF frontline aircraft

DSTO has provided advice and system design improvements on upgrades to improve Missile Approach Warning System (MAWS) capabilities for Australian Defence Force (ADF) aircraft being deployed in combat regions.

From May 2006 to July 2006, DSTO personnel visited Woomera and Townsville with teams from the Joint Electronic Warfare Operational Support Unit (JEWOSU), 16 Brigade (Army Aviation), 86 Wing and 92 Wing to conduct scientific and technical measurements to quantify and test the improvements.

First impression reports on all these trials have now been completed, with final reports also completed in one case. The results are being used to provide advice to Battle Worthiness Boards (BWBs) that are determining the suitability of various platforms for specific combat duties and operations.

# CALENDAR

- 5 - 9 Feb 2007      Complex Systems Beyond the Metaphor: Your Mathematical Toolset  
University of New South Wales, Sydney  
<http://www.maths.unsw.edu.au/complexity.html>
  
- 11 - 14 Feb 2007    Information, Decision and Control 2007  
Adelaide Hilton, Adelaide  
Contact: Keith Mason  
Tel: 08 8259 5354  
<http://www.plevin.com.au/idc2007>
  
- 14 - 16 Mar 2007    Human - Computer Interaction  
Chamonix, France  
<http://www.iasted.org/conferences/home-569.html>
  
- 20 - 22 Mar 2007    HUMS 2007 - Health and Usage Monitoring Conference  
Melbourne  
<http://www.dsto.defence.gov.au/events/3632/>
  
- 2 - 4 Apr 2007      Communications Systems and Networks (AsiaCSN 2007)  
Phuket, Thailand  
<http://www.iasted.org/conferences/home-561.html>
  
- 30 May - 1 Jun 2007 Antennas, Radar and Wave Propagation (ARP 2007)  
Montreal, Quebec, Canada  
<http://www.iasted.org/conferences/home-566.html>
  
- 24 - 28 Jun 2007    INCOSE 2007 - Seventeenth International Symposium of the  
International Council on Systems Engineering  
San Diego, California, USA  
<http://www.incose.org/symp2007/>
  
- 20 - 22 Aug 2007    Biomechanics (BioMech 2007)  
Honolulu, Hawaii, USA  
<http://www.iasted.org/conferences/home-580.html>
  
- 24 - 26 Sep 2007    Communication, Network and Information Security (CNIS07)  
UC Berkley, Berkley, California, USA  
<http://www.iasted.org/conferences/home-589.html>