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Good food guide to stay fighting fit

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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 2200 staff, including some 1300 researchers and engineers. It is one of the two largest research and development organisations in Australia.

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TopOwl for top guns

Night vision view of Army exercise with Black Hawk helicopter.

DSTO is investigating a new night vision system for Australian Defence Force (ADF) pilots as part of the introduction into service of the Tiger armed reconnaissance helicopter.

Despite the continuous improvement of night vision technology, flying at night is still a very demanding and hazardous exercise.

US Defence analysis of rotary wing accidents shows that these occur ten times more frequently at night than during the day. In the Australian context, the Board of Inquiry into the 1996 Black Hawk mid-air collision found that the use of night vision goggles contributed to the accident.

Explaining the shortfalls of this technology, DSTO researcher Dr Geoff Stuart says, "Night vision goggles do not simply turn night into day. The view they offer has restricted peripheral vision, no colour, and reduced visual acuity. As well as these limitations, the use of such aids can also increase the physiological stress load borne by the wearer."

TopOwl under study

The TopOwl night vision helmet, developed by international defence supplier Thales Avionique, is being introduced into service with the Tiger armed reconnaissance helicopter and with the MRH90 multi-role helicopter because it offers increased situational awareness, greater comfort and ease of operation over conventional night vision goggles. DSTO is assisting with the introduction by evaluating human visual performance when using the display.

One problem with conventional night vision goggle design is that the image intensifiers for these are mounted on the front of the pilot's helmet, requiring rear counterweights for balance that add to the strain placed on the pilot's neck. The TopOwl helmet by comparison, has its intensifiers mounted on either side of the helmet, eliminating the need for counterweights.

Test personnel in lab wearing TopOwl night vision helmet.

Another advantage of the TopOwl system is that the night vision imagery is projected onto the helmet faceplate where it can be integrated with flight symbology, meaning that the pilot can see the outside environment and monitor flight parameters at the same time.

However, there are concerns that the optical system for delivery of these combined views may be reducing the quality of the night vision imagery. This aspect of TopOwl's performance is a major focus of the studies being done by DSTO.

DSTO night vision lab

The work is being carried out in DSTO's state-of-art night vision laboratory at its Fishermans Bend site.

This facility was established after the Black Hawk incident in order to provide the ADF with ways of better understanding the use and limitations of available night vision technology. Designed by Dr Peter Gibbs, Mr Mike Spataro and Mr Fred Bird, the laboratory ofers a highly controlled environment in which moonlight and starlight conditions can be simulated.

During the most recent project undertaken there, Dr Stuart and Dr Gibbs, with assistance from students Sandra Lambeth and Ann Truong of Melbourne University, have been evaluating the image quality provided by the TopOwl helmet at various light levels.

The work has involved a detailed analysis of the optical characteristics of the TopOwl device, along with the visual performance of test subjects wearing TopOwl. In the process, the DSTO team has developed a novel night vision projection system that projects computer-generated imagery onto large display screens for simulation of night viewing conditions. This amenity was devised to enable a study of the ability of personnel equipped with TopOwl to see moving and briefly presented stimuli.

The results of the TopOwl research will be used to determine the safe operating envelope of the new generation helmet in order to minimise the risk of accidents during night operations.

PRISM gives clearer look at situational awareness picture

DSTO is working on an Electronic Support Measure (ESM) capability called the Passive Radar Identification System (PRISM) to provide better situational awareness information to military decision-makers.

PRISM is a field-deployed ESM facility used to collect information about aircraft movements by detecting microwave radar emissions via an omni-directional receive antenna, and displaying on screen the bearing line and radar characteristics of the signals.

The data collected by these Electronic Observation Posts (EOPs) is sent to a Regional Operations Centre (ROC) where it is correlated along with other data in a facility known as the WARDEN System into a situational awareness display called the Recognised Air Picture (RAP), which command and control teams use for decision-making.

Operation of the previous-generation PRISM system involved sending classified data from an EOP to a ROC by voice over a satellite communications network using code words, with this information transferred manually into the WARDEN System.

According to DSTO researcher Doug Carey, "DSTO personnel working on an Australian Defence Force exercise named Exercise Pitch Black in the late 1990s noted that this method was not only outmoded and cumbersome, but was also prone to errors during translation of the voice data at the ROC. They saw better ways of getting information between the remote EOP and the ROC than use of voice messages relayed across this 'air gap' by human operators."

Better bridges for air gaps

The solution they came up with involves a series of autonomous data processing functions carried out by a number of digital devices linked together.

The PRISM Control Unit (PCU) in the field that receives the radar signal information is interfaced with a ruggedised laptop computer called a PRISM Air Defence Interface Link (PADIL), which duplicates the information displayed on the PCU.

The PADIL delivers this information to a Tenix Speakeasy system that encrypts the data and provides modem functionality to upload it via a

PRISM system being deployed.

satellite communications link and a Defence Military Communications Network (DMCN) using the Public Switched Telephone Network.

At the ROC end, the data relayed by satellite is downloaded by another Speakeasy, which decrypts it for display on a PADIL, giving the exact same picture as seen by the RAAF operators in the field.

DSTO is continuing with this development work to devise a two-way keyboard chat capability between the two PADILs that improves on efficiency of system operations. The impetus for this development arises from the fact that communication between operators at the two facilities is occasionally required for management of the data transfer process, and this was previously carried out by voice over the system, which however, interrupts the ESM data flow. The two-way chat facility provides a way for operators to interact without such disruption.

DSTO is also working on eliminating the air gap between the ROC PADIL and the WARDEN System, making this transfer process more efficient and error proof. In addition, it has plans to investigate more reliable and robust encryption devices as well as the use of commercial satellite communications terminals.

Improved ease of deployment for EOPs

Along with these improvements in data transfer processes, DSTO and the Joint Electronic Warfare Operational Support Unit (JEWOSU) of Defence

PRISM fully deployed.

have developed a mobile field unit that enables PRISM EOPs to be deployed with greater speed and stealth.

The work, undertaken in support of exercise Pitch Black 06 (PB06) last year, involved modifying an Air Force FFR (Fitted For Radio) Land Rover F110 to house PRISM equipment. This vehicle plus the installed PRISM equipment became known as the Surveillance Network Integrated FFR (SNIFFR).

Deployment of the PRISM kit previously involved housing the various components in tents after transportation to the remote site. This required pitching tents and fitting them out with command post furnishings, siting of and securing the antenna mast, and setting up generators.

The development of SNIFFR enables PRISM equipment to be taken to the site ready for use inside the vehicle it is transported in.

Operators simply raise the antenna mast, which is connected to the vehicle itself, stabilise the vehicle using side-mounted jacks, and lower camouflage nets from the top of the vehicle. Power is provided from two 12-volt batteries in the vehicle to an inverter and made available through a distribution board as a 240-volt AC supply.

Quick success

A design requirement for the SNIFFR project was that the vehicle should not to be permanently modified in any way. In effect, this meant that equipment supports had to be bolted to the vehicle chassis, and mounts secured, using existing bolt-holes.

Despite this and other such engineering challenges, DSTO managed to complete the SNIFFR fit-out in basically just one week.

The advent of SNIFFR has brought significant gains in efficiency for deployment of the PRISM EOP, with a process that once involved the work of six men for half a day now being carried out by merely two men in around half an hour.

During the Pitch Black exercise, the SNIFFR EOP deployed as part of the exercise and supplied valuable data to the Northern Regional Operations Centre (NorthROC).

Commenting on the strategic worth of the work, Doug Carey says, “We believe that the ESM data provided by the PRISM equipment is a much under-valued resource within Defence. Our work with JEWOSU is not only aimed at developing a covert ESM capability, but is also about the demonstration of the value of the resultant data in the Recognised Air Picture.”

Smart way to ease stress **on aircraft tails**

High performance aircraft, especially those with twin vertical tails, encounter unsteady buffet loads during high-speed manoeuvres. This can lead to fatigue damage, a factor that limits the aircraft's performance capabilities and availability. DSTO is participating in a multi-national program to develop a system that actively opposes these destructive forces.

Twin vertical tail aircraft, such as the RAAF's F/A-18 Hornet, are often put under extreme buffet loading when they undergo a rapid change in direction or are required to sustain flight at what is known as a high angle of attack – a state in which the aircraft wings and fins travel at an oblique angle to the air rather than knife cleanly through it.

Under these conditions, vortices are generated at the leading edge of the wings and break down upstream of the empennage (tail section of fuselage) into a chaotic turbulent flow, causing the vertical tails and horizontal stabilators to shake violently.

DSTO researcher Dr Stephen Galea says this severe vibration response is known as buffeting. "The effect of vortices on the F/A-18's tail causes significant bending and twisting of the fins, subsequently inducing high stress levels in the root region of the fins. The oscillatory stresses and strains resulting on the rear of the aircraft are severe enough to cause eventual failure of this part of the airframe."

The problem has become a major research topic for countries which operate fleets of such aircraft. Emerging from a common interest in this issue in Australia, Canada and the United States, a joint research program has been mounted under the auspices of The Technical Cooperation Program (TTCP) and coordinated by the US Air Force Research Laboratory (AFRL).

According to Dr Galea, "The project is a truly unique collaborative venture in which we see the contributions of each of these countries merging to form a broad-ranging accumulation of technical knowledge and expertise for this one particular investigation."

Active vibration control

The approach taken towards alleviating the problem is to create counterforces that actively reduce buffeting stresses, using a combination of 'smart materials' and the aircraft rudders, in a technique known as active vibration control.

The smart materials (advanced directional piezoelectric actuators developed by NASA Langley Research Centre) are made from strips of piezoelectric material that contract or expand when voltage is applied to them. Piezoelectric devices of all kinds exploit the propensity of certain crystalline compounds to contract or expand slightly under the influence of an electric charge, or conversely, to produce an electric charge when compressed or extended.

The actuators, rectangles a few centimeters long and wide, and little more than a millimetre thick for a multilayer device, are fitted to the surface skin of the tail fins in a series of rows. The voltage supplied to them is controlled by computer software in response to buffeting vibration measured from accelerometer sensors on the tip of the fin.

Buffeting feedback is also used to simultaneously manipulate the aircraft's rudders to suppress vibrations. This aspect of the system serves to cancel out oscillations at lower frequencies than those damped by the piezoelectric devices.

1. Close-up of a piezoactuator.
2. F/A-18 tail fitted with piezoactuators for ground testing trials.
3. F/A-18 empennage undergoing vibration testing at DSTO Melbourne.

Effective stress alleviation research

Early research carried out by the TTCP established that piezoactuators are very effective in reducing the amount of fin twist caused by buffeting.

In the upper third portion of the fin where twisting causes high stresses, piezoactuators can be used effectively as a countermeasure because of the relatively low structural stiffness in this region. For the buffeting forces that bend the fin at its root, however, piezoactuators were found to have less impact due to the greater structural stiffness of the airframe, and manipulation of the rudder serves as a more effective countermeasure instead.

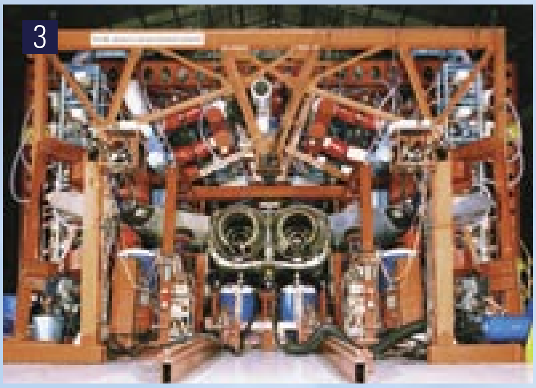
These findings were further studied in wind tunnel tests on a 1/6th scale model F/A-18 at NASA's Langley Research Center in Virginia, USA. In these tests the effectiveness of using the rudder and piezoactuators to control vibratory motions in different frequency bands was explored.

Dr Galea explains, "While this 10% figure may seem modest, previous analytical results have shown that a reduction in peak vibration stresses of this amount in the F/A-18 empennage would double the fatigue life of the fin structure."

Paving the way for in-flight testing

Commenting on the trial outcomes, Dr Galea says, "The full-scale ground test has demonstrated the capability and validity of the hybrid control system, using 'smart materials' and the aircraft rudder, to reduce buffet loads experienced by advanced fighter aircraft."

"The ground testing has validated many assumptions while putting many concerns to rest, specifically, the performance of the switch mode amplifier, a major component of the electronic control system. The system has demonstrated a level of performance sufficient to proceed with flight testing."



Following the scale model tests, a theoretical study was undertaken to establish a range of factors in preparation for full-scale ground tests of a blended rudder-piezoactuator system, including the desired number and position of the piezoactuators and peak power levels required. The theoretical study also showed that it was the oscillating inertial force caused by the back and forth rotation of the rudder – the force set up by moving this rudder mass from side to side – and not the oscillating aerodynamic force of the back and forth rotation of the rudder in the airflow, that reduced the bending stress on the fin.

The full-scale ground tests were carried out in late 2005 with an F/A-18 empennage at the International Follow-On Structural Test Program (IFOSTP) facility at DSTO Melbourne. The empennage was mounted in a test rig, incorporating both electrodynamic shakers and pneumatic actuators, with the capability of simulating the buffet and manoeuvre forces experienced in a range of flight conditions. The effects of testing were monitored and recorded throughout.

The findings of this work indicated that reductions in buffeting stress of greater than 70% were achievable using the blended rudder-piezoactuator active vibration control system for buffet excitation loads of about 40% of maximum. For maximum buffet conditions, reductions in peak vibration were calculated to be greater than 10%.

Aircraft research wins international award

Last November, Parliamentary Secretary to the Minister for Defence, Senator Sandy Macdonald, presented an international award for excellence in defence science to a group of DSTO researchers for their work in reducing buffeting and long-term structural damage in fighter aircraft.

The recipients included Dr Stephen Galea, Mr Donald Manokaran, Mr Keith Muller, Mr Ian Powlesland, Mr Carl Mouser and Dr Tom Ryall (posthumous). The award was presented as part of The Technical Cooperation Program (TTCP) in recognition of outstanding research projects undertaken collaboratively among the member countries USA, UK, Canada, New Zealand and Australia.

TTCP involves nearly 1,000 defence scientists from these countries with DSTO contributing to some 60 specialist areas of technology, allowing scientists to benchmark their work against the world's best. Each year, the TTCP countries recognise outstanding research projects undertaken collaboratively. A total of 7 TTCP awards were presented to DSTO researchers at last year's ceremony.

Protecting soldiers in the line of fire

For Australian Defence Force soldiers who go into harm's way in many arenas today, the main threats they face are posed by rifle fire and the impact of improvised explosive devices (IED). DSTO is looking at ways to improve on ballistic, blast and heat protection measures for individual combatants.

Cone deformations caused by impact of high velocity blunt objects on body armour vest.

A suit of combat body armour (CBA), consisting of a pack of ballistic resistance textile materials and a pair of hard plates, is designed to provide protection against strikes from fragments and a number of specified rifle bullet types in accordance with the National Institute of Justice (NIJ) standard.

While body armour offers a considerable degree of protection against penetrative injury from bullets, recent operational experience has shown that the impact of a high velocity blunt object can distend the back face of the protective materials into a sizeable cone-shaped deformation. Known as Behind Armour Blunt Trauma (BABT), this can result in a substantial body blow to the wearer. Although not usually fatal, injuries of the non-penetrating blunt trauma kind can have serious long-term health consequences.

Furthermore, another kind of explosive device increasingly deployed in conflict zones, called a thermobaric weapon, causes harm with the brutal shock wave and searing heat of a highly pervasive oxygen-depriving fireball that can asphyxiate, injure airways and air-containing organs, and inflict severe burns on unprotected skin. The body armour systems currently in use offer no protection against these hazards.

DSTO researcher Dr Bin Lee notes that "blast injuries and blunt trauma have in fact outstripped ballistic injury as a cause of fatalities for Coalition personnel in the current Iraq conflict."

Responding to these developments, DSTO is conducting research to test and evaluate current in-service protective equipment for effectiveness of protection, to determine ways of mitigating the BABT effect, and to provide blast and heat protective measures. As part of the research program, the effect of these protective ensembles on the physiological performance of the individual wearing them is also being addressed.

DSTO is working with several countries in The Technical Cooperation Program (TTCP) on research into Integrated Ballistic and Blast Protection for Warfighters.

Protection against the BABT effect

DSTO's work on reducing the energy transfer of non-penetrating projectile impact to the wearer involves developing a mathematical and physical model for predicting the force, energy and momentum transfer as a result of impact.

This research is complemented by impact tests on different kinds of energy absorbing materials and different designs of body armour to assess the effectiveness of particular configurations. Non-penetrating projectiles are fired at the test samples using fragment simulating projectiles (FSP) and pistol rounds.

Dr Lee observes that when developing measures to counter the BABT effect, there is a link between levels of protection offered by body armour and the operational efficiency of the wearer.

"A lighter weight CBA system with an equivalent or improved protection level against specific high speed projectiles would provide better operational capability, since the heavy weight of a body armour system imposes significant operational constraints on personnel who also have to carry essential equipment and munitions."

"However, the lighter the armour materials, the more likely it is that deformation of the back face of the body armour system will occur as a result of the impact of a ballistic projectile," he says.

Blast decoupling

Blast overpressure, the sudden momentary change in air pressure from extreme high to partial vacuum caused by the energy pulse of an explosion, can damage and even rupture air-containing organs in the human body such as the lungs, ears and gut.

The technology being developed to counter this hazard employs blast decoupling which acts to mitigate the impact of the blast shock wave on the human body, using materials in mismatching high and low acoustic impedance layers.

DSTO is undertaking research and development programs in this area on a number of fronts.

Tests are being conducted on blast decoupling materials using a shock tube that produces shock waves of pressurised air. Computer software predictive modelling tools are being used for the design of blast decoupling materials. The development of an integrated ballistic and blast protective armour system is also planned.

In conjunction with industry and university partners, advanced surrogate technologies to simulate humans are being developed for use in field testing. DSTO is undertaking test and evaluation trials using such surrogate test subjects, appropriately calibrated and instrumented to assess the protection effectiveness of various CBA and blast decoupling systems subjected to blast overpressure.

A further area of testing is on measures to protect against head injury. Concussion caused by non-penetration impact or blast can have severe adverse health effects in the long term.

A comparative study is under way into the effects of non-penetrating impact and blast overpressure on various protective helmet and face-eyewear systems. This study is being carried out with an anthropometrically calibrated crash dummy (known as a Hybrid III Head & Neck) widely used in the automobile industry.

Human factors studies on CBA systems

In addition to researching improvements for CBA materials, studies are being conducted on the stress levels for heat and exertion that using this type of protection entails for wearers, significantly affecting their performance on missions under harsh environmental and operational conditions.

DSTO is undertaking heat stress assessments and functional ergonomic assessment studies of the effect of various CBA systems to provide guidance for commanders on the use of modular CBA systems, and data for developing future armour systems.

Good food guide to stay fighting fit

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DSTO carries out research to ensure that Australian Defence Force (ADF) personnel on field service continue to be provided with ration packs that deliver nutrition as well as good taste.

DSTO Scottsdale in northern Tasmania has been conducting research on nutrition and food technology for ration pack development over the past 50 years, continuing the work of the founder of the Australian Army Catering Corps, Captain (later Brigadier Sir) Cedric Stanton Hicks who devised the first Australian Army ration pack in 1943.

Hicks, a university professor of physiology, used state-of-the-art 1940s science to maximise the nutritional quality of the Australian Military Forces Operation Ration. Before then, Australian soldiers had often been very poorly fed, and suffered substantial impairments to their health and military performance as a result. The pack developed by Hicks proved invaluable in sustaining Australian soldiers during the New Guinea campaign against the Japanese.

The ration packs available to ADF personnel today are considerably more efficacious, due to the many significant advances in food science and nutrition made over the last 60 years. As well as improving on the palatability and nutritional value of the foods included, the present-day packs come in a variety of eight menus to reduce monotony, unlike the sole menu on offer in the World War II ration pack.

Ascertaining nutritional requirements

One of DSTO's many achievements in the nutrition science field in recent years is to devise a way of accurately determining the nutritional requirements of ADF land forces on deployment.

This method, known as the doubly-labelled water (DLW) technique, enables the energy expenditure of free-living people – people engaged in normal daily activities rather than confined to laboratory conditions – to be determined to an accuracy of 5 to 7%.

By providing test personnel with water dosed with isotopes of deuterium and oxygen-18, both entirely harmless when ingested, the rates of elimination of these isotopes from the body can be monitored by mass spectrometry analysis of urine, sweat or saliva samples.

DSTO researcher Chris Forbes-Ewan explains, "Deuterium behaves in exactly the same way as hydrogen in the body, while oxygen-18 is a tracer for normal oxygen."

"Because hydrogen is lost from the body only as water, the elimination rate of deuterium is proportional to body water turnover. Oxygen, on the other hand, is lost as both water and carbon dioxide, so the elimination rate of oxygen-18 is proportional to the sum of body water turnover and carbon dioxide production."

"This means that the arithmetic difference in the elimination rates from the body of oxygen-18 and deuterium is proportional to carbon dioxide production, and hence to energy expenditure," he says.

The results obtained with soldiers in training or on land operations show that they expend about 15 megajoules per man per day during typical field exercises; this is about 20% to 25% more than the energy used by a typical relatively sedentary young Australian male. This then was the target figure chosen as the energy to be provided by ADF combat ration packs.

Other nutritional considerations

While energy is the first consideration when determining the nutritional criteria for ration packs, the macronutrient and micronutrient composition must also be appropriate for the levels and types of physical work being carried out.

1. Troops of the 2/33rd Australian Infantry Battalion examining the new field operational ration. New Guinea 1943. (Photo courtesy of Australian War Memorial.)
2. Combat ration pack in use today by ADF personnel.
3. Nutrition trial being conducted by DSTO.

When considering relative levels of protein, fat and carbohydrate, DSTO researchers turned to the principles of sports nutrition, and concluded that the contribution of each macronutrient to total energy should be 12% to 15% protein, 29% fat and 56% to 59% carbohydrate. The ration packs constituted along these lines are relatively high in carbohydrate and low in fat, in keeping with the known role of carbohydrate as the critical macronutrient for vigorous physical work.

To ensure that micronutrient requirements are met, several ration pack items have been fortified with vitamins and minerals. The ration chocolate is one such item, micronutrient-enriched with additional vitamin A, vitamin C and thiamine. The chocolate also differs from normal commercial kinds in that it does not melt at high temperature, ensuring ease of consumption even under very hot conditions. By including in the formulation some whey powder, derived from milk, the chocolate merely softens instead as the temperature rises.

In order to assess the outcomes of subsisting solely on these ration packs, the DSTO team has investigated the effects on military performance and immune status of soldiers taking part in short-term (10 days) and medium-term (23 days) field exercises.

The two studies conducted found no noticeable effect on military physical and cognitive performance, but there were indications of a decline in immune status – the ability to ward off infectious disease – and in blood levels of some vitamins.

Innovative foods and functional ingredients

Further to considerations of nutrient needs, the DSTO researchers take the view that ration packs should do more than simply provide adequate food of sufficient palatability.

Chris Forbes-Ewan says, “The advent of functional foods, such as yoghurts and other dairy-based foods that have beneficial bacteria added to them, means that we may now be able to use innovative foods or add functional ingredients to existing foods to improve specific aspects of health relevant to military performance.”

DSTO is carrying out research to identify probiotics – cultures of bacteria that have beneficial effects on gut function – that can be incorporated into ration pack foods. This, and related research, is being conducted collaboratively with the CSIRO as well as several universities.

Other current related research projects include the development of next-generation lightweight packs that will support short, high-intensity operations of up to 72 hours, and packs that are tailored to particular operational situations, such as those that are sustained for long periods or that take place in climatic extremes.

ADF combat ration packs

The combat ration packs developed by DSTO for use by ADF personnel today have improved on those developed by Captain Cedric Stanton Hicks in the early 1940s by providing a greater number and variety of items as well as improved nutritional and taste values.

The contents of a typical menu in today’s combat ration pack, catering for one man for one day, are listed below. Additional to the items in the changing day menu is a list of items in the second table that each ration pack contains every day.

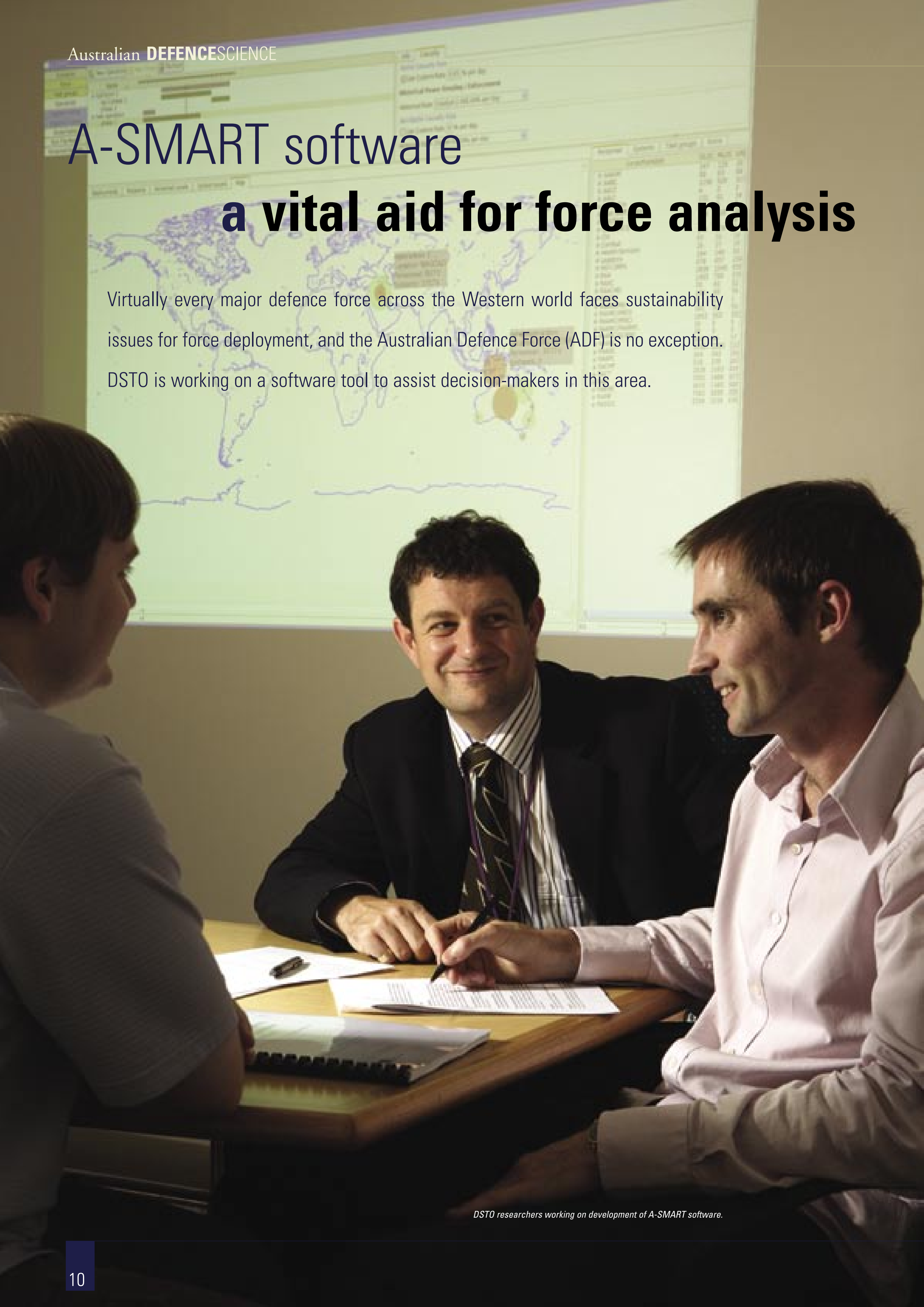
Chunky Chicken & Vegetables	*1 x 250 mL*
Beverage powder: Sport, lemon and lime	*1 x 12 g*
Biscuit: Brigadoon shortbread	*1 x 33 g*
Fruit Grains: Apricot	*1 x 15 g*
Muesli Bar: Apricot and Coconut	*1 x 32 g*
Muesli Bar: Forest Fruits	*1 x 32 g*
Chocolate: Ration	*1 x 50 g*
Spaghetti and Meatballs	*1 x 250 mL*
Beverage powder: Sport, orange	*1 x 12 g*
Chewing Gum: Juicy Fruit	*1 x pkt 4*
Fruit Spread: Peach	*1 x 26 g*
Sauce: Tomato ketchup	*1 x 15 g*
Confectionary: Cream chocolate	*1 x 50 g*
Freeze dried rice	*1 x 55 g*
Soup: low salt, chicken flavour	*1 x 30 g*
Sauce: chilli, sweet	*1 x 10 g*
Fruit: Peaches, diced, canned	*1 x 140 g*
Biscuit: Jam Sandwich Type 2	*1 x 45 g*
Candy: chocolate	*1 x 60 g*

Additional food items common to all 8 menus of the combat ration.

Beverage powder: Chocolate	*1 x 40 g*
Biscuit: Crispbread	*1 x 34 g*
Cheese: Cheddar	*1 x 56 g*
Milk: Condensed, sweetened	*1 x 85 g*
Beverage: Coffee, instant	*2 x 3.5 g*
Pepper: Black	*1 x 2 g*
Vegetable extract	*1 x 15 g*
Sugar	*8 x 7 g*
Beverage: Tea bags, pot	*2 x 2.5 g*
Candy: Hard	*2 x 30 g*
Muesli Bar: Tropical fruits	*1 x 32 g*
Salt	*1 x 2 g*

A-SMART software
a vital aid for force analysis

Virtually every major defence force across the Western world faces sustainability issues for force deployment, and the Australian Defence Force (ADF) is no exception. DSTO is working on a software tool to assist decision-makers in this area.



DSTO researchers working on development of A-SMART software.

With significant changes to the Army force structure planned as part of the implementation of the Hardened and Networked Army (HNA), and the anticipation that the current high operations tempo will continue into the foreseeable future, sustainability analysis tools are expected to become indispensable to ADF senior leaders.

Addressing this need, a small team of DSTO scientists led by Dr Robin Nicholson has worked for the last five years to develop such tools and conduct studies for sustainability analysis of Army force structures.

The research supports strategic decision-making by developing analysis techniques and software that assist the exploration of deployment options, force generation and the feasibility of proposed force structures.

The Army-Sustainability Modelling Analysis and Reporting Tool (A-SMART) being developed by DSTO, in its mature form, will use quantitative models to forecast the sustainability of a particular force structure, current or planned, to meet operational requirements.

Answers to a gamut of questions

According to DSTO researcher Dr Matthew Richmond, "The impetus for developing A-SMART came out of a need to assess Army's ability to sustain a brigade on extended operations and concurrently deploy a battalion group elsewhere, as set out in the 2000 White Paper.

"Analysis of a static snapshot of the Army provides some insight; however, to develop a quantitative understanding of how a proposed combat force would evolve over time (or in other words, its sustainability) dynamic modelling is required," he explains.

A-SMART is designed to provide answers to a number of questions, such as, 'What deployable options can Army provide and how long can they be provided?', 'How much is the deployment likely to cost?', 'What are the indicative resource requirements for the deployment?', 'If the operation is not sustainable, why not?', and 'What are the problem areas for personnel and equipment?'

The tool is designed to run rapidly so that 'what if' analyses of different options can be used as inputs into decision-making processes by Army.

A range of functionalities incorporated

The A-SMART model has design features that take into account a number of considerations.

The core model allows for flexibility of inputs and outputs; for example, to reflect the effects of changing policies, demographics and economics on recruitment and retention rates over time.

It enables modelling of force structure migrations, and hence, analysis of the introduction into service of major acquisitions under the Defence Capability Plan. It also enables investigation of issues associated with force expansion, for example, from the Army In Being to the HNA.

It includes a logistics and operational sustainment calculator to enable quick turnaround estimates of logistics and strategic lift requirements of different force structure and operational options.

Furthermore, the development of more detailed modelling allows for insights into individual training requirements and the generation of cost estimates for different operational scenarios.

In its early development stages the tool was first used to demonstrate and quantify the differences between two-rotation versus three-rotation policies. It has since been used to assess the sustainability of the HNA to support a Force Options Testing activity, and a study relating to rotation and respite policies.

It is also anticipated that the tool will be used to support Land projects; for example, to analyse the number of platforms required to underpin expected operational demands.

Progress to date

In November 2005, a Minor Capability Submission (Land) for about $1 million was approved in order to develop A-SMART as a full concept demonstrator and interim capability solution. This phase of development for A-SMART is planned to span 12 to 18 months, with the project having now progressed about half way through this phase.

The recent work of the A-SMART team has focused on integrating modules so that the first working version of the new tool suite can be demonstrated soon. Following this, the focus then will shift onto examining user interface issues and developing better operational costing models.

At the completion of the current phase of work, the feasibility of extending A-SMART to the Maritime, Air and Joint environments, as well as incorporating Coalition aspects will be examined. This would provide high-level decision-makers with a holistic view of the sustainability of the Australian Defence Force.

Another area to be investigated is optimisation. This ultimately will assist in designing a force structure that best meets government guidance, including the readiness posture of the force and the mix of full-time personnel with reservists, while minimising cost.

Cross-country collaboration for **command and control**

DSTO recently participated in a cross-country trial named Exercise Pozieres Development 2006 (Ex PD06) to study the operation of newly devised decision support tools and collaborative facilities.

Ex PD06 was a development-focused exercise involving a number of DSTO and military sites around Australia.

Two of three key sites were located in HQ 1 Div/Deployable Joint Force Headquarters (DJFHQ) in Brisbane, with the third being the Future Operations Centre Analysis Laboratory (FOCAL) in DSTO Edinburgh.

Also participating as observation points for the trial were the Effects Based Operations Planning Laboratory and LiveSpaces laboratories in DSTO Edinburgh and DSTO Fernhill in Canberra.

The exercise focused on key development areas identified by the HQ 1 Div/DJFHQ staff in conjunction with DSTO. They included collaborative planning in distributed and collocated environments; studies of complex systems and Centre of Gravity (COG) analysis; effects based planning and links between COG analysis and Course of Action Development; and developments in mapping, geospatial tools and concepts towards a commonly informed operating system.

Exercise infrastructure – LiveSpaces and Command TeamNets

DSTO's Command TeamNets constituted the foundation infrastructure for the exercise that enabled collaboration between locations and enhanced information sharing.

Exercise coordinator and Staff Officer (Science) at Headquarters 1st Division, Dr Glenn Moy explains, "Command TeamNets is a DSTO product that supports the development of future command and control (C2) decision-making capabilities by providing access to information for people spread across multiple geographically-dispersed locations."

"Command TeamNets is made up of a network of what are referred to as LiveSpaces – technologically advanced C2 rooms incorporating a range of DSTO technologies that enable collaboration and sharing of information across a room or across the country. During the exercise, the military staff at different sites could see and interact with each other, while geographically separated, as well as simultaneously share control of applications remotely and share common views of information across multiple sites," he says.

Both software and hardware capabilities were demonstrated in the course of the exercise, including touch-sensitive hardware platforms and associated methodologies for 'LiveSpaces in a box'; automated briefings and LiveSpace meta applications; screen forwarding, video switching and workstation input sharing; collaborative document generation; presence and messaging; and audio visual teleconferencing.

Emerging tools and processes

Working from this foundation base of collaborative technologies, a number of military-specific emerging tools and processes were also studied, demonstrated or discussed within the context of HQ 1 Div processes and the wider Defence context.

These applications support the intellectual processes of developing an operational plan under the Joint Military Appreciation Process (JMAP) and Joint Intelligence Preparation of the Battlespace (JIPB).

A range of DSTO software products was used by staff at Headquarters 1st Division for the military planning scenario under consideration. They included the JMAP Planning Tool (JPT), Centre of Gravity and Course of Action Scratchpads, Course of Action Scheduling Tool (COAST) and the Joint Seminar Wargaming Tool (JSWAT).

The exercise also provided an opportunity for developing an enhanced understanding of C2 evaluation and experimentation techniques.

In particular, a newly emerging technology, known as Teamscope, was used to support the capture and recording of events during the course of the week. Trials and demonstrations were captured on video media with analysts providing additional input using the Teamscope tool.

Demonstrations were also evaluated through a combination of observation techniques and user feedback. The feedback aspect was carried out with online survey questions for each demonstration. It was aimed at stimulating further development of command support system concept demonstrators and to help in the articulation of a living roadmap for a C2 system.

Above: DSTO and ADF personnel using LiveSpaces equipment during ExPD06.

Australian-US collaboration on hypersonics research

DSTO and the US Air Force have signed a US$54 million dollar agreement to carry out research into flight at speeds five times greater than the speed of sound.

The project was launched in Canberra recently by Australia's Chief Defence Scientist, Dr Roger Lough, and visiting Chief Scientist of the US Air Force, Dr Mark Lewis.

The Hypersonic International Flight Research Experimentation (HIFiRE) project, an eight year program, is one of the largest collaborative ventures to be undertaken by the two nations. In the course of the project, up to ten hypersonic flight experiments will be conducted at Woomera in South Australia over the next five years.

DSTO will undertake the lead role with the involvement of key personnel from The University of Queensland and the University of New South Wales at the Australian Defence Force Academy. US participation will include input by the US Air Force Research Laboratory, with contributions from NASA, US industry and US universities.

At the signing ceremony (L-R): Dr Warren Harch (Chief Weapons Systems Division, DSTO), Dr Roger Lough (Chief Defence Scientist), Dr Mark Lewis (Chief Scientist, US Air Force) and Mr Douglas Bowers (Associate Director, Air Vehicles Directorate, US Air Force Research Laboratories).

Hypersonic flight, powered by reusable air breathing propulsion systems, offers a means of low-cost high-speed transport of people and equipment across the globe, and for delivery of low-orbit payloads into space. A wide range of defence and civilian uses has been envisioned for this technology.

Australia's research credentials in hypersonics include an extensive team of experienced researchers along with state-of-the-art equipment for simulating velocities up to 50 times the speed of sound.

DSTO's MiniSec and Button secure transmission devices put on show

DSTO researchers Chris North and Dr Duncan Grove used their presence at the second Australian Internet Protocol Version 6 (IPv6) Summit in Canberra last December to publicly demonstrate DSTO's Annex technology, a platform for Multi Level Secure (MLS) communication and information processing.

Using prototype MiniSec and Button devices, they made 'classified' Voice Over Internet Protocol (VoIP) calls and conference calls with participants based at DSTO Edinburgh, although no actual classified data was exchanged. All voice traffic and call signalling was encrypted by custom security hardware, transmitted over an 802.11i link into the conference network, and routed between Canberra and Adelaide using native Mobile IPv6 via AARNET. The system was also demonstrated through an IPv6 tunnel over Telstra's 1xEVDO 3G service obviating the need for wired infrastructure.

Individual demonstrations were given to about thirty attendees, including several high-profile delegates from the Australian and US defence sectors, and Australian telecommunications service providers, generating strong interest in the technology.

DSTO achieves world record anti-missile laser power

Researchers at DSTO and the University of Sydney have developed a fibre laser that has exceeded previously published power levels for such devices by almost an order of magnitude, and at the same time has set new efficiency records.

The device emits in the 2 micron spectral range, making it useful as a jammer source against heat-seeking missiles.

As reported in the February 1, 2007 issue of Optics Letters (pg 241), these results were obtained from a holmium-doped fibre sensitised by special co-doping. The laser produced 83 watts with almost perfect beam quality and a 42% optical efficiency when pumped using standard near-infrared diode bars.

Traditional systems based on solid state lasers for use as infrared jammer sources usually emit at shorter wavelengths, needing more frequency conversion stages to transfer the energy to the hard-to-reach mid-infrared spectral band, making them complex, expensive and power-hungry.

The demonstration of such a simple and efficient technique is a significant advance towards development of a new class of smaller, lighter, cheaper and more powerful mid-infrared sources crucial to applications such as infrared-guided missile countermeasures for aircraft protection.

Other applications that could benefit from this work include eyesafe remote sensing, eyesafe laser cutting and welding for industry, and uses in medical procedures such as surgery.

CALENDAR

20 - 22 Mar 2007	HUMS 2007 - Health and Usage Monitoring Conference Grand Hyatt Hotel, Melbourne http://www.dsto.defence.gov.au/events/3632/
20 - 25 Mar 2007	Australian International Airshow 2007 Avalon Airport, Victoria http://www.airshow.net.au/
26 - 27 Mar 2007	Simulation in the Human Domain DSTO Fishermans Bend Melbourne Contact: Michael Ling Tel: 03 9626 7994 Email: michael.ling@dsto.defence.gov.au
9 May 2007	Radar and Industry Workshop 2007 Scott Alison Theatre DSTO Edinburgh, South Australia Contact: Stephen Mills Tel: 08 825 97251 Email: stephen.mills@dsto.defence.gov.au
4 - 7 Jun 2007	SimTecT 2007 Simulation Conference and Exhibition Brisbane Convention Centre, Brisbane www.siaa.asn.au/simtect/2007/2007.htm
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/
15 - 26 Aug 2007	Australian Science Festival Canberra http://www.sciencefestival.com.au
25 - 26 Sep 2007	SETE 2007 (Systems Engineering Test and Evaluation) Conference Sydney http://www.sesa.org.au/
22 - 26 Oct 2007	Land Warfare Conference Convention Centre, Adelaide Tel: 08 8259 6719 Email: vinod.puri@dsto.defence.gov.au
20 - 22 Nov 2007	MilCIS 2007 National Convention Centre, Canberra http://www.milcis.com.au/

ADS14/2-012/2006 Cover image: Test personnel in lab wearing TopOwl night vision helmet.