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Department of Defence
Science and Technology

ANNUAL REVIEW

2016–17

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Front cover
Geoff Day, Nicola Bilton and Vladimir Devrelis in the underground laser test facility at DST Edinburgh.

Back cover
Angela Consoli (pictured left) and DST's Future Integrated Mission System team.

Inside back cover
DST and Ron Allum Deep Sea Systems are building Australia's first high-performance underwater glider.

Contents page
Algora Group showing Diversity in DST.
Front: Ana Novak, Vivian Nguyen.
Back: Mina Shokr, Kristan Pash, Terrence Caelli.

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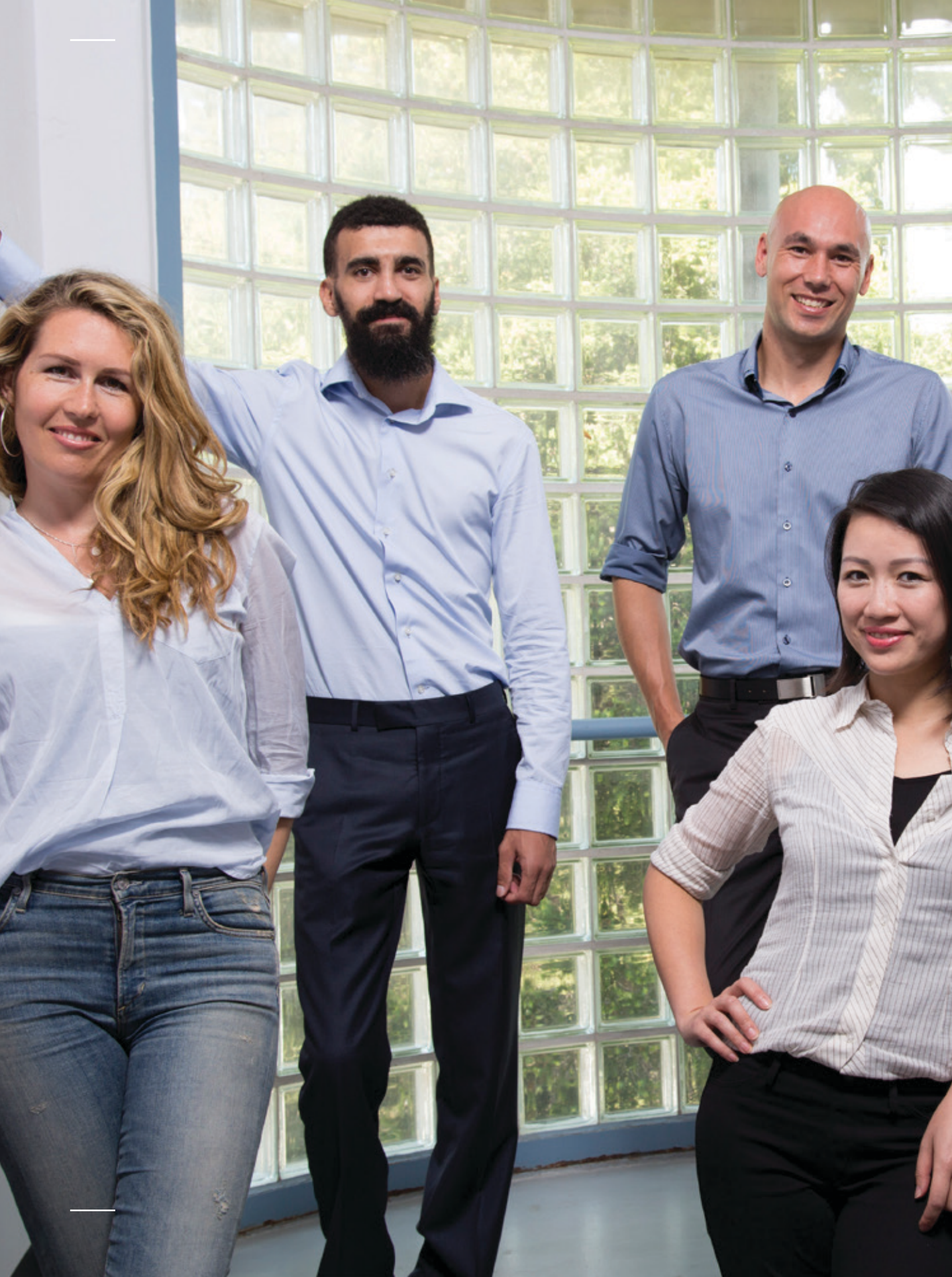

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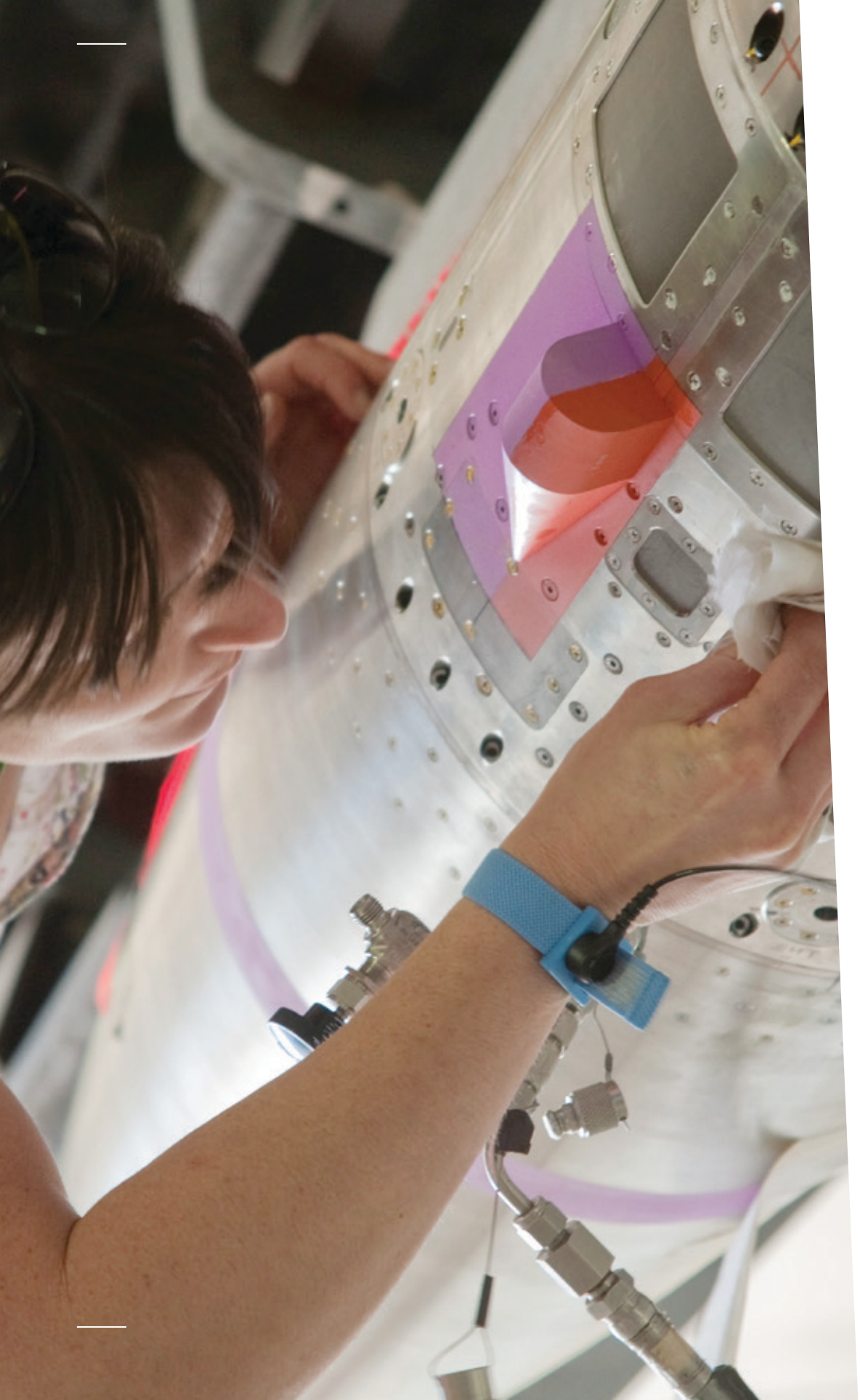


OVERVIEW FROM THE CHIEF DEFENCE SCIENTIST

The year 2016-17 was dominated by our efforts to implement the $730 million Next Generation Technologies Fund established by Defence to develop game-changing capabilities in collaboration with industry and academia.

This flagship program was formally launched by the Minister for Defence Industry Christopher Pyne in March 2017, following significant preparatory work and has since gathered a full head of steam, with $16.3 million being invested to 30 June 2017. The supported initiatives include Grand Challenges, Defence Cooperative Research Centres, Small Business Innovation Research for Defence, university research networks, strategic research, technology foresighting and participation in accelerators.

One of the first and largest of these initiatives is the Grand Challenges program which attracted more than 200 submissions in response to a call for proposals to counter improvised threats. Thirteen proposals, valued at $19 million, are to be funded for universities and industry to develop prototype and threat detection and defeat systems.

A Defence Cooperative Research Centre (CRC) for Trusted Autonomous Systems is also being established with an investment of $50 million over seven years. This proven model for research collaboration will be mission driven with an outcomes focus, led by Defence and delivered by industry to develop robotic systems that can be trusted to operate effectively in dynamic environments. The CRC is expected to be incorporated as a limited liability company by the end of 2017 under the chairmanship of Mr Jim McDowell, former CEO of BAE Systems.

To increase participation by small business in Defence capability, a targeted program is being rolled out with an investment of $10 million over the ten-year life of the Next Generation Technologies Fund. The Small Business Innovation Research for Defence is a two-stage program allowing Small to Medium Enterprises (SMEs) to establish a proof-of-concept for a Defence application and subsequently testing it in a laboratory setting.

New and expanded research networks are being established with universities under the Next Generation

Technologies Fund to collaborate on topics relevant to the development of future Defence capabilities. Following the success of the Defence Science Institute in Victoria, two new state-based research networks were established during the year – the Defence Innovation Partnership in South Australia and the Defence Innovation Network in NSW.

Twenty-two Australian universities recently received $5.7 million for submitting 59 successful early research projects addressing priorities under the Next Generation Technologies Fund. These projects were selected from a strong field of 428 proposals from 31 universities.

Australian universities were also given the opportunity to receive funding under the Next Generation Technologies Fund to join the US Department of Defense's long-standing program called the Multidisciplinary University Research Initiative or MURI. Eligible universities that are successful in a collaborative US MURI submission will receive a grant of $1 million per year for three years to support their research on topics of interest to Defence. The first successful proposal will be announced during December 2017.

We continued to build momentum in our program of Technology Foresighting to monitor global trends and emerging futures that will impact Defence capability. The program involves hosting a series of high-level seminars in partnership with industry and universities on Defence's priority research areas such as information, knowledge and digital disruption, and advanced materials and manufacturing.

Cyber and quantum technologies are two strategic research initiatives that mirror the priority technology areas identified under the Next Generation Technologies Fund. With CSIRO/Data61 we began a cyber research program across four technical themes and involving eight tertiary institutions. For quantum technologies, six research projects with nine national centres of expertise have been scoped and targeted for commencement in the areas of computing, communications and quantum sensors.

In 2016–17 we completed the fourth year of the five-year Defence Science and Technology Strategic Plan. This Annual Review documents our progress with the implementation of the plan and the ten strategic initiatives. We have delivered significant parts of our Strategic Plan and we will seek to wrap up delivery of the plan by December 2017.

During the year, as part of the Scientific Excellence initiative of the Strategic Plan, the external benchmarking of Major Science and Technology Capabilities continued. By 1 July 2017, 25 of the 37 capabilities had been externally benchmarked since the review program began in 2014. Of the 25, nine capabilities have been rated as world class in 2017 and eight have been judged as world leading. External benchmarking of the remaining twelve MSTCs will be completed by the end of 2017.

Client satisfaction surveys are a key indicator of our ability to deliver outcomes for Defence. The desk officer survey in March 2017 shows the level of satisfaction with DST performance remains high at 92%.

Our scientists continued to provide practical solutions to Defence personnel on operations. These included a simulation study on the implications of the Mosul Dam failure in Iraq to assist in preparing contingency evacuation plans, a vibration analysis to return grounded P-3 Orion maritime patrol aircraft to service for a critical operation, determining safe flight envelopes for helicopters arriving and departing from landing helicopter dock vessels, and protecting soldiers from toxic smoke emanating from a sulphur plant fire near Mosul by modelling the trail of the plume.

It was wonderful to see our people being recognised for their achievements. Darryn Smart received the prestigious Clunies Ross Knowledge Commercialisation Award from the Australian Academy of Technology and Engineering for developing the Redwing suite of equipment that protects against improvised explosive devices. Our cyber experts led by Suneel Randhawa, Mark Beaumont and Chris North were recognised with two awards from the National Information Industry Association for the Cross Domain Desktop Compositor which allows content of different classifications from multiple computers to be viewed securely on a single screen. The Military Operations Research Society in the US presented our operations research analysts, Denis Shine and Nicholas Kempt, with the David Rist Prize – the first ever for a non-US team – for their study on coastal environments for Defence.

These well-deserved achievements reflected the strong emphasis in the organisation on fostering a culture of innovation. For the second year running, an Innovation Day (now called DSTrupt Day) was staged for participation by all staff, a Hacking for Defence seminar was organised with world-renowned innovation guru Steve Blank from Stanford University, and a joint challenge between Australian and UK defence scientists called S&T Ashes or STASHES was staged to solve a future technology problem, which has opened up a new avenue for research for both DST and Dstl (UK).

Partnerships and collaboration featured prominently in the year's external engagement activities, with more than 400 delegates participating in the third Partnerships Week, now a sought-after event in the Defence industry calendar. Technology pitches continued to be a drawcard at defence industry events like the Avalon Air Show. Collaboration agreements were signed with DefendTex, Sonar Atlas, Grollo Aerospace and Chemring Australia while a number of technologies were licensed to LRM Technologies and Precise Advanced Manufacturing Group.

New project arrangements were initiated with our Strategic Alliance partners ASC, BAE Systems, Lockheed Martin, Qinetiq and Thales. Significantly, Defence spun out its first company, Silentium Defence, with two of our scientists James Palmer and Simon Palumbo participating in the CSIRO/ON-Prime accelerator program to commercialise the innovative passive radar technology developed by DST. The company aims to supply high-technology products to Defence as well as market them overseas.

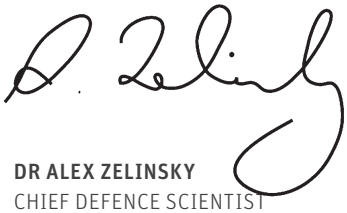
Under our Defence science partnerships with Australia's 33 universities, we signed 348 agreements with a value of $34.9 million, compared to $20 million the previous financial year. We expect this number to grow to over $50 million in 2017–18.

On the international front we continued to work closely with our traditional five-eyes allies on outcome-focused joint projects while strengthening relations with Japan, South Korea, Singapore, India and Indonesia. A recent highlight of the Japanese engagement was the successful staging of the Australia-Japan Multi Function Technology Symposium during the Pacific 2017 event in Sydney, aimed at involving Australian universities in joint research projects with Japan.

As part of our efforts to improve diversity, career development and promotion of science, technology engineering and mathematics (STEM), we awarded a record number of 21 STEM cadetships and increased the number of student placements to 68 during the year. A recent agreement with the Australian Mathematics and Science Institute will see up to 100 PhD interns join DST for 4–6 month secondments over a period of four years.

The year has seen a new DST Leadership Team (DLT) take shape with the promotion of senior scientists, Dr Lynn Booth, Dr Dale Lambert, Dr Richard Davis and Dr Mike Davies to the chief's position in four divisions and the appointment of external chiefs, Dr Ian Dagley, Dr Dong Yang Wu and Dr Andrew Seedhouse in three divisions. This new team now has the challenge of driving Defence's future science and technology program as we roll out the remaining initiatives in the Next Generation Technologies Fund. Our new DLT will work with colleagues both in Defence and outside Defence to set the agenda for the Strategic Plan 2018–2023.

I have every confidence that this team will lead the organisation successfully in the next phase of our journey – with the support of all DST staff in collaboration with the ADF and our external partners in industry and academia.



DR ALEX ZELINSKY
CHIEF DEFENCE SCIENTIST

MAJOR HIGHLIGHTS

Next Generation Technologies Fund being launched by the Hon Christopher Pyne MP Minister for Defence Industry.

LAUNCH OF NEXT GENERATION TECHNOLOGIES FUND

The Minister for Defence Industry formally inaugurated the Next Generation Technologies Fund under which the first Grand Challenge to defeat improvised threats, and the first Defence Cooperative Research Centre for Trusted Autonomous Systems were launched along with a number of smaller initiatives.

TECHNICAL BENCHMARKING OF MAJOR SCIENCE AND TECHNOLOGY CAPABILITIES

DST undertook a third round of Major Science and Technology Capability benchmarking during 2016–17 and seven capabilities were also externally benchmarked. By 1 July 2017, a total of 25 had been externally benchmarked since benchmarking began.

CLIENT SURVEY OUTCOMES

The annual desk officer survey, completed in March 2017, showed 92 percent of respondents were satisfied with DST performance – the same as in 2015–16, indicating that overall, DST's science and technology (S&T) support is meeting the needs of Defence. Many DST staff were praised by name or by work area for the support they gave clients.

RAAF F/A-18 Hornet.

SAVINGS IN F/A-18 HORNET WING REPLACEMENT COSTS

The Hornet Outer Wing Static Test program has confirmed that the outer wing of the Royal Australian Air Force's (RAAF) F/A-18 Hornets will not require refurbishment prior to the planned withdrawal date, saving about $300,000 per wing in refurbishment costs and increased aircraft availability.

PROTECTING DEPLOYED ADF SOLDIERS AGAINST TOXIC SMOKE

DST's Chemical Biological Radiological and Nuclear Effects modelling team assisted ADF commanders in Iraq by responding within hours to a request for advice on ways to protect personnel against noxious smoke from a sulphur plant fire caused by Islamic State activities.

CONFORMAL ANTENNAS FOR MICRO AIR VEHICLES

Antennas for micro air vehicles were developed to enable them to sense their surrounds using radar rather than light-based lidar. This allows them to operate in conditions when large amounts of airborne particles, which impair lidar performance, are prevalent.

DOMAIN S&T STRATEGIES

For the first time, DST published a set of long-term Defence Science and Technology Strategies for the Maritime, Land, Aerospace, Joint and Intelligence domains, agreed with the respective Services and Groups. The Domain Strategies are a key element in DST's strategy-led investment decision-making process.

DST and Navy personnel undertaking a Sky Kraken human-in-the-loop simulated exercise.

SKY KRAKEN STUDY FOR ENHANCED ROYAL AUSTRALIAN NAVY CAPABILITIES

A two-week human-in-the-loop experimentation program investigated ways of stationing unmanned aerial systems operators on board Royal Australian Navy vessels, thereby assisting the integration of these systems into vessel capabilities.

RAPID DELIVERY MISSION-SPECIFIC CAMOUFLAGE

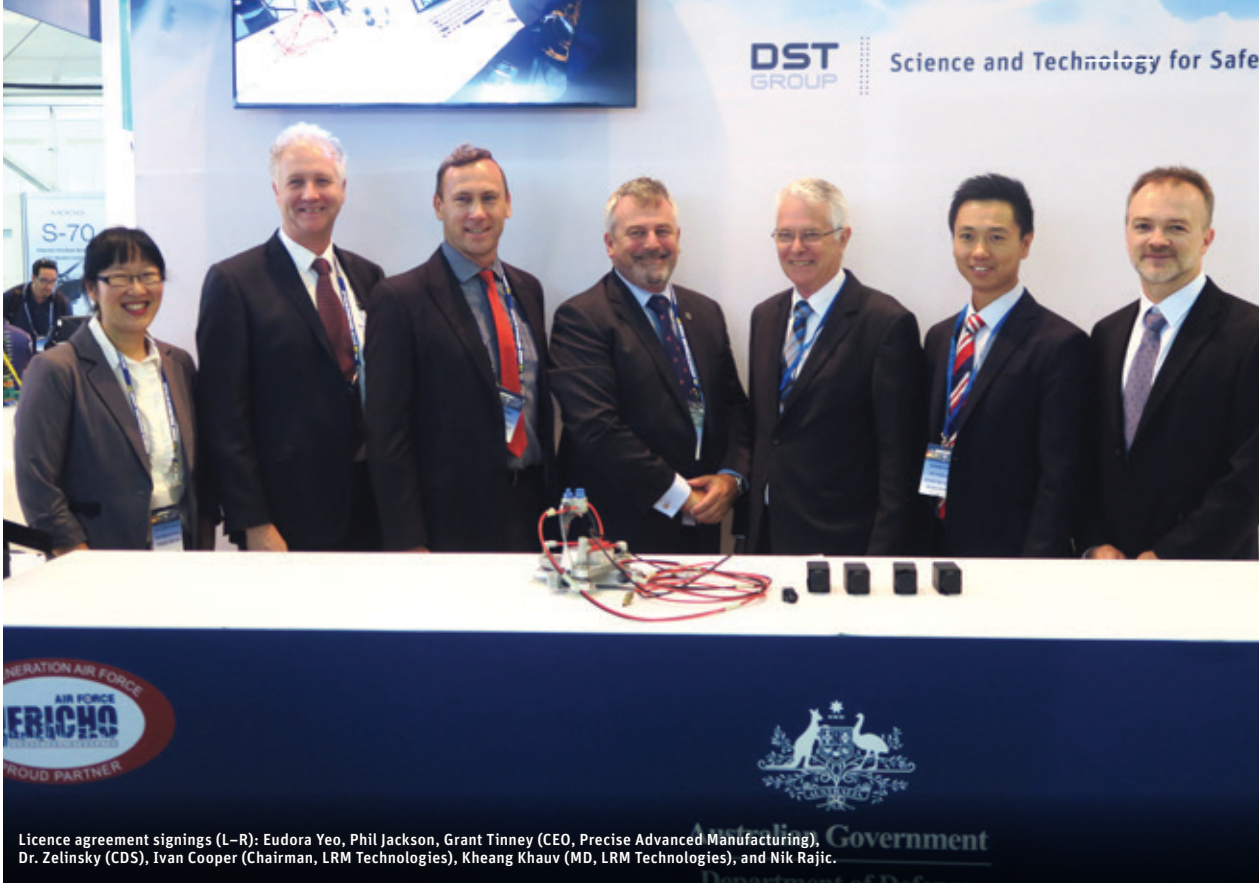
Scientists developed a capability for rapidly transforming photo images of terrain into camouflaged products that blend highly effectively with the terrain photographed, requiring just 15 working days to complete five camouflage combat uniforms and ensembles.

NANOFIBRE DERMAL PROTECTION

DST, working with the Defence Materials Technology Centre, developed a nanofibre composite material with improved dermal protection against aerosol threats. The material, also being air permeable, will enable the production of protective ensembles that shed body heat.

HIFIRE 4 HYPERSONIC FLIGHT TRIAL

The Hypersonic International Flight Research Experiment (HIFiRE) program conducted another experimental flight that successfully tested the complex avionics and flight systems needed to control the flight vehicle.



Licence agreement signings (L–R): Eudora Yeo, Phil Jackson, Grant Tinney (CEO, Precise Advanced Manufacturing), Dr. Zelinsky (CDS), Ivan Cooper (Chairman, LRM Technologies), Kheang Khauv (MD, LRM Technologies), and Nik Rajic.

TECHNOLOGY TRANSFER

Two technologies developed by DST were licensed to industry for production and sale worldwide. The breakthrough microbolometer thermoelastic stress measurement system that captures images of stress in structures was licensed to LRM Technologies. The hole rework alignment tool which improves the speed and accuracy of repairs to fatigue damaged aircraft structures was licensed to Precise Advanced Manufacturing Group.

NATIONAL SECURITY COORDINATION COMMITTEE

A National Security Science and Technology Inter-Departmental Committee co-chaired by DST and the Department of Prime Minister & Cabinet was established to steer the national security science and technology program and provide governance.

ADDITIVE REPAIR AND STRENGTHENING OF AIRCRAFT COMPONENTS

DST, in conjunction with RMIT University and industry partners, developed a laser-based additive manufacturing repair technology that can remediate aircraft components affected by corrosion, wear and fatigue cracking.

ADVANCED VISUALISATION FOR OPERATIONS ANALYSIS

DST explored the application of virtual and augmented reality technologies to operations analysis, which, when combined with other data analysis techniques, are expected to have a transformative effect on the levels of understanding that can be drawn from simulations.

VISION-AIDED NAVIGATION

DST researchers, in collaboration with their partners in the United States (US), developed an unmanned aerial system flight capability with closed-loop vision-aided navigation that successfully managed to complete a 100-kilometre flight over sparse terrain with few significant landmark features.

1

OUR ORGANISATION

ABOUT US

Defence Science and Technology (DST) is Australia's second-largest publicly funded research organisation. It is part of the Department of Defence and provides the Australian Government with scientific advice and innovative technologies to meet Australia's Defence and national security challenges.

Headed by the Chief Defence Scientist, Dr Alex Zelinsky, DST had a budget of $438 million for the 2016–17 year and employed 2,100 staff, predominantly scientists, engineers, IT specialists and technicians.

DST's diverse, professional and specialised staff members work in offices, laboratories, test facilities, weapons ranges and operational theatres. DST staff are located in nearly every state and territory in Australia. Internationally, DST has liaison offices in Washington DC, London and Tokyo, and research scientists located around the world, working on postings, exchanges, fellowships and joint research projects. A small number of DST personnel operate in the Middle East, providing direct support to Australian military operations.

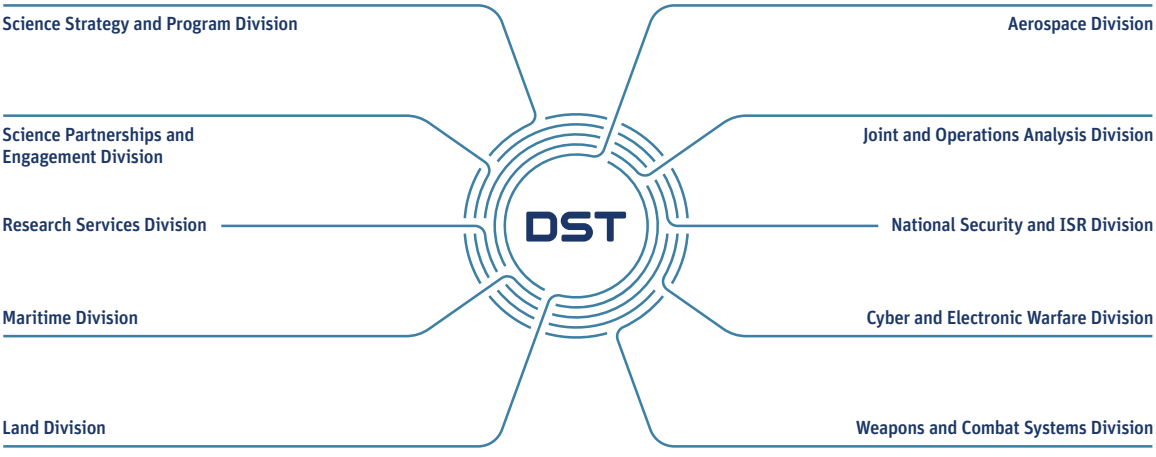
DST provides a work experience that is both challenging and career-developing and treats a safe, healthy and secure working environment as a key priority.

PURPOSE

DST is a national leader in safeguarding Australia by delivering valued scientific advice and innovative technology solutions for Defence and national security. It delivers its mission through seven research divisions and three corporate divisions.

VISION

DST aims to be a world leader in Defence science and technology – indispensable in supporting and transforming Australia's Defence and national security.



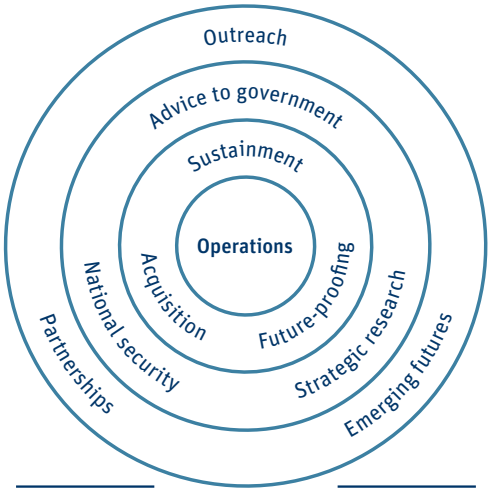
OUR ROLES

DST's core roles are focused on supporting Australian troops on the ground, sustaining and enhancing existing Defence capabilities, ensuring Defence is a smart buyer of military equipment and future-proofing Defence to ensure that the Australian Defence Force can meet future challenges.

DST has a role in providing expert, impartial advice to Government on Defence and national security matters as well as coordinating the delivery of whole-of-government science and technology support for national security.

As a science and technology organisation, DST conducts strategic research to identify high-impact areas for Defence and monitor emerging technologies to assess their potential impact on Defence capability.

Underlying all of its activities is an increased emphasis on external engagement and collaboration. This includes taking a stronger role in knowledge and innovation integration, strengthened through partnerships with industry and academia.



DST Group enablers

Technical services

Science and Technology training and development

Business services

CORE

OPERATIONS

Supporting operational capability with science and technology expertise.

SUSTAINMENT

Providing support to Defence to sustain and enhance current capability.

ACQUISITION

Providing support throughout the genesis, development, acquisition and introduction into service of major capability projects.

FUTURE-PROOFING

Investigating client-focused future concepts, contexts and capability.

EXTENDED CORE

ADVICE TO GOVERNMENT

Shaping Defence and national security strategic policy through expert and impartial advice.

NATIONAL SECURITY

Leading the coordination and delivery of science and technology to enhance whole-of-government national security.

STRATEGIC RESEARCH

Conducting research into high-impact areas for future Defence capability.

SUPPORTING

EMERGING FUTURES

Scanning the environment to gain an understanding of emerging science and technology threats and opportunities.

PARTNERSHIPS

Enhancing impact by collaborating with research and industry partners, nationally and globally.

OUTREACH

Promoting defence science and education in the broader Australian community.

DST LEADERSHIP TEAM

AS AT 30 JUNE 2017

DR ALEX ZELINSKY

Chief Defence Scientist

CORPORATE DIVISIONS

DR JANIS COCKING

Chief of Science Strategy and Program Division

DR MARK PETRUSMA

Acting Chief of Science Partnerships and Engagement Division

DR MIKE DAVIES

Chief of Science and Technology Program

MR PETER LAMBERT

Chief of Research Services Division

RESEARCH DIVISIONS

DR DAVID KERSHAW

Chief of Maritime Division

DR PETER SHOUBRIDGE

Chief of Land Division

DR PETER FRITH

Acting Chief of
Aerospace Division

DR LYNN BOOTH

Chief of Joint and Operations
Analysis Division

DR PHIL STIMSON

Acting Chief of National Security
and ISR Division

DR DALE LAMBERT

Chief of Cyber and Electronic
Warfare Division

DR RICHARD DAVIS

Chief Technology Officer
National Security

MR BRIAN REID

Acting Chief of Weapons and
Combat Systems Division

OUR VALUES

DST values guide behaviour and decision-making, and help to demonstrate the attitudes and actions for organisational success.

EXCELLENCE IN SCIENCE
We strive to lead, and take pride in, all our scientific undertakings.

INTEGRITY
We are trustworthy and honourable in all our interactions.

PEOPLE
We develop and support each other to achieve organisational deliverables in a safe environment.

COURAGE
We act with strength of character, both in the courage of our convictions and in our intellectual courage.

PROFESSIONALISM
We strive for excellence in everything we do.

INNOVATION
We actively and consistently look for better ways of doing business.

LOYALTY
We are committed to each other, our leaders and the organisation.

TEAMWORK
We work together with trust, respect and a sense of collective purpose.

IMPLEMENTATION OF THE STRATEGIC PLAN

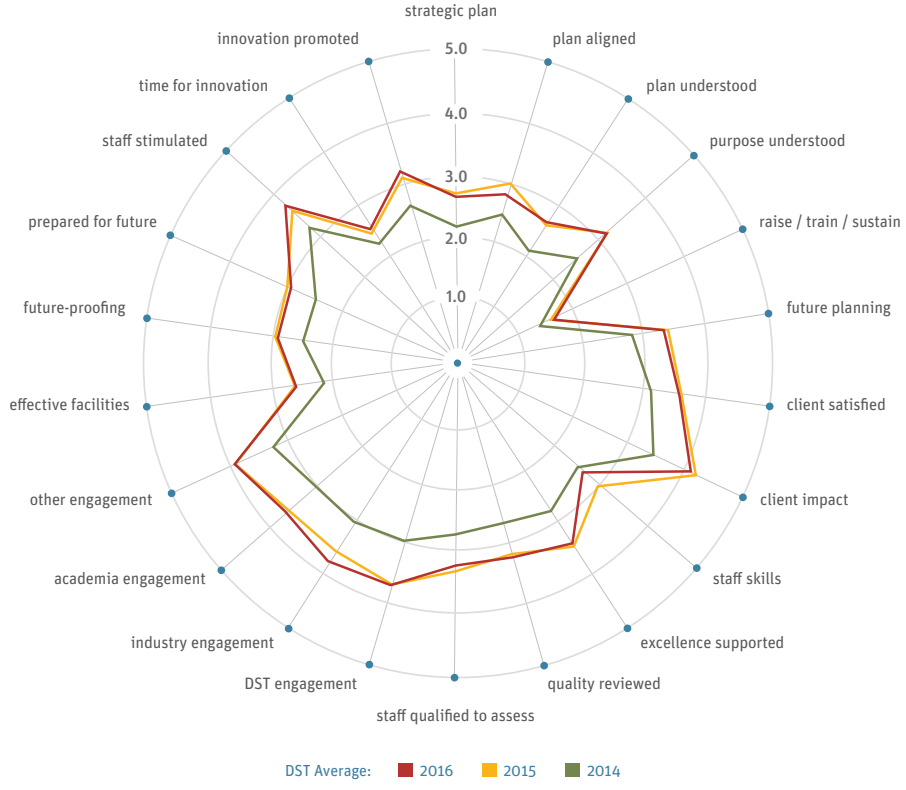
The Strategic Plan 2013–18 was further implemented during the 2016–17 year with significant progress recorded for each of the strategic initiatives.

SCIENCE AND TECHNOLOGY EXCELLENCE (D1 STRATEGIC INITIATIVE)

TECHNICAL BENCHMARKING

In 2014–15, DST instigated a process of benchmarking the performance of its Major Science and Technology Capabilities (MSTCs). A third round of internal benchmarking was undertaken during 2016–17 and seven MSTCs were also externally benchmarked. By 1 July 2017, 25 MSTCs had been externally reviewed,

FIGURE 1: OUTCOME OF INTERNAL REVIEWS OF DST'S MSTC PERFORMANCES FOR THE YEARS 2014, 2015 AND 2016



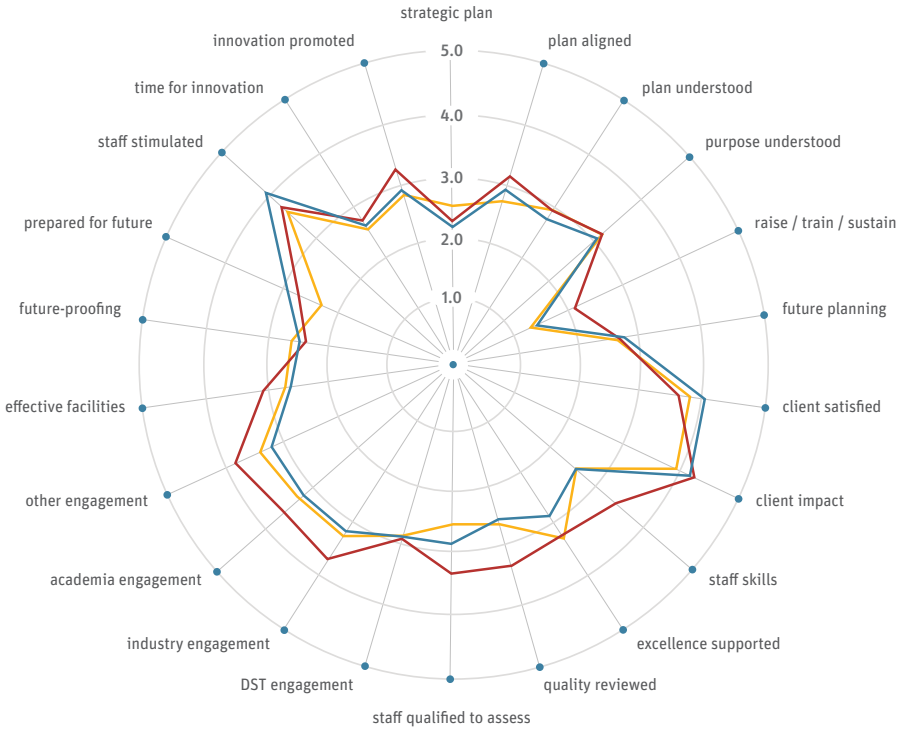
Rating scale: 5: World benchmark capability 4: Best practice capability 3: Favourable capability 2: Tenable capability 1: Capability at risk

and external benchmarking of the remaining twelve MSTCs will be completed by the end of 2017. The third round of internal benchmarking showed strong consistency with the previous year's results, indicating the maturity of the process. The strong performing dimensions of the review were client impact, internal and external engagement, and stimulated staff (see Figure 1).

All seven MSTCs that were externally benchmarked in the first half of 2017 were assessed overall as 'favourable capability' (rating of 3).

'Client satisfaction', 'client impact' and 'staff stimulated' were the strong performing categories of the 2017 external reviews (see Figure 2).

FIGURE 2: OUTCOME OF EXTERNAL BENCHMARKING OF DST'S MSTC PERFORMANCES FOR THE YEARS 2015, 2016 AND THE FIRST HALF OF 2017



A number of S&T capabilities (STC) were assessed as World Benchmark and World Class/Best Practice (see Table 1).

TABLE 1: S&T CAPABILITIES ASSESSED AS WORLD BENCHMARK AND WORLD CLASS/BEST PRACTICE FOR THE MSTCS EXTERNALLY BENCHMARKED IN THE FIRST HALF OF 2017

COGNITIVE WORK ANALYSIS	*Aerospace Organisation and Management STC within the Air Capability Analysis MSTC* Demonstrated in peer recognition, benchmarking interviews and citations.
ATHENA	*Air Capability Analysis MSTC* Demonstrated in peer recognition, benchmarking interviews and citations.
SHAPE AND REWORK OPTIMISATION	*Structural and Damage Mechanics STC within the Airframe Technology and Safety MSTC* The capability for shape optimisation research and its translation to Defence outcomes is recognised as world-leading, as evidenced by high-quality publications, the reputations of key science leaders, the awards gained and the significant defence outcomes achieved. Examples include the F/A-18 SUU62 rework modification.
THE BLAST AND BALLISTIC MODELLING CAPABILITY	*Vehicle Survivability (VS) STC within the Land Vehicles and Systems MSTC* Key staff in the VS STC are widely recognised and respected in the North Atlantic Treaty Organization (NATO) and The Technical Cooperation Program (TTCP) environments for the world-class capability they have developed in blast and ballistic modelling. This capability has also contributed to Defence Materials Technology Centre activities and vehicle development activities in industry, and has ensured that new vehicle procurements for Defence, such as the Protected Mobility Vehicle-Light, are afforded the highest practicable levels of protection.
ADVANCED COMPOSITE TECHNOLOGIES	*Aerospace Composite Technology STC within the Airframe Technology and Safety MSTC* Research on advanced multifunctional materials is internationally recognised as a world-leading capability, as evidenced by high-quality journal publications, citations, awards, reputation of science leaders, partnerships with leading universities and the translation of research into Defence outcomes. Some examples include (but are not limited to) the incorporation of an antenna into a Hawkei composite bonnet, unmanned aerial system (UAS) sensing structures, a lightweight composite shield for Navy, and new supportable low-observable technologies.
THE APPLICATION OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING TO CYBER	*Automated Analytics and Decision Support (AADS) STC within the Systemic Protection and Effects MSTC* AADS is engaged with the US in the Mission Assurance Research Collaboration (MARC) Bilateral Agreement. Dr King from the US Office of the Secretary of Defense (OSD) and the OSD lead for all their cyber programs, believes this is unique work and said that the quality of research being done in AADS is on a par with any US Department of Defense laboratory. AADS has been invited to present this work at numerous conferences.
DEVELOPMENT OF TRACKING ALGORITHMS	*Human Systems and Information Integration STC within the Undersea Command and Control MSTC* The fundamental research in tracking algorithms, including the incorporation of soft data and target motion analysis automation, is assessed as world benchmark.
CONTROL ROOM CONCEPTS AND OPTIMISATION	*Human Systems and Information (HSI) Integration STC within the Undersea Command and Control MSTC* The analysis of control room concepts using novel HSI techniques is assessed as world benchmark.
HEAVY-WEIGHT TORPEDO DEVELOPMENT FOR ARMAMENT COOPERATIVE PROJECT (ACP)	*Undersea Weapon Systems STC within the Undersea Command and Control MSTC* The collaboration between DST and US Navy under the ACP, such as that undertaken for wake model development, is delivering a product that is assessed as world benchmark.
AGENT-BASED TEAM TACTICS AS IMPLEMENTED IN AIR COMBAT ENVIRONMENT SIMULATOR	*Air Capability Analysis MSTC* Best-practice status for the capability has been established through discussions with US research partners and through peer recognition.

FORENSIC CAPABILITY

Aircraft Forensic and Metallic Technologies STC within the Airframe Technology and Safety MSTC

The forensics group is acknowledged by clients to be a world-class capability that provides exemplary outputs of critical importance for ongoing safe aircraft operation and improved aircraft availability.

DISTRIBUTED ELECTRONIC WARFARE IN A COMPLEX ENVIRONMENT TO INCLUDE MULTIPLE PLATFORM CAPABILITIES AND EW RESOURCE MANAGEMENT

Distributed Electronic Warfare Experimentation and Simulation STC within the Systemic Protection and Effects MSTC

The Systemic Protection and Effects MTSC's efforts in distributed Electronic Warfare (EW) are recognized worldwide, and are developing capabilities for the Growler that will advantage the US and Australia. The MSTC is also developing models and simulations, including hardware-in-the-loop capabilities, that are benefiting the US, UK and Australia.

NAVIGATION WARFARE (NAVWAR) CAPABILITY DEVELOPMENT

Positioning, Navigation and Timing (PNT) Technologies and Systems STC within the Systemic Protection and Effects MSTC

The Systemic Protection and Effects MTSC's work on NAVWAR is recognised nationally and internationally. The MTSC staff serve as trusted advisors to the US DoD company, PM PNT, representing the program manager on all matters of S&T and technical decisions. The staff are also well-respected members of the international NAVWAR Memorandum of Understanding (MoU) research community. Age demographics and resources put this capability at risk.

WEDGETAIL SUPPORT INCLUDING THE WEDGETAIL INTEGRATION RESEARCH ENVIRONMENT AND THE AUTO-IDENTIFICATION WORK

Tactical Systems Integration MSTC

Excellent stakeholder feedback given on the impact of Wedgetail upgrades.

MARITIME HUMAN AND AUTONOMOUS DECISION SUPERIORITY WORK

Tactical Systems Integration MSTC

Capability established as world leading through excellent stakeholder feedback, solid publication work and the ability to support projects and conduct innovative research.

JOINT STRIKE FIGHTER AIR BATTLESPACE MANAGEMENT SYSTEM AND SITUATION AWARENESS WORK

Tactical Systems Integration MSTC

Excellence established through approach taken in modelling distributed tactical decision aids.

TECHNICAL LIAISON OFFICER EMBEDDED WITH CLIENTS

Tactical Systems Integration MSTC

Stakeholder feedback indicates that posted individuals listen to the needs of clients and provide feedback on any requirements to STC.

COMBAT SYSTEMS ARCHITECTURE FOR ARMAMENT COOPERATIVE PROJECT

Combat System Architectures, Analysis and Optronics STC within the Undersea Command and Control MSTC

The virtualisation of combat systems work has been assessed as world best practice.

UNDERSEA ENVIRONMENT PREDICTION MODELS

Undersea Environment and Warfare Assessment STC within the Undersea Command and Control MSTC

The integration of disparate data sources to generate models specific to our operating region is assessed as best practice.

INTERNATIONAL COOPERATION FOR WARFARE EFFECTIVENESS MODELLING

Undersea Environment and Warfare Assessment STC within the Undersea Command and Control MSTC

TTCP collaboration with Canada and the UK is generating an effectiveness modelling tool that has been assessed as best practice.

MERLIN

Aircraft Performance and Survivability MSTC

Excellence of the capability is evidenced by its in-demand status with research partners, and UK Defence Science and Technology Laboratory (Dstl) staff are visiting to better understand its capability.

INFRARED SIGNATURE WORK

Aircraft Performance and Survivability MSTC

Excellence of the capability is evidenced by its in-demand status with research partners and recognition from clients.

PARTNERSHIP TRIANGLE

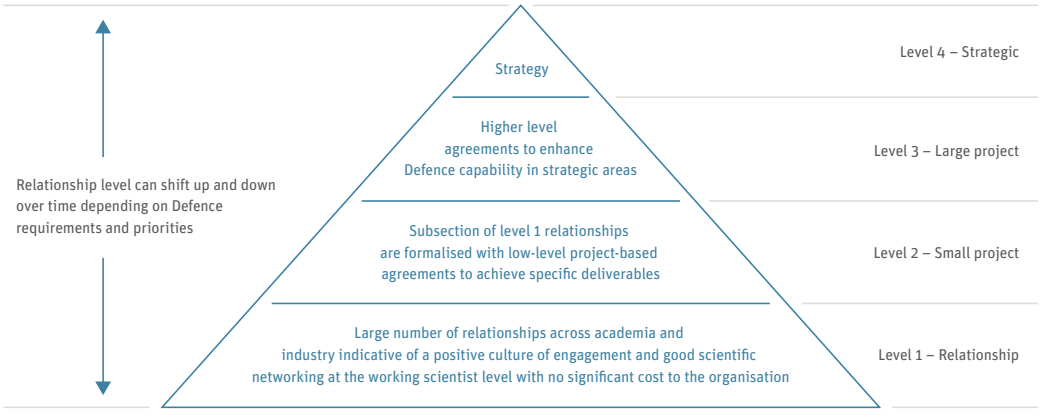
A partnerships triangle framework was developed for classifying external partnerships according to level and linking them to an MSTC. The partnerships triangle data aggregate information from a diverse range of partnering arrangements to provide a complete data set, which can be mined to facilitate a better understanding about external partnerships at an organisational level and to identify any capability gaps or areas for growth. This framework was embedded into the 2016 internal benchmarking process, and data were collected from 34 MSTCs.

FIGURE 3: EXTERNAL PARTNERSHIP CATEGORIES DEFINED BY SCALE

Engagement level	Descriptor	FTE	Examples*
4 Strategic	Formalised Key Strategic relationships identified to meet a long term complex objective		Strategic alliances, DMTC, DSI, AMC, TTCP Groups
3 Large project	Higher level relationship involving groups of scientists engaging with partners to develop or enhance Defence capability in specific areas	< 5 FTE $500,000 per annum	CTDs, PAs, Bilats, NICOP Programs, TTCP Technical Panels
2 Small project	Working-level relationship conducted on an *ad-hoc* basis between individuals to achieve specific low-level Defence-related deliverables	< 1 FTE $100,000 per annum	TPO contracts, DSP agreements, IEP and SVS Placements, TTCP CPs and SAs
1 Relationship	Non-formalised relationship developed or maintained for networking with external partners in related fields		All professional relationships without active formal agreements in place

** See page 131 for abbreviations*

FIGURE 4: PARTNERSHIP TRIANGLE SCHEMATIC REPRESENTATION OF ORGANISATIONAL RELATIONSHIP BALANCE



DEFINING EFFECTIVE PARTNERSHIPS

Two statements have been developed to define the key drivers for, and qualities of, an effective partnership for DST. These are summarised in the following figures.

FIGURE 5: STATEMENT DEFINING THE KEY QUALITIES OF EFFECTIVE PARTNERING AT DST

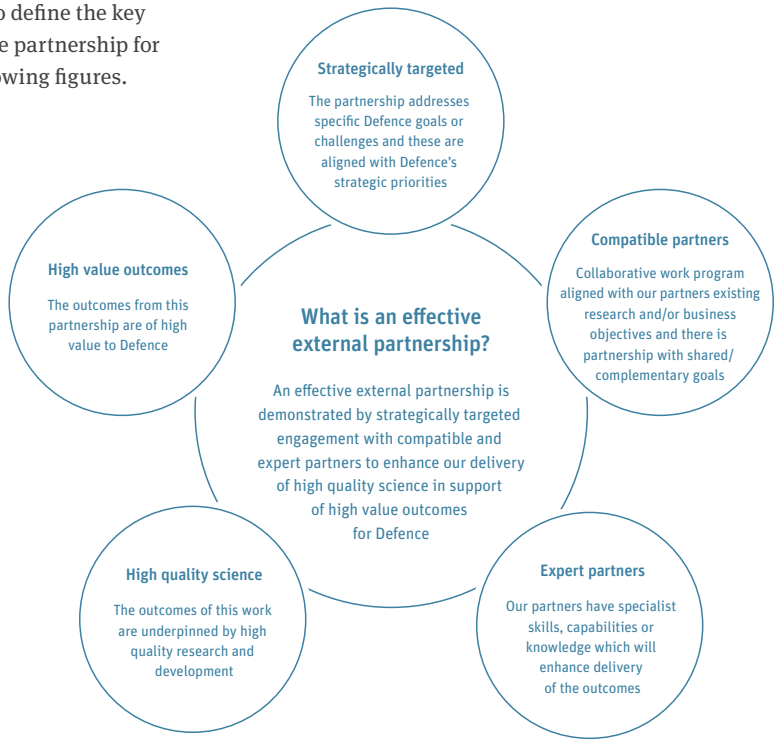


FIGURE 6: STATEMENT DEFINING THE KEY DRIVERS FOR EXTERNAL PARTNERING AT DST

PROMOTING SCIENTIFIC EXCELLENCE

Throughout the year, DST has been active in maintaining and promoting its scientific reputation in the public domain through activities that include award ceremonies (see awards section) and lectures.

In October 2016, DST and Engineers Australia hosted the first of a three-year program of lectures to be given by recipients of the Defence Minister's Achievement Award. The aim of the program is to present the best of Australian defence science to a wide audience while also highlighting the research achievements of DST and its most eminent scientists.

For the 2016 program, the lecturers were Dr Andrew Amiet and Dr Stephen Burke, who gave lectures in Adelaide, Melbourne, Canberra, Sydney, Brisbane and Perth.

Dr Amiet provided insights into the work done by DST on the management of radar, infrared and acoustic signatures of ADF ships, submarines and aircraft, while Dr Burke discussed DST's work in the field of non-destructive evaluation techniques for composite structures.

Promotional material for the lecture series *Exploring Innovation in Australian Maritime Defence Science and Technology*, mounted by DST and Engineers Australia.

STRATEGIC ENGAGEMENT WITH CLIENT FOCUS (D2 STRATEGIC INITIATIVE)

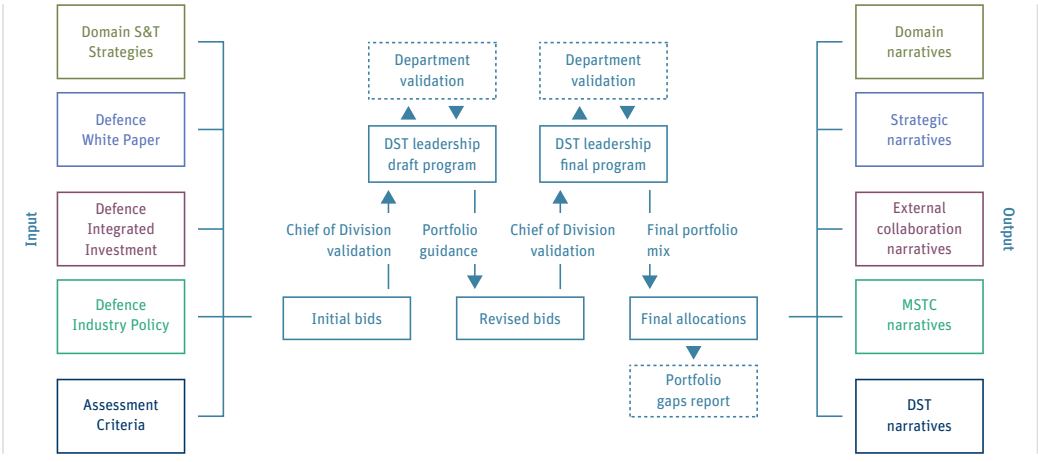
In 2015–16, DST introduced a new methodology to guide decisions on the distribution of the available budget across the annual S&T program of work and the sustainment of its S&T capability. Refined in 2016–17 (see Figure 7), this methodology provides a robust, transparent and contestable platform for investment decision-making, with client representatives included on investment review assessment panels for enhanced transparency. The process aligns investment to Defence priorities described in the domain S&T strategies. In addition, investment in S&T capabilities and the programs was influenced by existing commitments to major Defence projects and international agreements as well as client feedback and client requests for support. In future, guidance provided by the Defence Capability Assessment Program and generated through activities for assessing strategic risk will increasingly influence the investment process.

The prioritised S&T program for 2017–18 developed through this refined investment process was endorsed at the Defence S&T Client Forum in June 2017 – a meeting of senior stakeholders from the Defence groups and services. At this meeting, the balance of investment for 2017–18 across Defence domains, services and groups was reviewed. Based on consultation and guidance obtained during both the investment reviews and the Defence S&T Client Forum, the S&T program was balanced to meet Defence's highest priorities within the constraints of available capacity and S&T staff skills (see Figure 8).

The specific guidance that emerged from the 2016 Client Forum and Defence Investment Committee was to grow investment in the Joint Program in response to the Defence First Principles Review and the 2016 Defence White Paper. Accordingly, the level of investment planned in the Joint Domain was increased in the high-priority S&T focus areas of Strategic Analysis to Shape Defence, Force Design, Preparing for Emerging Contingencies and Support to Current Operations. The level of investment in the Maritime, Land, Aerospace, Intelligence and National Security domains remained either largely unchanged or was reduced slightly. Much of the increase in the Joint Domain was accommodated through a reduction in 'raise, train and sustain' investment in DST's S&T capabilities.

The S&T Program was approved by the Defence Investment Committee in July 2017.

FIGURE 7: THE DST INVESTMENT PROCESS



Bids are developed based on Defence research priorities and these are assessed by investment panels that include client membership before consolidation and presentation to Defence seniors for approval.

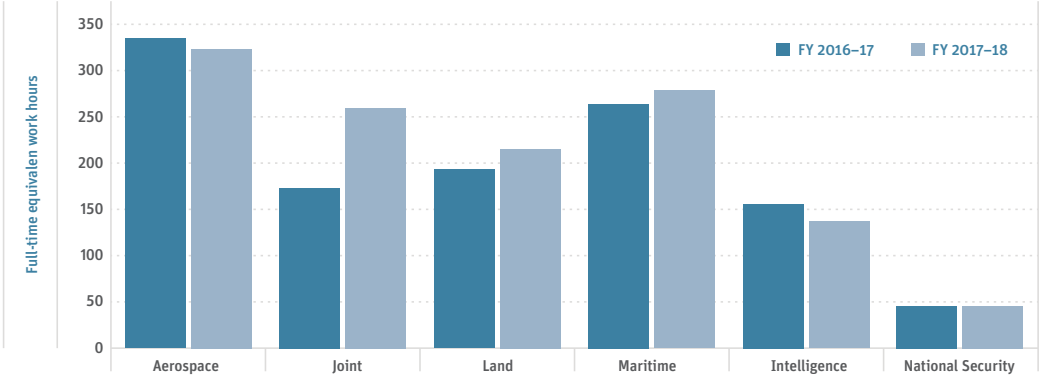
CLIENT SURVEYS

DST continued its use of client satisfaction surveys to gather feedback on the quality and timeliness of S&T support, as it has done in previous years at both the desk officer and senior stakeholder level. One recent change is that the surveys now reflect the satisfaction accorded by Defence domains rather than by client groups as was the case previously.

The survey results clearly show that, overall, DST's S&T support is meeting the needs of Defence. The annual desk officer survey, completed in March 2017, shows 92 percent of respondents were satisfied with DST performance (see Figure 9) – the same as in 2015–16. In 2014–15, a 94 percent satisfaction rating was achieved. Many DST staff were praised by name or by work area for the support they gave clients.

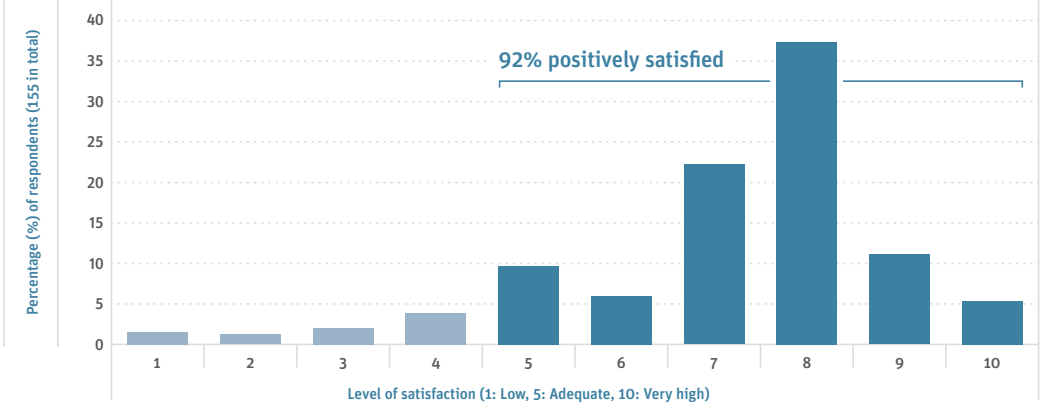
Senior stakeholders at the two-star/SES Band-2 level were also interviewed. The feedback from these interviews was also positive. However, some feedback received revealed that clients had concerns in the areas of project planning and management, reporting, resourcing and communication. These issues are being addressed via the DST Strategic Initiatives and training.

FIGURE 8: DISTRIBUTION OF FULL-TIME EQUIVALENT WORK HOURS



Distribution of full-time equivalent work hours across the client domain programs for 2017–18 in comparison to 2016–17. In 2017–18, investment in the Joint Domain was increased in response to Defence research priorities.

FIGURE 9: 2016–17 LEVELS OF OVERALL SATISFACTION



BIG-PICTURE ANALYSIS ON THE SHAPE OF DEFENCE (S1 STRATEGIC INITIATIVE)

As part of its role to keep abreast of emerging technology trends, DST continued to engage with Australian and international stakeholders by hosting relevant events, most notably, the Emerging and Disruptive Technology Assessment Symposiums (EDTAS) which are now occurring biannually to allow for broader exploration of themes. Each of these technology foresighting symposiums focuses on a specific theme and is structured around a campaign of studies and events, drawing together industry, academic, Defence and government leaders.

The two-day 2017 event, titled Information, Knowledge, and Digital Disruption, was held on 10–11 April at the Maritime Museum in Sydney, attracting 101 attendees. With a focus on the Defence priority topics of cyber and integrated intelligence, surveillance and reconnaissance, it explored future technology opportunities on the first day, and future capability concepts of potential importance to Defence on the second. The success of the 2017 EDTAS will be encapsulated in a big-picture assessment report and a DST technical note outlining the Defence impacts.

DST, meanwhile, has incorporated technology horizon scanning into planning for each S&T capability, thereby drawing on deep S&T knowledge to minimise strategic surprise. Work also continues on developing a strategic S&T outlook position paper that will inform Defence on technology developments and serve as a guide for DST on force design, Defence innovation programs and strategic policy. DST supports force design work through multiple phases of the Defence Capability Assessment Program by embedding analysts and undertaking experimentation, concept development and supplementary deep analysis.

The 2017 EDTAS on Information, Knowledge and Digital Disruption held at the Maritime Museum in Sydney.

Next Generation Technologies Fund being launched by the Hon Christopher Pyne MP Minister for Defence Industry.

NEXT GENERATION TECHNOLOGIES FOR SAFEGUARDING AUSTRALIA (S2 STRATEGIC INITIATIVE)

The 2016 Defence White Paper established the Next Generation Technologies Fund as part of a broader Defence innovation policy. This program will enable Defence to better respond to emerging strategic challenges by developing game-changing capabilities. DST was assigned the task of establishing and leading this novel program, a fundamental tenet being that its $730 million ten-year budget must be invested across Australia's wider innovation enterprise.

Many technologies that may prove critical for future Defence capabilities currently attract little or no research investment from research funding bodies such as the Australia Research Council.

The Next Generation Technologies Fund will enable Defence to attract researchers and build capacity to generate new knowledge in the priority areas of:

- Integrated intelligence, surveillance and reconnaissance
- Space capabilities
- Enhanced human performance
- Medical countermeasure products
- Multidisciplinary material sciences
- Quantum technologies
- Trusted autonomous systems
- Cyber
- Advanced sensors, hypersonics and directed energy capabilities.

The anticipated outcomes from this research will align with future Defence capability needs. Initial research will build understanding and capacity in individual technology areas before broadening in scope to include cross-disciplinary research activities.

Game-changing concepts that show promise can be further matured and realised into military capability through the Defence Innovation Hub.

The Next Generation Technologies Fund supports a diverse range of multi-year, large-scale and small-scale collaborative projects delivered under various initiatives. These initiatives include the Grand Challenges program, Defence Cooperative Research Centres, university research networks, a strategic research program, Small Business Innovation Research for Defence, participation in existing research accelerators, and technology foresighting.

These initiatives have a strong focus on partnering. By linking researchers from academia, Small-to-Medium Enterprises, Defence primes and publicly-funded research agencies, they aim to blend diverse skills and build a critical mass of effort that can accelerate the identification and maturation of key technologies.

Roger Neill gives his address at the Grand Challenges Program information session at Shine Dome Acton, ACT.

HIGHLIGHTS OF THE FIRST YEAR OF OPERATION

The first Grand Challenge, to Counter Improvised Threats, was announced by Defence Industry Minister, Christopher Pyne, on 26 April. More than 600 people from industry, academia and government attended information sessions to support the development of research proposals, and in excess of 200 proposals were subsequently received. The second stage of the selection process, the development of detailed proposals by potential participants, will facilitate the selection of initial partners by the end of 2017.

A Defence CRC for research on Trusted Autonomous Systems was established and an initial call was issued for potential engagement partners. This CRC aims to deliver game-changing unmanned platforms that ensure reliable and effective cooperation between people and machines during dynamic military operations.

Strategic partnerships aligned with Defence priorities have been initiated with the university sector. On 26 May 2017, the Defence Industry Minister announced the selection of 59 projects with $5.7 million in funding to be awarded to 22 Australian universities. These projects were selected from the 400-plus proposals that were received through a national open call.

A new University Research Network construct was developed to drive cross-disciplinary interaction and build academic communities. These networks will focus on challenging research problems of interest to Defence. Research networks, supported by State governments, have been established with universities in Victoria, South Australia and New South Wales. A discipline-based research network was also established by DST and Army, involving seven national universities with expertise in the physical and cognitive sciences to enhance soldier performance. The research network concept extends to Australian universities participating in joint Defence projects under the Multi-Disciplinary University Research Initiative (MURI) administered by the US Department of Defense.

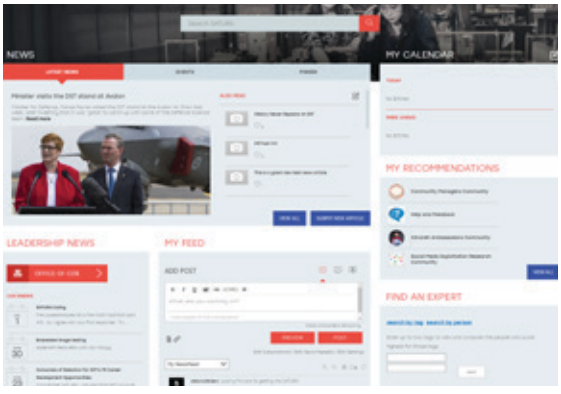
The agreement with CSIRO's Data61 to address the Defence S&T priority in cyber was signed in March 2017. This agreement is now funding collaborations with nine Australian universities over three years, with CSIRO and Defence co-funding the research program.

A program called Small Business Innovation Research for Defence was developed to enable Small-to-Medium Enterprises and start-ups spawned by academia to undertake priority early-stage research. The first stage of its work will involve a nation-wide open call for research proposals by the end of 2017.

FOSTERING INNOVATION (T1 STRATEGIC INITIATIVE)

DST innovation culture continues to grow in a very dynamic way as staff increasingly embrace new ways of doing business. Significant developments during 2016–17 include the following:

VIRTUAL AND REAL COLLABORATION SPACES



The new intranet and collaborative community portal Science and Technology Unified Research Network (SATURN) was launched, and has continuing uptake amongst staff. In the online communities that were piloted this year, staff were seen to engage in work processes with heightened collaborative approaches. As well, detailed planning by the Collaboration Spaces project teams, which involved consultations with DST staff, produced highly innovative spaces to be established at several DST sites.

DSTRUPT DAY

Idea generation activity on DST's DSTrupt Day held on 6 June 2017.

DSTrupt Day was again a huge success following on from last year's innovation event, Innovation Day. During the one-day Hackathon, DST staff explored a range of challenging issues facing the organisation and came up with several innovative ways to address and potentially resolve them.

Participants at the creative innovation and lean launchpad methodology workshop.

Steve Blank talking with DST staff after his presentation in Canberra.

Participants and facilitaors in discussion during a workshop.

PROBLEM SOLVING HACKATHON

The successful Hacking 4 Defense (H4D) program created by Stanford University in the US was piloted in Australia. H4D draws together some of the best students in universities to find technology solutions to the toughest national security problems. The Australian pilot included a problem-sponsors course, a five-day H4D sprint working through a problem sponsored by the Vice Chief of Defence Force Group, and an educator's course to accredit Australian university educators.

A Creative Innovation and Lean Launchpad Methodology workshop was attended by 36 staff from a range of sites, divisions and classifications. Its aim was to build capabilities in creative thinking across DST, and to develop a sustainable culture of innovation and intrapreneurship leading to ongoing idea generation and implementation of innovative solutions.

CSIRO PARTNERSHIP

DST has significantly benefited from its partnership with CSIRO's ON program for S&T innovation acceleration. DST's Silentium Defence team participated in the ON Accelerate program, and James Palmer was awarded the Stanford Australia Foundation CSIRO scholarship to attend an executive course at Stanford University.

The first ever ON Prime:Defence program was held with participating teams from the University of Queensland, Flinders University, ANSTO and DST. ON Prime:Defence helps research teams validate their research and discover a real-world application for it with a particular focus on Defence.

Joyce Mau and Nicola Bilton (Team SPAD) also at ON Prime:Defence.

Jonathan Boan (Team LASAGNE) giving a presentation at CSIRO's ON Prime:Defence.

INVIGORATING AUSTRALIA'S RESEARCH EFFORTS IN NATIONAL SECURITY (T2 STRATEGIC INITIATIVE)

A number of significant developments occurred in the national security domain during 2016–17 in the following areas.

WHOLE-OF-GOVERNMENT COORDINATION

A National Security Science and Technology inter-departmental committee (NSSTC) co-chaired by CDS and the Department of Prime Minister and Cabinet, was established to steer the national security science and technology program and provide governance.

The purpose of the committee is to provide strategic direction for national security S&T, coordinate investment across the sector, enable interdepartmental coordination and oversee the development and delivery of the S&T program.

The previous cross-agency Band 1 Round Table meeting was thus repurposed to actively shape national security S&T requirements against agreed priorities, with the first NSSTC meeting being held on 8 May 2017. In order to better understand and refine individual agency requirements, NSSTC is embedding science counsellors within them and is holding regular workshops on specific themes.

Extensive consultation with the national security community has identified S&T priorities that will shape program investment, government policy and engagement with the innovation sector (academia, industry and international). The following six national security S&T priorities have been endorsed by the NSSTC:

- Cyber security
- Intelligence exploitation
- Border security and identity management
- Investigative support and forensics
- Preparedness, protection, prevention and incident response
- Technology foresighting.

The June 2017 DST–CTTSO meeting. (L–R) Mr Adam Tarsi (CTTSO), Mr Brian Lewis (Department of State), and Mr Robert Newberry (CTTSO).

The June 2017 DST–CTTSO meeting. (L–R) Dr Susan Shahin (NS), Dr Katerina Agostino (NS), and Dr Richard Davis (NS).

FOSTERING INTERNATIONAL COLLABORATIONS

DST continues to maintain bilateral MoUs with a number of international agencies that have a specific focus on national security. These collaborations include the US Combating Terrorism Technical Support Office (CTTSO) and the US Department of Homeland Security, Defence Research and Development Canada and the UK Home Office. A bilateral engagement meeting was held with CTTSO in June 2017, during which, about 15 active projects were reviewed.

FOSTERING ACADEMIC AND INDUSTRY PARTNERSHIPS

The NSSTC continues to strengthen national science and technology partner capabilities to enhance targeted delivery to the Australian national security agencies.

DST's Biometrics Group and the University of Adelaide began a research collaboration to develop techniques for automated video analytics and identity intelligence.

TECHNOLOGY DEVELOPMENT

The NSSTC fosters technology developments for application in both military and national security environments. Black Canary, a wearable device that warns of the presence of toxic chemical vapours, is one such technology that has been developed in recent years by DST in association with a US partner. Patent applications have now been filed to protect this technology.

LEADERSHIP, ACCOUNTABILITY AND PERFORMANCE MANAGEMENT (O1 STRATEGIC INITIATIVE)

In 2016–17, a range of training programs was instigated to develop a workforce capable of delivering the outcomes needed by Defence and national security clients in years to come.

One of the programs, One Defence Leadership Behaviours, is now an integral component of all leadership training delivered by DST. This is designed to provide leaders at all levels with an understanding of the strategic context in which they work and ways of cultivating a collaborative, innovative and high-performance culture.

A second round of workshops for S&T6 staff was delivered to continue the Science Strategy Innovation and Excellence (SIX) program. These workshops focused on encouraging greater collaboration within local leadership teams to enhance strategic client focus and S&T excellence. Around 470 staff participated in 29 workshops.

A new FIVE Next Generation Leadership Program for S&T5 staff was piloted with twelve participants. The FIVE Program aims to prepare the S&T5 cohort as future leaders, with a focus on developing enhanced strategic awareness, building and maintaining partnerships within and external to DST, promoting best practice S&T professionalism and embedding One Defence Leadership Behaviours. A total of 23 courses are scheduled for delivery to all S&T5 staff during 2017–18.

A new Mentoring Circles program was piloted for women in DST. Two mentoring circles commenced with twelve and thirteen participants in each circle. This twelve-month program aims to provide personal and professional development with increased potential for career mobility, leadership development and promotion.

The ongoing Science Leadership Development Program and the Graduate Program in Scientific Leadership provided staff with skill sets critical for scientific leadership. Additional courses were offered for the Leadership Exploration and Development in Science Program, which equips DST staff at all levels with skills and tools for scientific leadership in times of change. A total of 95 participants attended five courses.

DST is committed to helping staff attain higher-level research skills and experience. Its PhD Initiative has enabled around 30 staff to undertake PhD studies, while its S&T Education Initiative has enabled 27 staff to undertake other undergraduate or postgraduate studies.

DST conducted induction programs for approximately 60 participants in the cohort of new employees, cadets, students and a number of Defence employees.

GPSL 2017 graduation.

TALENT, DIVERSITY AND CAREER DEVELOPMENT PIPELINE (O2 STRATEGIC INITIATIVE)

The O2 Strategic Initiative has been promoting an increased focus on career development. This has included the rollout of the career planner tool, which was designed to assist and encourage staff and supervisors at all levels to have discussions about their careers (see Figure 10).

The O2 initiative is also leading DST's participation in the Science Australia Gender Equity (SAGE) pilot program to increase gender diversity in the science, technology, engineering and mathematics (STEM) workplace. In March 2017, the SAGE Pilot Self-Assessment Team was established to gather information and develop an action plan that will facilitate completion of the Athena Swan Bronze Award Application.

In recognition of the important role that peer mentoring can play when building a culture of diversity and inclusion, DST has established a program titled A Defining Program for Women in DST, which offers support to women through structured mentoring circles with professionally facilitated sessions.

Adopted because of its proven success in other STEM organisations, the program builds strong support networks for women while they engage in leadership activities for professional growth and career development. Over the ten-month mentoring program, participants share challenges and solutions, learn skills, deliver feedback, exchange information, impart knowledge and provide guidance. Two mentoring circles were launched in May 2017.

FIGURE 10: DST CAREER PLANNER

TRANSFORMATION OF ICT TO DRIVE INNOVATION AND COLLABORATION (O3 STRATEGIC INITIATIVE)

The transformation of science information and communications technology (ICT) continued as the Information Management and Technology Operations Plan for 2016–17 was progressively implemented.

DST now has more stable and reliable platforms for research and development (R&D) as a result of further investment and service enhancements that have significantly upgraded research ICT infrastructure and networks.

Scientific endeavour agility was improved through the full implementation of a DST-wide unclassified wireless internet service and the pilot introduction of virtualisation capabilities for scientific software development environments, in addition to the establishment of a bulk research data ingest capability for the movement of big data through and between networks.

New digital information services were made available to researchers, providing instantaneous desktop access to a worldwide variety of scientific journals and research findings.

DST has improved capabilities for workspace collaborations internally and externally using meeting room videoconferencing and Skype for Business connectivity.

BEST PRACTICES FOR BUSINESS PROCESSES AND ADMINISTRATION (O4 STRATEGIC INITIATIVE)

The mapping of business processes has been completed for international travel, research agreements with universities, and international agreements. The automation of these business processes is at various stages of completion, having been completed for international travel but with implementation delayed in order to fit in with wider Defence considerations. In the interim, DST will be piloting the automated process to best identify how to integrate this with the Defence enterprise initiatives.

O4 staff continue to look for opportunities to simplify the international travel process, and have especially focused on identifying and removing areas where DST has unnecessarily added to the process. A workshop on this work area was held in August 2017.

The delivery of the Next Generation Technologies Fund is significantly increasing the number of agreements that DST is executing with its partners. Automating the processing of both research agreements and international agreements will significantly improve the efficiency of generating these documents.

The automated publications workflow is now available and mandated on DST networks. During 2016–17, the process has been increasingly put into practice, leading to improvements in the efficiency and timeliness with which DST publishes its scientific findings.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DELIVERING CAPABILITY FOR DEFENCE AND NATIONAL SECURITY

SUPPORTING AUSTRALIAN DEFENCE FORCE OPERATIONS

DST's support for operations is the highest priority work it undertakes. This support helps ensure that Defence personnel undertaking military operations overseas can do so safely and successfully. The ways in which support is offered include: S&T staff deployments for immediate on-the-ground advice and assistance; expedited access to DST's S&T laboratories through a program called the Operational S&T Support Request; and access to high-readiness S&T capabilities.

DEPLOYMENTS

The DST Operations Support Centre (DOSC) manages and certifies a pool of deployment-ready staff. It selects, prepares and deploys S&T personnel to operational theatres to support significant operational decision-making, address immediate operational needs and provide S&T advice and assessments to Joint Task Force (JTF) commanders.

'Fly Away Teams' made up of scientists with particular skills to address particular problems can be put together at short notice in cases of urgent need. Should these scientists face a problem they are unable to solve with available resources, they can access DST scientific assistance back in Australia through a support system called 'Reachback'.

During 2016–17, ten scientists were deployed to provide operations analysis and S&T liaison support to JTF headquarters for Operations ACCORDION, MANITOU and OKRA. A further nine scientists were deployed on a short-term Fly Away Team in support of Operations ACCORDION, OKRA and AUGURY.

Key successes from the deployment program during this period are included in this section.

DST Operations Support Centre staff.

OPERATION OKRA ASSESSMENT

A combined team of DST scientists and military subject matter experts was deployed to assess progress made toward achieving the strategic objectives of Operation OKRA. This operation is the ADF's contribution to international efforts to combat the Daesh (also known as the Islamic State) in Iraq and Syria. To facilitate the assessment, the Fly Away Team collected data from more than a hundred ADF and Coalition personnel from every major base in the Middle East.

The assessment informed the formulation of a number of subsequent planning activities and decision points, including a review of the Headquarters Joint Operations Command (HQJOC) operational design and the drafting of a Defence Cabinet Submission on Operation OKRA.

A Combat Support Unit dismantles tented working accomodation at the Air Task Group's main operating base in the Middle East.

HEAT STRESS MANAGEMENT FOR AIR TASK GROUP PERSONNEL (OPERATION ACCORDION)

DST deployed a Fly Away Team to mitigate the risks associated with heat stress for RAAF personnel operating in the United Arab Emirates. An instrumented trial was undertaken at Al Dhafra Air Base during the peak of summer. The trial captured real-time physiological data during typical working conditions. Data collected included core body temperatures, skin temperatures, heart rates and respiratory rates. The results were used to validate and refine current guidance relating to work-rest cycles and continuous work regimen strategies.

SEASONAL TREND ANALYSIS FOR SMUGGLING ROUTES (OPERATION MANITOU)

Deployed scientists working at the Combined Maritime Force Headquarters in Bahrain undertook analyses to understand current trends in narcotic seizures at sea in the Middle East.

The analysis identified new seasonal patterns associated with common transiting routes and correlated these with types of seizures by various Coalition partners.

The results were used to determine designated search areas for Coalition maritime assets in the region.

HMAS Newcastle's boarding party conducts a flag-verification boarding while on patrol in the Middle East as part of Operation Manitou.

OPERATIONAL SCIENCE AND TECHNOLOGY

Through the Operational S&T Support Request (OPSTSR) program, deployed Joint Task Force Commanders can immediately access research assistance from DST's S&T laboratories in order to enhance situation awareness, mission survivability and mission success. Much of the OPSTSR work is focused on understanding, anticipating and mitigating operational risks to deployed forces. Successes over the 2016–17 year are highlighted.


Afghanistan National Police Brigadier General Anwar Paigham with Greengum.


Major Jason Perkins demonstrates the easy operation of Greengum.

IMPROVISED THREAT COUNTERMEASURES (OPERATIONS HIGHROAD AND OKRA)

DST staff developed and implemented new countermeasure techniques to address several types of radio-controlled improvised threats posed to ADF personnel.

The team also continued support to Redwing, a suite of unique low-cost robust and lightweight protection systems developed to counter improvised explosive devices (IEDs). During 2016–17, Afghan National Security Forces ordered a further 34,000 Redwing systems, bringing the total for systems manufactured and sold over the past three years to 190,000. In partnership with industry, a follow-on Redwing development program has resulted in Phase 2 production prototypes currently being assessed for potential sale.

The development and commercialisation of Redwing is considered to be an exemplary success story of DST and industry collaboration. The Australian Academy of Technological Sciences and Engineering recognised this success by presenting the prestigious Clunies Ross Knowledge Commercialisation Award to DST staff member, Darryn Smart, for his work on Redwing.

MOSUL DAM FAILURE ANALYSIS (OPERATION OKRA)

DST led a modelling and simulation study with the purpose of understanding the implications of a failure of Mosul Dam. The experts working on this study included staff from the Bureau of Meteorology, CSIRO, Geosciences Australia, the University of NSW, the Australian National University, HARC Consulting and WMA Water Consulting. The work reviewed extant flood modelling and provided approximate inundation timings for ADF personnel at Taji Military Complex, thereby informing contingency evacuation plans for the base.

COUNTER-IED EXPERIMENTATION

DST has undertaken a number of counter-IED trials in support of several urgent operational S&T support requests. These trials were conducted at the Counter-IED Test Facility located near the Woomera Test Range, which is under construction and is now mainly completed. This facility will enable far more extensive and rigorous over-the-air testing of IED countermeasure techniques.

RAAF F/A-18 Super Hornet over Rawah, Iraq, during an Operation OKRA sortie.

SUPPORT TO AIR TASK GROUP OPERATIONS (OPERATIONS HIGHROAD AND OKRA)

DST conducted several activities in support of the Air Task Group operating in the Middle East. A DST study informed the Air Task Group on options for enhancing intelligence and imagery systems and databases.

DST's specialist engineering capability developed equipment enhancements for flight crew, and trials were conducted to test weapons systems on the F/A-18A/B aircraft operating in the Middle East.

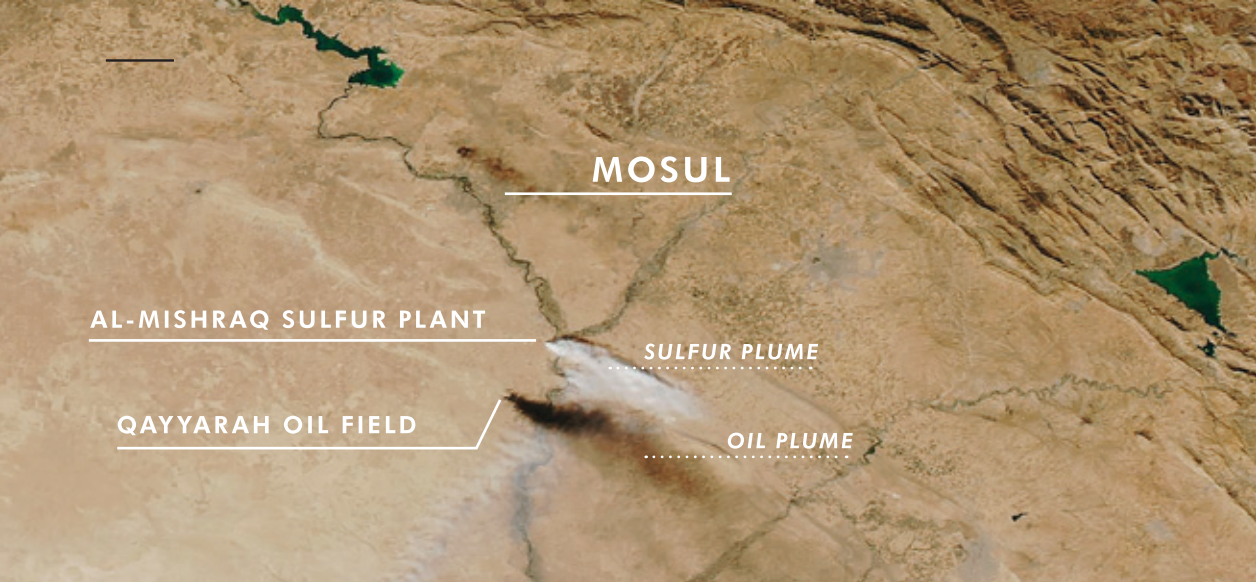
HIGH-READINESS SCIENCE AND TECHNOLOGY CAPABILITIES

The DST Operations Support Centre maintains a 'watch keeper' function and facilitates the management of specified high readiness S&T capabilities for an emergent operational contingency or national crisis.

These capabilities are to be listed on the Chief of Defence Force (CDF) Preparedness Directive. Successes from the High Readiness S&T program over the past year are highlighted.

HIGH-READINESS S&T CAPABILITIES REVIEW

DST conducted a review of its posture for responding at very short notice to emergent operational crises or national emergencies. Recent emergency experiences, such as the Lindt Café siege and South Australian bushfires, were examined and two DST Leadership Team papers were subsequently produced. As a result of this review, a new framework for managing high-readiness capabilities across DST was developed and implemented. This framework put in place workforce management policies and call-out procedures, governance arrangements for endorsing entries into the CDF Preparedness Directive and it also established a DST watch-keeper function. In addition, twenty new high-readiness S&T capabilities were instituted with 50 scientists being maintained in readiness to respond at short notice.



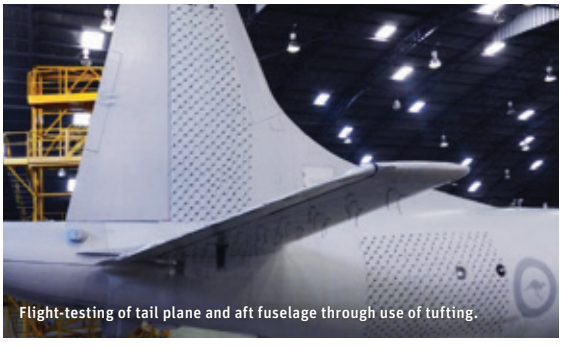
PROTECTING ADF SOLDIERS FROM TOXIC CHEMICAL SMOKE (OPERATION OKRA)

In October 2016, Islamic State militants set fire to toxic industrial chemicals at the Misraq Sulphur Plant in the al-Shura area south of Mosul, creating a plume of noxious smoke that drifted over a base where ADF troops were stationed. The force commander issued a request for support that was received in Australia in the early hours of a Sunday morning, and DST Operations Support Centre immediately activated DST's high readiness S&T capabilities for atmospheric hazard modelling and chemical agents analysis. Within a few hours, DST had produced a first set of findings on the force protection measures required, which were then sent to the deployed ADF force.

DST also assisted the deployed force by modelling the consequences of other intended and unintended releases of hazardous materials in various contexts.

ORION P-3 VIBRATION ANALYSIS

RAAF's P-3 aircraft were rendered unavailable for operations due to in-flight structural vibration issues. DST specialists in aero elasticity, vibration analysis and in-flight testing were asked to assist.

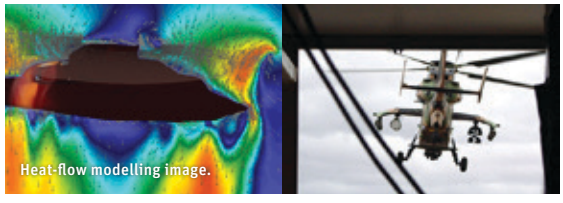


Flight-testing of tail plane and aft fuselage through use of tufting.

Working out of normal hours to tight timescales and under conditions of changing aircraft operational requirements, the team conducted tests and analysis that enabled an expanded aircraft flight envelope to be cleared in time to ensure the aircraft were available for a critical operation.

AIRCRAFT INFRARED SIGNATURE ANALYSIS

During 2016–17, DST provided the ADF with validated datasets for the infrared (IR) signatures of the CH-47F, MRH-90 and MH-60R helicopters, with the datasets to be used in IR signature management work.



Heat-flow modelling image.

These deliveries mark the successful development and testing of advanced *a priori* signature modelling tools for aircraft by DST within the Australian Airborne Countermeasures Team.

The new tools form the backbone of a world-leading capability in IR signature management as assessed by external technical benchmarking in June 2017. Their development was assisted by DST's role as co-chair of a three-year NATO Research Task Group (AVT-232 Joint Exercise in IR Signature Prediction).

SUSTAINING AND ENHANCING EXISTING DEFENCE CAPABILITY

One of DST's prime responsibilities is to sustain and enhance current Defence capability. This work involves improving the ADF's operational effectiveness, enhancing the safety of troops, maximising the availability of Defence platforms and minimising the costs of owning and operating Defence assets.

BETTER SOLDIER PROTECTION

DST analysed stab and spike protection levels offered by soldier body armour systems in order to arrive at an understanding of the failure and damage mechanisms involved and the resistance of body armour systems to various edged and pointed weapon threats.

In another study, DST investigated the influence of key parameters on the ballistic and blast fragment protection of selected body armour systems. The factors under consideration included the location, size and configuration of the body armour system, the directions of bullet trajectories and the standoff distance, and orientation of the body armour system to IED blasts.

DST also conducted a study of the effectiveness of high curvature armour protection, as used in the soldier's helmet. The work tested the anti-ballistic and fragment protection offered by helmet shells with different material properties, hybridisations and geometries when subjected to various bullet and projectile impacts.

The results of all these studies will ultimately lead to increased protection for soldiers.

Major Con Eracleous with light-weight body armour.

BODY ARMOUR AFFECTED BY SALT WATER

DST assisted an investigation into the failure of body armour hard ballistic plates after exposure to salt water.

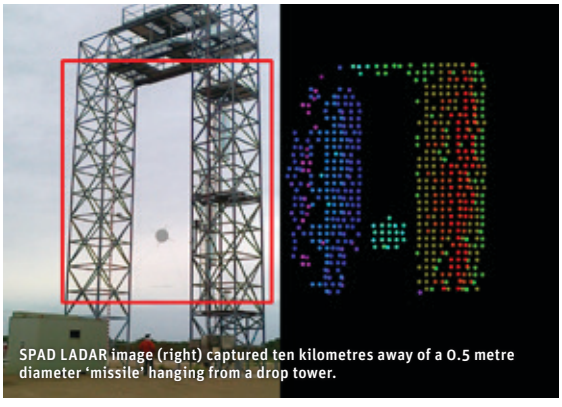
By analysing existing data and undertaking extra ballistic tests to help determine possible causes, the researchers arrived at findings that prevented an unwarranted rejection of the armour, thereby resulting in considerable cost savings for Defence.

Armour plate undergoing resilience testing after exposure to salt water.

DST researchers Nicola Bilton and Joyce Mau (reflected in lens) with SPAD chip and apparatus used in CSIRO ON Prime:Defence investigations into the possible use of SPAD chip in a laser-based airborne depth sounder application.

LADAR SENSOR CAPABILITY FOR DETECTION OF SMALL TARGETS

DST demonstrated the ability of laser ranging and detection (LADAR) devices equipped with its single photon avalanche diode (SPAD) light detector arrays to capture quality 3D images with centimetre accuracies at ranges of more than ten kilometres. These SPAD arrays are the outcome of a four-year research effort by DST and its academic and industry partners. This work has delivered major improvements in SPAD performance, with DST's devices offering superior functionality and at lower cost than most other kinds. Being able to detect single photons, SPADs are eminently suited for use in low-light surveillance and active sensing applications.



SPAD LADAR image (right) captured ten kilometres away of a 0.5 metre diameter 'missile' hanging from a drop tower.

In another area of SPAD technology development, DST's SPAD team participated in the inaugural CSIRO ON Prime:Defence Program to investigate the possibility of using a SPAD sensor in a laser-based airborne depth sounder (LADS) system. Working in a previously existing international collaboration with NATO and its partners, DST plans to mount a SPAD-based LADAR system on an unmanned aerial vehicle (UAV), thus also addressing a capability need for Navy for rapid littoral mapping in contested environments. The SPAD LADS team won the best team award for its ON Prime:Defence work.

NAVY GUNNERY FIRING SAFETY RULES

DST has provided support for Navy's quest to update its gunnery firing safety rules. These rules had been derived decades earlier based on the performance of weaponry and on methods of calculating the outcomes of firing current at the time.

One notable problem area for gunnery firing safety was that of ricocheting rounds, which were seen to sometimes behave in unexpected ways and to occasionally land outside the impact area designated by previous firing safety rules. A study conducted by DST on medium-range gunnery ricochet behaviour provided findings applicable to modern gunnery operations that Navy could use to revise its safety rules and safety range calculations.

This work included a review of how such calculations are made by Army and armed forces overseas, including NATO.

The weapon system used for a study of close-in weapon system effectiveness on Navy ships.

COUNTERING FAST INSHORE ATTACK CRAFT

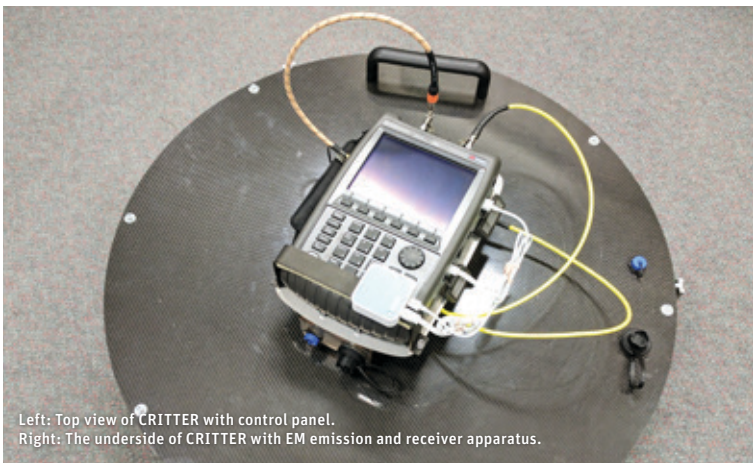
DST assisted Navy to update the tactical instructions for shell burst sizes and open-fire ranges for modern weapons when used to defend against attacks by fast inshore craft. With the algorithmic basis for previous tactics being unknown, DST's work has provided a more credible basis for these calculations.

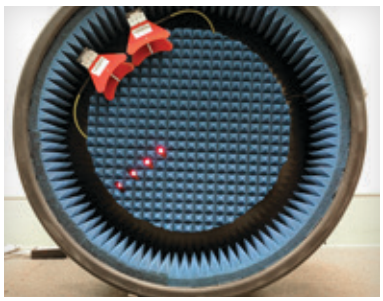
In related work, DST also undertook to study the fragmentation patterns of medium-calibre air-bursting munitions and their ability to counter the threat posed by small watercraft, and examined the effectiveness of the number and placement of close-in weapon systems on HMAS *Canberra*, *Adelaide* and *Choules*.

CRITTER FOR NEXT-GENERATION COMPOSITE AIRCRAFT STRUCTURE ANALYSIS

DST has developed the Coherent Radar Imaging Tool for Target Evaluation and Repair (CRITTER) that allows the condition of next-generation composite aircraft structures with low-observable stealth properties to be assessed. CRITTER does so by measuring the local electromagnetic (EM) response given off by a structure when exposed to EM radiation. This tool will be critical for checking the capability of new RAAF aircraft structures to perform optimally and for ensuring that aircraft maintenance is being effectively carried out.

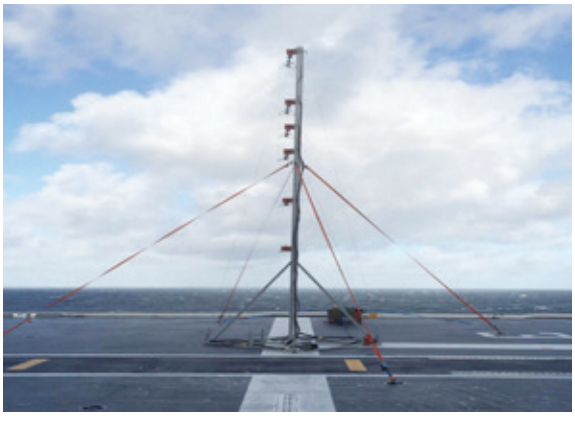
Another use is assisting the training of RAAF maintenance personnel by giving them direct feedback on work to restore structures made with low-observable composite materials. DST's R&D work has now delivered a second prototype version of CRITTER, which is lighter and more compact, offering faster analysis time along with greater sensitivity. Version 2 has reached the stage of readiness for field trials by RAAF with a third prototype under development that will have superior capabilities for assessing curved surfaces.





Left: Top view of CRITTER with control panel.
Right: The underside of CRITTER with EM emission and receiver apparatus.

Apparatus used for CH47F Chinook flight trials onboard HMAS *Adelaide*.



SUPPORTING CHINOOK HELICOPTER OPERATIONS AT SEA

DST assisted the first-of-class flight trials of the CH47F Chinook on landing helicopter dock (LHD) vessels to determine safe flight envelopes (predictable and stable modes of flight) for arriving on and departing from these vessels. The work included the use of DST modelling capabilities to predict the onset of blade sailing – a potentially dangerous rotor motion when rotating at low speed in high wind conditions.

The outcomes delivered prior to and during the flight trials assisted Navy's Aircraft Maintenance and Flight Trials Unit, and the Cargo Helicopter and Unmanned Surveillance Program Office, to develop preliminary ship-based helicopter operating limits.

Risk-reduction analysis was also provided for the flight trials by simulating and predicting the performance of helicopters when flying in the LHD air wake. During the trial, DST personnel collected data for Chinook and LHD air-wake interactions to support and predict the effect of concurrent helicopter operations on LHD vessels in future operations.

This additional analysis will help Defence achieve optimal LHD operational capability by allowing the informed development of knowledge on safe concurrent helicopter operations.

DST's Brad MacPherson, Wing Commander Michael Tully and Simulation Solutions Australia's Dan Stogkobski observe Air Force's training in the 'Virtual' and 'Constructive' environment during Exercise Diamond Thunder at RAAF Base Williamtown.

SUPPORT FOR RAAF AIR WARFARE CENTRE

The RAAF recently established its Air Warfare Centre (AWC) and DST helped by developing the Distributed Training Centre and by providing operations analysis support. Two analysts were embedded in the Centre to enable the RAAF to develop an in-house operations analysis capability. DST simulation staff helped connect a range of simulation capabilities to provide a virtual environment for various training events.

This support assisted the work of the AWC during the Diamond Thunder series of exercises, Exercise Pitch Black 16, the Air Warfare Instructor Course and on current air operations.

The contributions also helped ensure that the military exercises could be designed and conducted in ways that achieved training outcomes with maximum benefit in addition to optimising the design and development of air operations and air operation tactics.

Other assistance included producing a long-term AWC operations analysis capability development plan with provision for education and training, identifying professional competencies and for career development. This plan will undergo refinement as RAAF gains a better understanding of the usefulness of the new capability.

EXERCISE ANALYSIS OF ANTI-SUBMARINE WARFARE EXERCISE

During the year, analytical support was provided to the Theatre Anti-Submarine Warfare Exercise and Exercise Ocean Raider. Observers on HMAS *Waller*, *Adelaide* and *Newcastle* and at Headquarters Joint Operations Command collected data for later analysis of theatre and force anti-submarine warfare activities.

The outcomes included a reconstruction debrief at the Navy Fleet Warfare Forum to inform Navy and Air Force staff on what happened and why. This debrief corrected an inaccurate perception of events, with these findings being very favourably received by the Fleet Commander.

To share the knowledge gained, an exercise analysis report was subsequently published providing evidence and recommendations to support decisions on improvements in tactics, techniques and procedures, organisation, training, equipment and manning.

Top: Static testing of Harpoon rocket motor. The small sphere flying to the left is the nozzle plug which is ejected after ignition.

Static testing of Nulka rocket motor immediately after ignition, with igniter ejected to right of image and timer running above.

SUPPORT FOR NULKA AND HARPOON IN-SERVICE ROCKET MOTORS

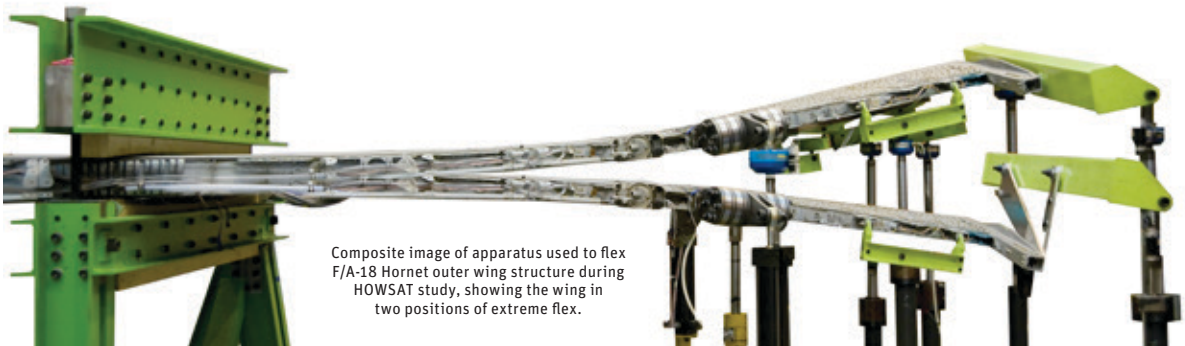
Two large-scale programs were completed to assess the in-service safety and performance reliability of in-service Nulka and Harpoon rocket motors. Both rocket motor systems had been in prolonged operational use with concomitant exposure to the rigours of transportation and agents of decay.

DST's assessments were supported by its expertise in rocket motor degradation mechanisms and were informed by a set of static firings designed to demonstrate the ongoing safety and performance reliability of aged motors under severe operational conditions.

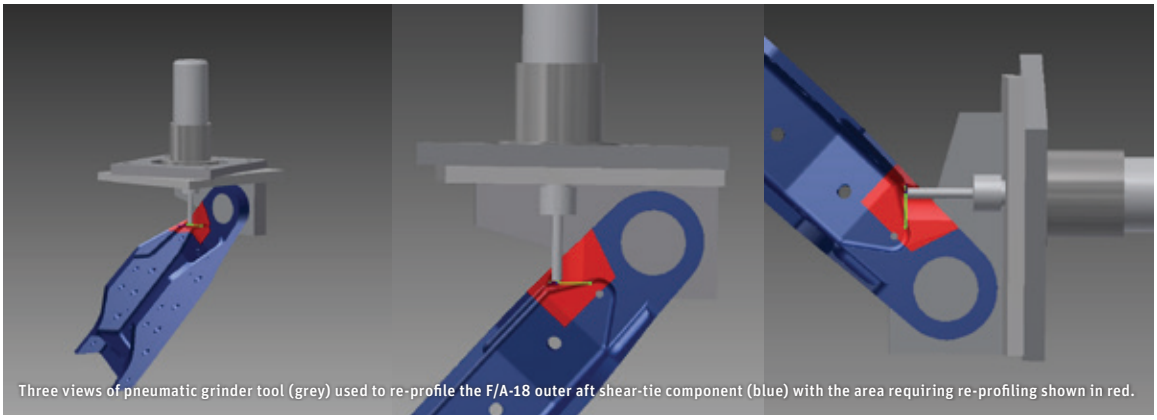
The tests produced evidence that the deployment life of the Nulka and Harpoon rocket motors could be extended, obviating a capability gap for Navy and providing significant savings to Defence estimated at $15 million.

HORNET OUTER WING STATIC TEST

Novel methods for airframe structural integrity testing developed by DST have confirmed that the outer wing of RAAF's F/A-18 Hornet aircraft should not require refurbishment prior to the planned withdrawal date. DST's first version of the Hornet Outer Wing Static Test (HOWSAT) was used to test 64 locations in the metallic structure and eleven locations in the upper composite skin. HOWSAT II was then developed to enable testing of a further 31 damage locations in the metallic structure. This applied new damage induction methods and the novel application of strain gauges to access hard-to-get-to structures, along with more extensive fatigue cycling and several novel high-precision inspection methods. The work will result in increased aircraft availability and save approximately $300,000 per wing in possible refurbishment costs for the ADF.



Composite image of apparatus used to flex F/A-18 Hornet outer wing structure during HOWSAT study, showing the wing in two positions of extreme flex.



Three views of pneumatic grinder tool (grey) used to re-profile the F/A-18 outer aft shear-tie component (blue) with the area requiring re-profiling shown in red.

MAINTAINING F/A-18 INNER WING STRUCTURAL HEALTH

The inner wings of RAAF's F/A-18 Hornets have a history of fatigue cracking at a location known as the outer aft shear-tie. This problem had previously been managed by reshaping the profile of the component by hand to remove cracks – a process that involves removing some material. However, since reshaping, several cracks have reappeared.

DST therefore arrived at a design for a new profile shape that would reduce the potential for further cracking. This was applied using specialised tooling. A high-fidelity inspection method not normally used in a maintenance environment was then used to confirm that the cracks had been removed. The remediated wings are now expected to remain in service until the planned withdrawal date of the F/A-18 A/B.

NEW TRAINING SYSTEMS DECISION TOOLS FOR DEFENCE

DST has developed a Training Authority Aviation scheduling tool for Navy, currently in beta testing, which Navy has already put to use. The tool enables short courses for individual students to be optimally scheduled, thereby enhancing the effectiveness of an instructional process critical to the delivery of trained aircrew.

Also during the 2016–17 period, a suite of training decision support tools called Athena was developed by DST to address considerably more complex problems with the aircrew training process.

Athena has been applied by the Fleet Air Arm on studies and has informed Navy's decision to increase the capacity for MH-60R helicopter aircrew training. It will also be used by the RAAF Aviation Academy and Army Aviation.

The development of these tools was supported by academics embedded in the team along with the engagement of students from the University of Melbourne and the Australian Mathematical Sciences Institute.

UNDERWATER COATINGS RESEARCH

DST research on underwater coatings to reduce vessel hull biofouling has delivered a new underwater coating scheme with reduced levels of volatile organic compounds that will improve environmental outcomes as well as increase vessel performance efficiencies.

This work has led to a technical directive issued by Defence to change the underwater antifouling scheme across the majority of the Navy fleet.

The research done by DST on aluminum compatible underwater coatings has also led to changes across the Armidale Class Patrol Boats, the Cape Class Border Force vessels and specialised areas of the Collins class submarines. These changes have resulted in reduced biofouling and increased operational performance.

CASE STUDY

ADDITIVE REPAIR AND STRENGTHENING OF MILITARY AIRCRAFT COMPONENTS

In conjunction with the RMIT University and industry partners, DST has developed a laser-based additive repair technology for remediating aircraft components damaged by corrosion, wear and fatigue cracking.

The repair process involves fusing powdered metal particles to a component's surface with the heat of a high-energy laser beam. In many cases, the process can provide a more cost-effective way of keeping aircraft in the air than replacing the faulty part, and in some cases, the repaired part will have properties superior to those it had in its original state.

The technology has already been applied to repair the rudder anti-rotation bracket on the F/A-18 Hornet aircraft, with the repaired component having been certified for flight. It has also been applied on a steel landing gear component of the C-130J Hercules military transport aircraft, which typically shows signs of corrosion after years in service. For the C-130J repair, stainless steel powder was used to give the component greater corrosion resistance.

DST is working with Australia's TTCP partners to explore the possibility of using the additive technology for both repair and manufacturing at military operating bases. The work is currently focused on quantifying variability in the performance properties of components made by additive manufacturing techniques. This work is of particular importance for enabling applications of the technology in the aerospace domain where components have to be certified as airworthy.

Meanwhile, analysts see that the ability for parts on deployed assets to be repaired will simplify the logistics of operations and further increase the speed at which they can return to service. In future, maintenance staff operating overseas could upload a computer-aided design file and print the part when required. This would reduce the supply chain timeline and nullify the need for large warehouses full of spare parts, resulting in increased warfighting readiness at a reduced cost.

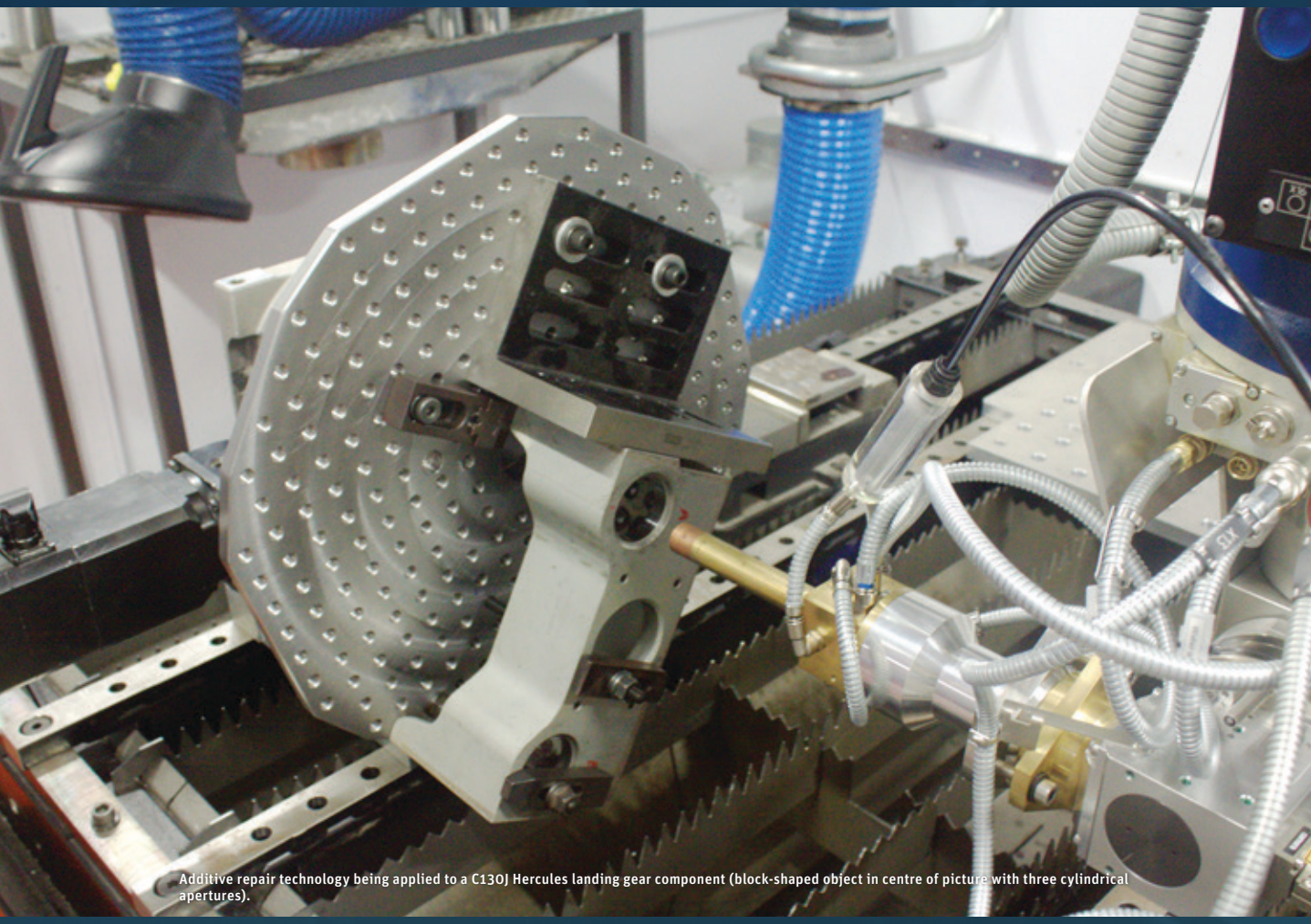
Through its ability to print complex geometry, additive manufacturing also offers the prospect of manufacturing parts of similar strength but significantly reduced weight compared to those made conventionally. In addition, the technique may result in less wastage of materials, which is of importance particularly for components made of expensive materials like titanium.

PARTNERSHIPS

RMIT UNIVERSITY

INDUSTRY

FIVE EYES ALLIES



Additive repair technology being applied to a C130J Hercules landing gear component (block-shaped object in centre of picture with three cylindrical apertures).

ENSURING DEFENCE IS A SMART BUYER

DST supports Defence acquisitions by providing critical scientific and technical advice, assisting all stages of the process from initial capability definition through to selection and introduction into service. Each project submission made to a Government capability acquisition committee includes work done by DST to produce a technical risk assessment and to provide certification of the technical risks associated with acquiring a new capability.

PROJECT ANALYSIS AND ADVICE

During 2016–17, DST generated 77 technical risk assessments for Defence capability acquisition projects, and certified the technical risk for 61 such projects. Significant capability acquisition projects for which risk assessments were conducted include:

- SEA 1000 (Phases 1, 2) Future Submarine Program
- SEA 1448 (Phase 4) ANZAC Air Search Radar Replacement
- AIR 2025 (Phase 6) Jindalee Operational Radar Network
- LAND 2110 (Phase 1B) Chemical, biological, radiological and nuclear defence
- LAND 200 (Phase 2) Battlefield command system.

In summary, DST provided analysis and advice for:

- 61 Cabinet or ministerial submissions
- 142 project briefs for Investment Committee (104) and Capability Manager Gate Review (39) in 2017 alone, plus other project briefs
- 20 technical risk assessment reports
- 24 technical risk assessment minutes
- 33 technical risk indicator reports.

Some examples of the work done by DST to support Defence acquisitions are as follows.

REFINING FUTURE SUBMARINE PERFORMANCE REQUIREMENTS

DST has undertaken analysis of the effectiveness of the Future Submarine currently under construction on anti-submarine warfare missions against an evolving threat set. This analysis was carried out using a DST-developed tactical simulation capability. The outcomes were used to refine the requirements for the Future Submarine's sonar performance and acoustic signature parameters. In addition, analysis of submarine usage and upkeep cycles was carried out to ensure that the Future Submarines can sustain the required period of time on station. This work supported the refinement of provisional functional performance specification requirements, and also informed decisions to be made about the process of transitioning from the Collins class submarine to the Future Submarine. DST's analysis was completed prior to the commencement of initial design activities by DCNS, the maker of Australia's next submarine fleet.

PREPARATIONS FOR TRITON ACQUISITION

RAAF is acquiring the MQ-4C Triton UAS for surveillance and maritime patrol missions over northern Australia. Since the aircraft, made predominantly of adhesively bonded composite materials, was designed for operations in the northern hemisphere, RAAF's aircraft face a new set of environmental challenges.

DST therefore investigated the effects of long-term exposure to high humidity environments on composite materials. This information was then used by the Capability Acquisition and Sustainment Group to determine the conditions under which Triton should be stored.

DST also undertook analysis using mathematical and modelling tools, supplemented by input from UAS technology experts, to provide evidence-based defensible estimates of the fleet size required to maintain a maritime surveillance capability for the next 30 years.

This work was an important part of the Defence acquisition business case put to Government.

RAAF MQ-4C Triton UAS.

CLEAR STUDY PROVIDES ANSWERS ON ARMY'S FUTURE WATERCRAFT NEEDS

DST has undertaken a coastal littoral estuarine and riverine (CLEAR) capability study for Army. Using interdisciplinary teams that applied diverse research methods, the study provided a wealth of advice to stakeholders in both Army and Navy. A key outcome was the identification of a set of assets the ADF should prioritise for acquisition to realise a modern littoral watercraft capability. The work investigated the viability of a number of fleet design paradigms that could be chosen, depending on stakeholder priorities. While the capability for riverine patrol was considered to be important, the analysis identified heavy coastal lift to be a higher priority capability, delivering greater utility to an Army Brigade. The quality of DST's work on the CLEAR study was recognised by the US Military Operations Research Society as worthy of its 2017 Rist Prize, which went to a non-US entrant for the first time.

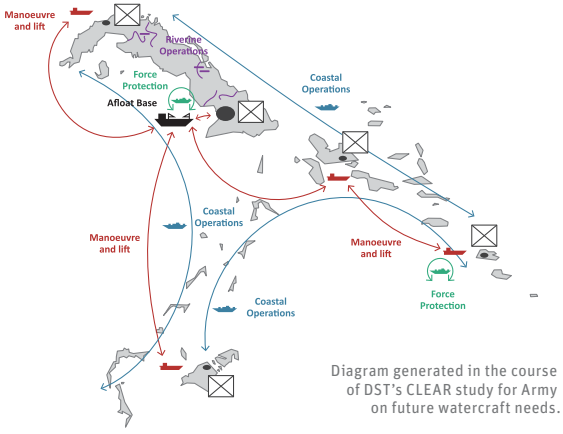
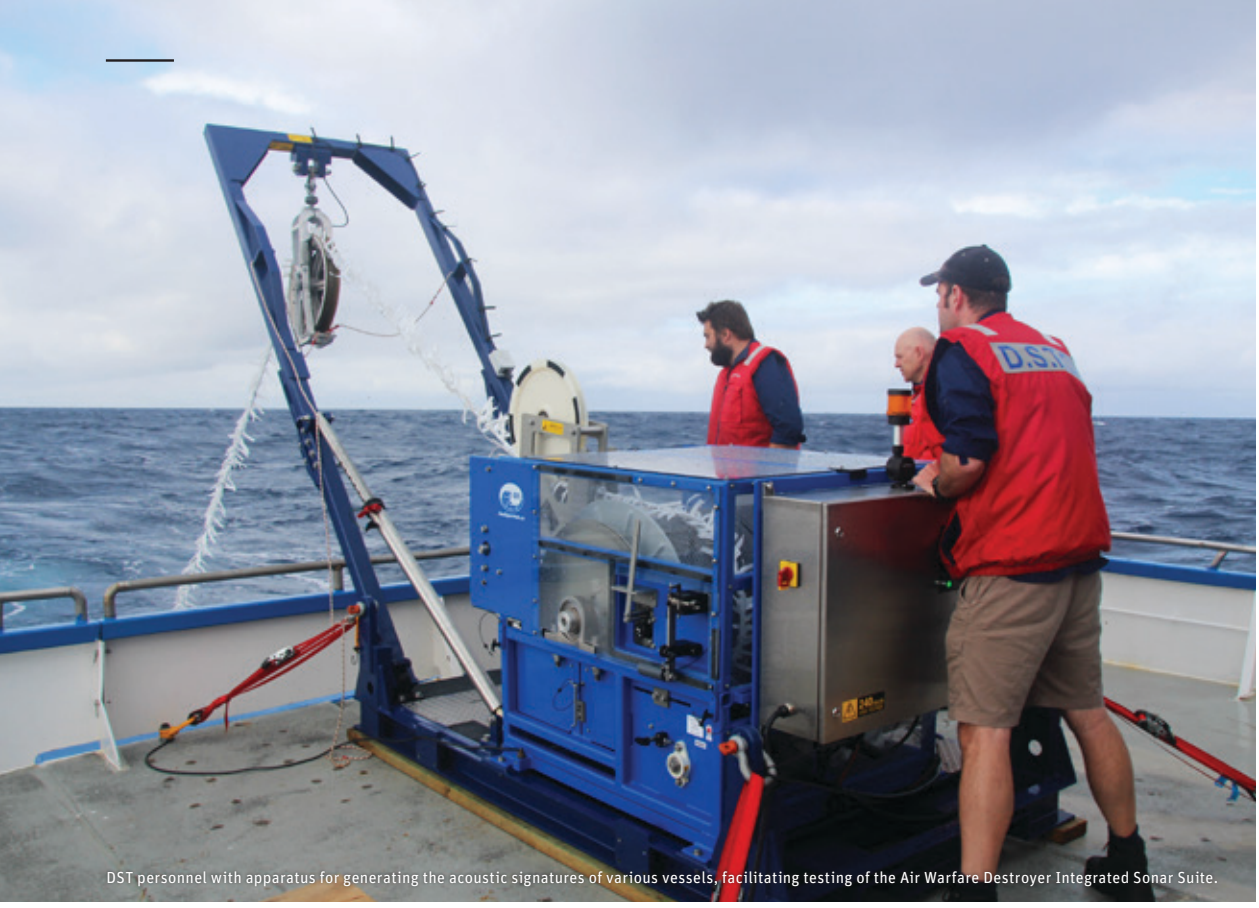


Diagram generated in the course of DST's CLEAR study for Army on future watercraft needs.

FUTURE FRIGATE OPERATIONS RESEARCH

ADF seeks to acquire nine multi-role ships for Navy with capability strengths in the area of anti-submarine warfare. DST, in collaboration with the SEA5000 Project Office, used force-level modelling and simulation tools to support the development of project requirements and to assess the anti-submarine warfare effectiveness of the candidate ship options in a competitive evaluation process.



DST personnel with apparatus for generating the acoustic signatures of various vessels, facilitating testing of the Air Warfare Destroyer Integrated Sonar Suite.

SONAR SYSTEM ASSESSMENT

In February 2017, a DST team worked onboard HMAS *Hobart* and MRV *Ngerin* to conduct initial testing of the Integrated Sonar Suite (ISS) for the Air Warfare Destroyer being acquired by ADF. This testing was undertaken using DST-developed instrumentation and analysis tools. DST has been closely engaged with Project SEA4000 during the entire sonar acquisition process, with previous work having included modelling to forecast sonar capability levels, participation in a build review before initial testing, and identifying a suitable marine environment for testing. Having more recently provided findings on the performance of this new sonar capability, DST will continue to remain closely involved in ISS development as the capability is brought into service.

CAPABILITY ANALYSIS STUDIES TO INFORM SENSOR PERFORMANCE REQUIREMENTS FOR FUTURE SUBMARINE (SEA1000) PROGRAM

A series of capability analysis studies were completed by DST to define the necessary Future Submarine sensor performance to meet the SEA1000 program's capability objectives. The scenarios assessed were developed in close consultation with the SEA1000 program and the results obtained were presented to stakeholders.

These classified results have provided DST and the SEA1000 program with a quantitative basis to compare sensor options, and are also being used to define the platform design margins required for critical sensor systems, such as sonar arrays.

DST has, in addition, applied specialised sonar performance modelling to objectively compare the undersea warfare capability provided by candidate Future Submarine sonar array options.

A more detailed investigation will be undertaken during 2017–18, and the final results will provide DST and SEA1000 with a comprehensive technical understanding of Future Submarine sonar array options, enabling informed selections to be made.

Colour boards are used for reference when taking samples of colour from various environments.

EVALUATION OF PASSIVE MULTI-SPECTRAL CAMOUFLAGE SYSTEMS

In response to a request from Army Headquarters, DST conducted an evaluation of several military off-the-shelf (MOTS) passive multi-spectral camouflage systems (MSCSs). The evaluation involved field-based human-observer assessments of MSCS abilities to conceal the signatures of dismounted combatants as well as mission-essential equipment such as armoured fighting vehicles.

Field assessments were also made of MSCS usability and functionality. This work was supported by in-laboratory evaluations of textile durability, and analysis was undertaken to consider MSCS effectiveness in a range of applications. Some systems were found to be more suitable for defeating particular electromagnetic sensor threats, depending on the application.

The outcomes obtained provided a general understanding of the performance of the systems investigated, and informed the development of Army User Requirements for systems that can be used to camouflage dismounted and mounted combatants and mission-essential equipment.

Measuring properties of dismounted combatants.

Measuring vehicle camouflage properties.

The land combat vehicle system trials team with the two types of combat reconnaissance vehicle being tested.

LAND COMBAT VEHICLE SYSTEM RESEARCH

In support of the acquisition of a new land combat vehicle system, DST worked with Army and the Land Test and Evaluation Agency (LTEA) on several field trials to test the performance of two combat reconnaissance vehicles. The two selected vehicles were BAE Systems Australia's AMV35 and Rheinmetall Landsysteme GmbH's Boxer. The trials were conducted over fifteen weeks in a wide range of environmental conditions at the Puckapunyal and Mt Bundy training areas to ascertain how well the vehicle systems support key requirements in the areas of situation awareness, lethality, mobility, survivability, command and control, communication, protection and habitability. Quantitative and qualitative data were collected, findings on the compliance of the vehicles systems to key requirements were made to LTEA, and risks associated with the use of each vehicle were identified and reported to the acquisition project office.

SPECIFYING THE STEEL FOR AUSTRALIA'S FUTURE SUBMARINE

Since August 2016, DST has offered substantial support to the Future Submarine Technical Office to assist its engagement in technical discussions with DCNS on steel requirements for the vessel. This work has resulted in a significant evolution of DCNS contract documents, which now contain an entire section detailing additional Australian Government requirements for the steel to be used. These outcomes will help ensure that the pressure hull steel for Australia's Future Submarine will be suited to all operations.

(L–R) Experimental setup for explosion crack starter test. The explosion crack starter test. Sample of steel that performed poorly. Underwater explosion test.

PREDICTING PRESSURE HULL COLLAPSE

DST provided software and advice to assist the design of the pressure hull for Australia's Future Submarine.

A Canadian steel cylinder after undergoing a collapse test.

DST developed its capabilities in pressure hull strength analysis through collaboration in the international Submarine Structures Working Group, which provided access to design methods, experimental data and first-hand experience in the conduct of large-scale cylinder collapse tests. This information was used to develop software and capabilities for the mathematical analysis of pressure hulls with geometric and other imperfections so that the collapse strength of the Future Submarine structure could be reliably established.

Further work is being undertaken to develop a capability for evaluating the effect on the pressure hull's collapse strength of residual stresses induced by cold-rolling metal fabrication processes, corrosion damage and subsequent weld repairs.

TESTING NEW FORCE PROTECTION ELECTRONIC COUNTERMEASURE SYSTEM CAPABILITIES

In support of the Project LAND154 Phase 2 Force Protection Electronic Countermeasure (ECM) Counter IED Program, DST hosted and co-led test and evaluation trials of several force protection ECM systems over an intensive six-week period in 2016.

The program, which included laboratory-based tests using DST's Countermeasure Development and Validation test facility, resulted in eleven separate reports being produced. These were used to inform decisions for the preferred vehicle-mounted, dismounted and explosive ordnance disposal force protection ECM systems. The selection decisions were subsequently endorsed in December 2016.

Australian Husky ground penetrating radar detection vehicle.

CASE STUDY

SKY KRAKEN
STUDY OF UAS INTEGRATION

DST conducted a two-week human-in-the-loop experimentation experience in support of Navy acquisition programs to integrate maritime tactical unmanned aerial systems (MTUAS) into vessel capabilities.

The experiment, named Sky Kraken, involved a scenario in which an offshore patrol vessel was required to conduct boarding operations. The purpose of the experiment was to evaluate the strengths and weaknesses arising from different placements of crew, and the concomitant levels of integration attainable between the areas of MTUAS operation, command and picture coordination.

The experiment was undertaken in a simulated environment created by DST at its Edinburgh laboratories that featured a command space replicating a Navy vessel bridge, an operations room and a MTUAS control station. Sixteen Navy personnel were tasked to carry out the simulated operation, forming four different teams with each including combat system operators, aviation technicians and maritime warfare officers.

A key part of the experiment was facilitated by DST's Synthetic Human-in-the-loop Operations Research Environment and its VIRsuit visualisation system – a real-time visible and infrared scene generator. DST's industry partners, CAE (formerly Canadian Aviation Electronics), Advanced VTOL Technologies, Simulation Solutions Australia and Consilium Technology, assisted the work undertaken to produce a simulation system suitable for this trial.

Because of the simulation's high-level authenticity, the experiment was considered to be the next best thing to actually carrying out the operation at sea, with the advantages that simulation enables experimental control to be exercised and for repeatability of experiments. The experiment managers were thus able to investigate key aspects of the task and to run multiple crews through the experiment to test different ways of working in order to arrive at consistent findings.

A second simulation experiment is planned for 2018 and will focus on investigating MTUAS warfare tactics within a task group. The reports from these trials will directly inform the integration approach that offers the best capability for the investment made by Defence.

PARTNERSHIPS

ROYAL AUSTRALIAN NAVY

CAE

ADVANCED VTOL TECHNOLOGIES

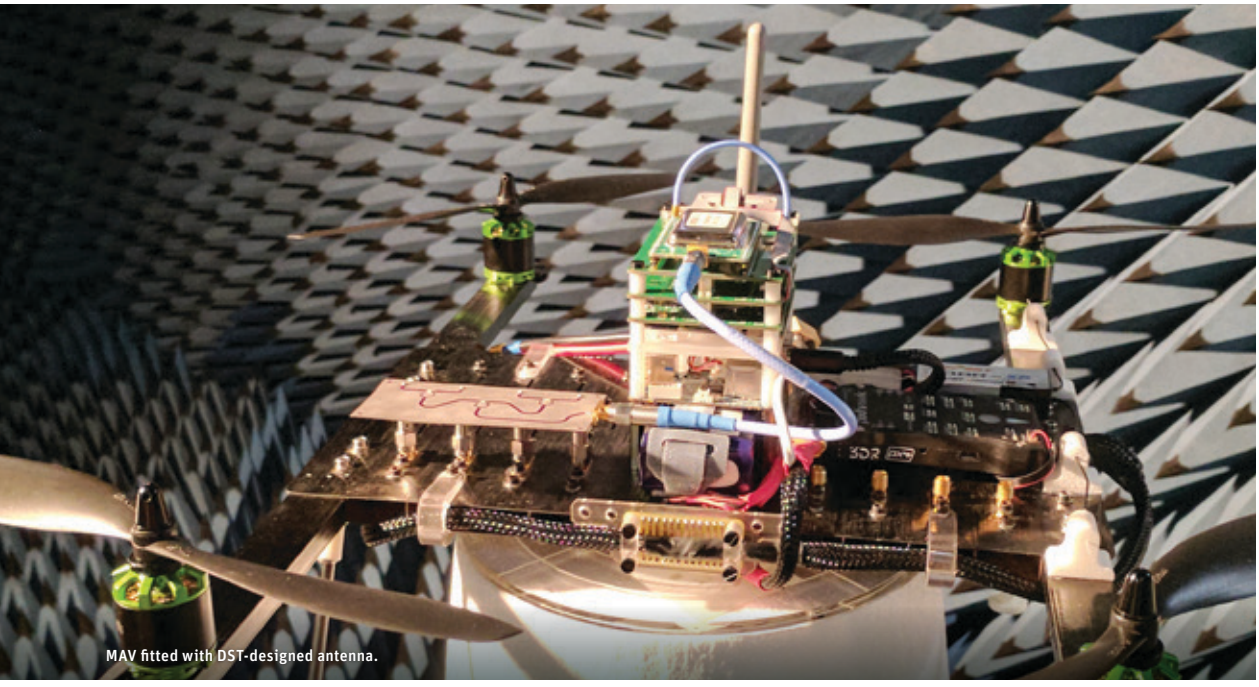
SIMULATION SOLUTIONS AUSTRALIA

CONSILIUM TECHNOLOGY

DST and Navy personnel undertaking a Sky Kraken human-in-the-loop simulated exercise.

FUTURE-PROOFING DEFENCE

An important responsibility for DST is to ensure that Australia is prepared for the Defence and national security challenges of the future. This involves keeping abreast of emerging technologies to assess their potential as possible threats or critical capabilities. DST undertakes forward-looking strategic research in technologies that may provide game-changing capabilities for Defence in the future. These include autonomous systems, cyber and electronic warfare, undersea warfare, intelligence, surveillance and reconnaissance, signature management, bioterrorism preparedness, hypersonics, materials and energy, and space systems.



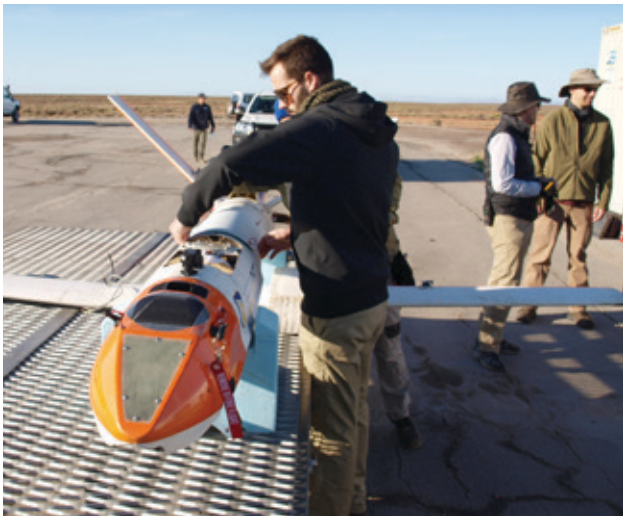
MAV fitted with DST-designed antenna.

CONFORMAL ANTENNAS

DST has been researching antenna technologies to enhance the abilities of micro air vehicles (MAVs) to operate in urban terrain. MAVs operating in such environments, which include the interiors of buildings, require sophisticated spatial mapping sensors to ensure safe flight. Laser-based range sensing devices, such as lidar, are commonly used for this purpose, but if the MAV encounters smoke, dust or rain, lidar reliability may be compromised. Under these circumstances, a microwave-based sensing device, such as radar, could provide more reliable spatial awareness, albeit with reduced spatial resolution.

Given the very small size of MAVs – typically one metre or less – and the comparatively large wavelengths of microwaves, the MAV requires an electrically small, structurally integrated and light-weight antenna in order to operate radar-based sensing. DST has developed antenna designs for this purpose featuring multi-functional composite antenna structures, which have been fitted to and flown on prototype MAVs.

DST personnel with UAV at Woomera Test Range for vision-aided navigation trials.



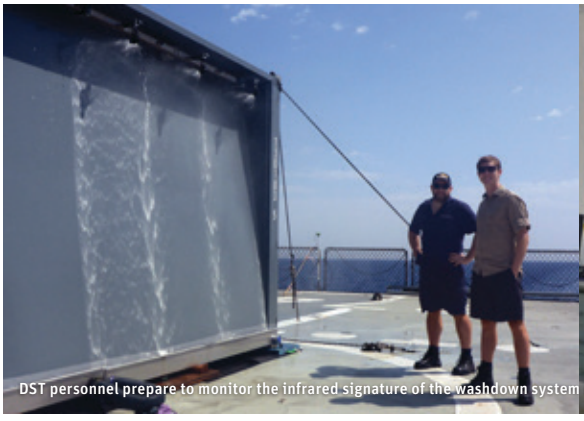
VISION-AIDED NAVIGATION

In a joint US-Australian project, DST is collaborating with American researchers to develop and demonstrate closed-loop vision-aided navigation by an Unmanned Aerial System (UAS) for operations over environments with few distinguishable landmark features.

The program's third and final trial was conducted by DST in association with the US Air Force Research Laboratories and US Army Aviation and Missile Research Development and Engineering Center. Building on the previous year's success in demonstrating closed loop navigation along a long-range 100-kilometre flight path in sparse environments, this trial demonstrated a navigation functionality enhanced by the inclusion of an autonomous path-selection-to-target capability that improves navigation system robustness.

This system was developed using the same design approaches that will be applied in future on smaller platforms to achieve a navigation capability with similar performance but with low space, weight and power requirements. Following the implementation of these system enhancements, the team has started investigating the possibility of achieving reliable navigation over water, a capability that needs to be established before visual navigation can be usefully applied.

DST personnel with the washdown test item onboard the Greek naval vessel HS *Prometheus*.



DST personnel prepare to monitor the infrared signature of the washdown system as HS *Prometheus* passes their observation post on the Drapanos Range, Crete.

MINOTAUROS SHIP INFRARED SIGNATURE TRIALS

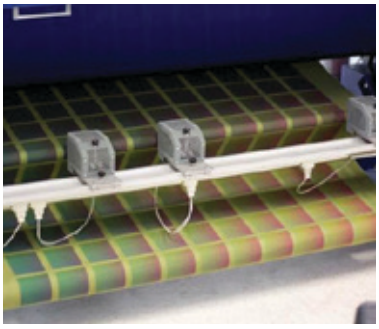
DST constructed a test item to assist NATO investigations into the efficacy of ship washdown systems for reducing the likelihood of an infrared-guided missile strike by reducing vessel heat emissions. The DST containerised washdown system consists of a twenty-foot shipping container with sloping sides, inbuilt water tanks and control electronics to mimic the behaviour of the water washdown systems fitted on front line warships. The test item was designed to be easy to transport, capable of spraying water at various rates and operable from the rear deck of a naval vessel.

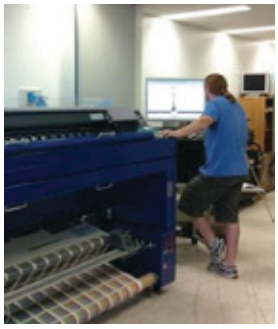
The test item featured in NATO's Trial Minotauros held off Crete during August–September 2016. The trial was attended by teams from nine NATO countries with each using thermal imaging cameras to investigate the cooling effect produced under a range of environmental and water flow conditions. The trial was conducted for five days on the Hellenic Navy ship *Prometheus*. The data gathered will inform Navy into ways of best using the washdown systems installed on Navy's Hobart and Canberra class vessels.

HEADLINE EXPERIMENTAL CAMPAIGN

Analytical support was provided during the year to the Headline Experiment 2016 (HE16) that identified key issues concerning the ADF's ability to lead a combined joint task force in the near region. The findings made, while identifying these issues, will help future-proof the ADF by informing its processes for Joint Force and capability life-cycle design. HE16 was designed to produce a prioritised list of joint issues for Army and Joint Force to consider when building Joint Force options for 2025–30.

DST conducted investigations into force projection, inter- and intra-theatre lift during entry and intra-theatre sustainment as well as command, control, communications, computers, intelligence, surveillance and reconnaissance, with a focus on information collection, sharing and analysis. The key outcomes were a series of discussion papers, which were presented to senior Army leaders and formed the basis for VCDF Group's 2017 experimentation campaign. Headline 2016 was one of the most challenging ADF-wide experiments ever attempted by DST, involving more than a hundred military and DST personnel. DST's contribution to the event was acknowledged by Chief of Army.





(L–R) Printing camouflage pattern tests, colour samples from environmental photos, printing workshop.

MISSION-SPECIFIC RAPID CAMOUFLAGE CAPABILITY

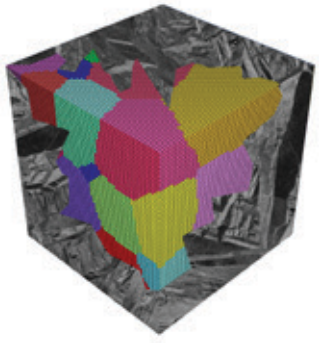
DST has demonstrated a capability for rapidly transforming photo images of terrain into concept camouflage designs that blend highly effectively with the terrain photographed. This work is part of a DST project to develop an in-house rapid camouflage prototyping capability that will provide Special Operations Command with a means to acquire new combat uniforms and equipment camouflaged for specific terrains in operationally relevant timelines. DST has developed a software program to allow for pattern designs that take into account the colour and lightness of the terrain as well as its structure, clutter and orientation.

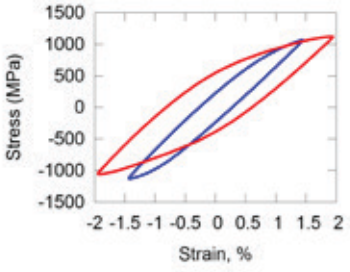
These concept pattern designs have been produced using an in-house fabric printing facility capable of rapidly generating sufficient fabric for multi-garment production. A production timeline of 15 working days (three weeks) after the capture of terrain images has been established for the completion of five camouflage combat uniforms and the associated soldier combat ensemble.
The capability currently delivers camouflage in the visible spectrum only, but is intended in future to provide near-infrared and short wave infrared signature management and if possible, thermal infrared signature management also.

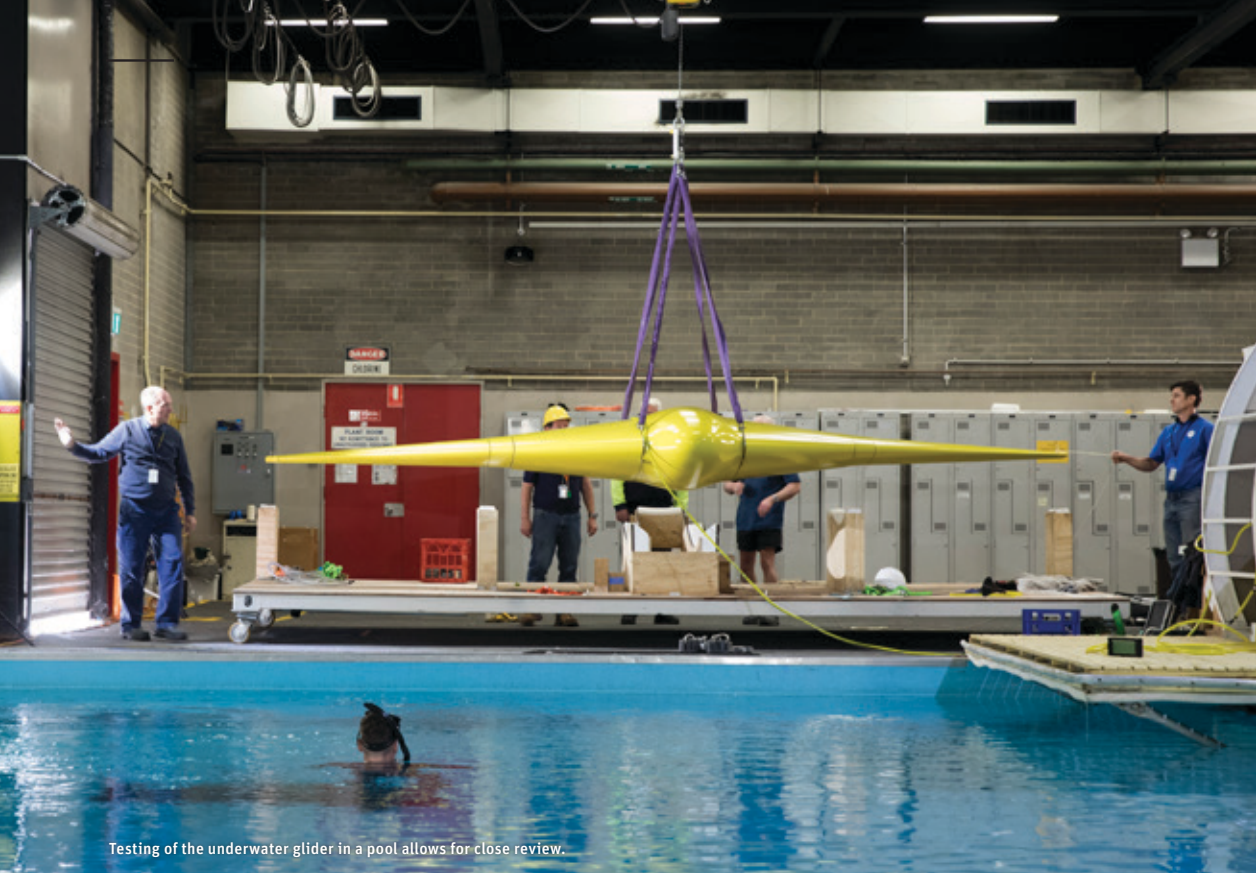
MODELLING THE BEHAVIOUR OF ADDITIVELY MANUFACTURED TITANIUM

In collaboration with RMIT University and the University of Limerick, DST has developed a modelling capability to characterise the elastic-plastic material behaviour of additively manufactured titanium. Titanium is widely used in the aerospace domain due to its light weight, high strength and high corrosion resistance. New additive manufacturing technologies, in which a component is produced by fusing powdered material with laser heat energy, enable the manufacture of titanium components with highly optimised and purpose-tailored geometries with low wastage.

However, the behaviour of such components under static and dynamic loading can be significantly affected, including the introduction of some behaviours not previously observed. DST has therefore been examining the elastic-plastic behavioural response of additively manufactured titanium under a wide variety of loading conditions to develop fit-for-purpose performance modelling capabilities. These modelling capabilities will become integral to the design, development and certification of future structural aerospace components made of titanium using additive manufacturing.







Testing of the underwater glider in a pool allows for close review.

HIGH PERFORMANCE SEA GLIDER DEVELOPMENT

DST is working with industry partner Ron Allum Deep Sea Systems to build Australia's first high-performance underwater glider. High-performance 'cross country' underwater gliders show great promise as mobile acoustic surveillance platforms, having greater potential than most conventional vertical profiling ocean gliders to support useful combinations of payload, autonomy and endurance capabilities. The experience being applied in this project includes the company's world-leading expertise in the deep-sea platform engineering areas of energy systems and structural flotation rated for use at extreme pressures.

Meanwhile, DST and its university partners will provide the robust autonomous control system required for reliable operation in a communications-restricted environment. DST will also partner with industry and universities on work in computational modelling and simulation, underwater acoustics and communication, adaptive mission planning for autonomous underwater vehicles, human-robot interfaces, oceanography, and hydrography, meteorology and marine monitoring.

DEVELOPING ARMY'S NEXT-GENERATION INFANTRY CAPABILITIES

Small business company DefendTex and DST are investigating the operation and use of 40 mm grenades to enhance next-generation infantry capabilities. The work aims to reduce the operator burden and enhance the lethality of small guided weapons by adding algorithms that not only control the individual weapon but also enable the actions of several fired simultaneously to be coordinated. Together these new features will create the first Australian 'operator-in-the-loop' weapon. Once fired, the soldier can immediately return to task while each weapon autonomously steers itself, in conjunction with peer weapons, onto a target to create a synergistic effect. With greater lethality achievable, these small soldier-portable weapon systems are expected to usher in a new offensive mode for a fire team or squad – the tip of the war fighting spear – that will then be able to project a degree of firepower currently only available at the troop or company level.

Test explosion of a plastic explosive newly developed using the RAM facility.

PARTNERING WITH INDUSTRY FOR NEW ENERGETIC MATERIALS CAPABILITY

DST is partnering with industry to transition the manufacturing of next-generation energetic materials to industry. A resonant acoustic mixing (RAM) facility for the formulation and manufacture of new energetic materials has been commissioned along with equipment for the production of nano-materials.

A new plastic explosive is being developed using the RAM facility that will offer a more commercially viable product for Australian manufacture. The benefits of the new explosive are ease of manufacture along with a binder system that contains less ingredients and is not at risk of becoming obsolete.

ADVANCED PYROTECHNIC SMOKE COMPOSITIONS

In collaboration with the US Army Research and Development Engineering Command, DST has developed a new phosphorous compound containing boron phosphide for smoke compositions using modelling and computational chemistry. This shows significant potential for use in next-generation pyrotechnic smoke compositions.

CASE STUDY

HEAT INFRARED HYPERSPECTRAL SENSOR TRIALS

DST undertook two airborne trials in 2016–17 demonstrating the abilities of onboard sensors to detect chemical agent releases and to automatically pass on data collected to intelligence, surveillance and reconnaissance (ISR) analysts on the ground. The trials were conducted using its Beechcraft 1900C aircraft as part of a demonstration of standoff chemical agent detection capabilities.

The technologies applied were a hyperspectral emissive slant angle spectrometer (HEAT) infrared remote sensor integrated with a MX20HD full-motion video sensor. The imagery captured was processed by an automated hyperspectral on-board processing system that delivered the detections to a ground station in near-real time via a tactical data link.

The two trials carried out, HEAT BREAKIN and HEAT ROUNDUP, employed a series of calibration panels, camouflage materials, gas plumes and surrogate targets, with some test items being damaged or destroyed in the conduct of the trials. The use of fresh materials for each experiment ensured the traceability and comparability of results for every hyperspectral image-cube produced and provided a reference for cross-checking sensor performance.

Fire, gas and aerosol plume experiments were conducted to gain operational expertise in hyperspectral imaging, to develop ways of evaluating chemical agent releases and to further understand the chemical agent threat.

The trials also produced an advanced understanding of thermal infrared hyperspectral applications. A large range of datasets were collected to enable assessments to be made of this novel ISR capability. Future work will explore data ingestion into an integrating framework to enhance Defence situational awareness and support decision superiority.

EXPERIMENTATION

HEAT BREAKIN

HEAT ROUNDUP

Liquid material ignition during a fire experiment in the HEAT ROUNDUP infrared hyperspectral sensor trials.

ENHANCING NATIONAL SECURITY

DST leads the co-ordination of science and technology research to enhance Australia's whole-of-government program for national security.

DST works with other government agencies to:

- Coordinate whole-of-government National Security science and technology, to prioritise science and technology requirements, reduce duplication and improve impact
- Foster academic and industry science and technology partnerships to build national science and technology capability and enhance targeted delivery to Australian national security agencies
- Foster international research collaboration to leverage state-of-the-art capabilities for Australia
- Manage DST's national security science and technology program, maximising dual-use application of DST sovereign capabilities.

Soldiers from 4th Battalion Royal Australian Regiment Commando's conduct an urban assault at the new Special Forces Training Centre Facility in Holsworthy.

SOFTWARE INTELLIGENCE CAPABILITY ENHANCEMENT

DST has assisted the ADF and Australia's international partners on a variety of domestic and foreign counter-terrorism operations by contributing to, and amassing a library of counter-terrorism techniques. This led to an improved intelligence-gathering capability for Australia and its allies. A separate piece of software written entirely by DST was used by one of its international partners to gain intelligence on another terrorism-related operation.

The May 2017 International Home Made Explosives Working Group Conference.

TOWARDS A BETTER UNDERSTANDING OF HOME-MADE EXPLOSIVES AND CYBER

In May 2017, DST promoted efforts to understand and counter the threats posed by home-made explosives by hosting the International Home Made Explosives (HME) Working Group Conference, which was attended by 101 delegates from six nations.

This annual classified conference brought together policy, intelligence, research, forensic and first responder personnel for discussions on current and emerging global HME threats and the counter-technologies being developed.

The event provided an opportunity to exchange training material, equipment and research developments, countermeasure techniques and software to ensure operational forces and national security agencies have the best tools to face these threats.

DST also hosted a Cyber Open Source Methods and Operations course. This specialist course, previously only available in the US, was provided courtesy of a collaborative arrangement and tailored for Australian use. Delivered in Canberra, the Australian course was very well attended by Defence and other agencies.

BIOMETRICS COLLABORATION WITH THE UNIVERSITY OF ADELAIDE

DST has established an interdisciplinary collaborative arrangement with the University of Adelaide to research and develop biometrics technologies that will support automated video analytics and the acquisition of identity intelligence. Current areas of interest include improving the ability to process video from very large surveillance networks as well as video captioning and querying.

In the latter area of interest, textual descriptions of the activities taking place in a video are generated to describe the individuals involved and their behaviours and interactions. The advantage of using textual descriptions is the greatly reduced volume of data to be analysed, enabling the video to be queried and processed by a wide range of existing text-based analysis systems.

CASE STUDY

BLACK CANARY TOXIC VAPOUR DETECTOR

In collaboration with Ideation Product Solutions and the US Combating Terrorism Technology Support Office, DST has developed a wearable device called Black Canary that provides warnings when toxic chemical vapours are present.

Many toxic chemical vapours are invisible, odourless and dangerous even at extremely low concentrations. Toxic chemical vapours released through nefarious means or by accidents can have dire effects on anyone – military personnel, first responders, law enforcement officers and civilians – who happens to be in the vicinity without protection.

The Black Canary sensor system devised for detecting these threats is based on color change chemistry paired with a cutting edge opto-electronics design. Thumbnail-sized, swappable cartridges, specifically targeted for the toxic vapors of interest, plug into receptors on a mobile phone-sized device. Black Canary can thus monitor the presence of up to eight kinds of toxic vapour simultaneously in addition to providing real-time readings of oxygen levels.

Each cartridge is a miniaturised, single wavelength spectrometer comprising a reactive chemical sample, casing and electronics package. The device draws air past the reagents located on each cartridge, and handles signal data processing and pattern recognition automatically, thus allowing the user to operate unhindered until an alarm is triggered.

Designed for military and civilian uses, Black Canary is an affordable, easy-to-operate and adaptable system with a level of sophistication usually only found in larger handheld devices, thereby filling a critical gap in the available capabilities for toxic chemical vapour detection. In February 2017, patent applications for most of the world's marketing territories were filed for the technology.

PARTNERSHIPS

COMBATING TERRORISM TECHNOLOGY
SUPPORT OFFICE (US)

IDEATION PRODUCT SOLUTIONS

(L–R) early and most recent versions of Black Canary.


EXIT
15
R FORCE

SUPPORTING THE CIVILIAN SECTOR

Defence scientists are frequently called upon to offer their unique expertise in crisis situations or to contribute to activities of national significance.

READINESS TO ASSIST UNITED NATIONS INVESTIGATIONS

DST staff with expertise in the areas of chemical, biological and toxin weapons were invited to participate in training given by the United Nations Office for Disarmament Affairs (UNODA) to prepare them to undertake investigations into the alleged use of such weapons.

The United Nations deploys teams of inspectors in accordance with the rules and regulations that apply under the Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons.

An introductory course provided participants with an understanding of their rights, roles and responsibilities under the Mechanism. It also gave information on how to interact with representatives of the host nation, conduct themselves in a country with very different cultural practices, respond to security events, and take forensic samples, while ensuring sample chain of custody and transporting forensic material across state borders.

An advanced course provided Head of Mission training that discussed elements of leadership as well as reporting and operational planning, with an overview of what the United Nations can provide to an investigative team and how to get it.

The DST personnel, having undergone training at the introductory or advanced levels, now form part of a roster of available UNODA experts.

CORROSION HEALTH MANAGEMENT FOR AIRCRAFT

BAE Systems Australia and DST have developed a corrosion prognostic health management system that can be fitted on any aircraft and will deliver improved corrosion health monitoring outcomes.

The system uses sensors located onboard an aircraft along with ground-based corrosion growth modelling tools to supply data that enables the optimum time for maintenance to be determined. Current maintenance practices for aircraft rely on routine inspections to find corrosion, and in many instances, when the inspections are conducted, no corrosion is found. However, the disassembly required to gain access for inspections may lead to damage resulting in later corrosion events. By using the new system, the number of inspections required is reduced, which lowers maintenance costs while increasing aircraft availability.

Different elements of this system have been, or are being, evaluated and tested on the RAAF Hawk Lead-In Fighter, RAN Seahawk helicopter and F-35 JSF aircraft in various parts of the world. The DST and BAE Systems Australia team were awarded the 2017 Aerospace Australia Defence Industry Innovation award for their work.

FORENSIC SCIENCE SUPPORT TO KING AIR B200 VH-ZCR ACCIDENT INVESTIGATIONS

DST assisted the Australian Safety Transport Bureau with its investigations into the accident involving the Beechcraft King Air B200 aircraft, VH-ZCR, which crashed shortly after takeoff from Essendon Airport.

DST has a long history of providing S&T investigative support and advice for military incidents and accidents, and has a Memorandum of Understanding with the Australian Safety Transport Bureau through which it provides assistance on air accident investigations.


ss Domain Desktop Composito
Heritage Corner

3

PARTNERSHIPS AND OUTREACH

COLLABORATION AND ENGAGEMENT

DST recognises that collaboration and engagement significantly enhances its ability to provide world-class scientific advice and innovative solutions for Australia's defence and national security. Through its partnerships and alliances with industry, academia and other research organisations within Australia and overseas, DST greatly benefits from the knowledge, expertise and capability thus obtained, thereby ensuring it can continue to provide world-class outcomes for Defence.

PARTNERING WITH INDUSTRY

No new alliance agreements were signed during 2016–17 but there were noteworthy developments with existing alliances.

INTERACTIVE PROJECT AGREEMENTS

New interactive project agreements (IPAs) were established with:

BAE Systems

- Development, deployment and operational assessment of corrosion prognostic health management
- Corrosion management system support for Joint Strike Fighter
- Characterisation of single photon avalanche diode camera
- Sensor performance mine blast survivability study.

Lockheed Martin

- Over-the-horizon radar 2D array
- Passive sonar tracking for future undersea warfare.

Thales

- Sonar processing and performance prediction.

Qinetiq

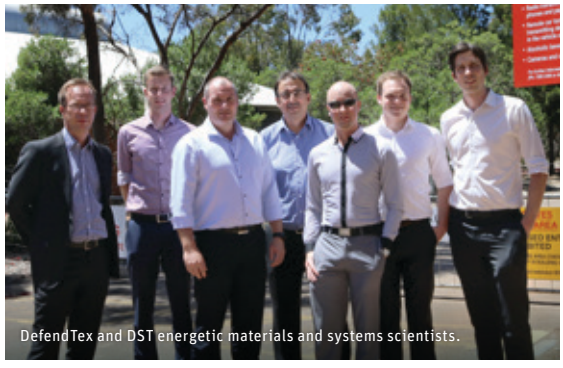
- Assessing damaged composite aircraft structures.

ASC

- TIG welding of submarine pressure hull plates
- Collins diesel engine reliability and performance improvement support (building on a previous IPA that concluded).

SMALL-TO-MEDIUM ENTERPRISES

A collaborative R&D agreement was signed with Grollo Aerospace to enhance the performance of its supersonic aerial target, Evader, which replicates the flight characteristics of advanced airborne threats. This will give Defence a means to gauge the effectiveness of enemy weapons systems targeting Defence aircraft.



DefendTex and DST energetic materials and systems scientists.

A collaborative R&D agreement was also signed with DefendTex Pty Ltd to explore innovative next-generation technology applications in the areas of energetic materials and systems, collaborative weapons and hypersonics. DST and DefendTex have, in addition, signed a staff secondment and exchange agreement to provide opportunities for staff placements and exchanges in support of the collaborative program.

Nick Beagley attaches a Fight Recorder prototype which is being developed by two SMEs as a tracking beacon to monitor battlefield incidents.

SMALL BUSINESS INNOVATION RESEARCH FOR DEFENCE

The Small Business Innovation Research for Defence (SBIRD) program has been developed to further enhance engagement with small-to-medium enterprises (SMEs) during the early research stages of a project. The program will help SMEs explore their technology potential through research projects aligned with Defence strategic research priorities under the Next Generation Technologies Fund.

There are two stages in the SBIRD program. Stage 1 (6–9 months) will research the feasibility of a technology solution while in Stage 2 (12–24 months) the concept will be tested against the application in a laboratory setting. SBIRD projects will produce a concept demonstrator.

The program has a focus on future applications (such as adaptive camouflage) to be developed in a two to three year timeframe. Promising early stage concepts will be fast tracked for further development within the Defence innovation system.

The total investment in the SBIRD program is estimated at $10 million over ten years.

Workshop on Small Business Innovation Research for Defence (SBIRD).

TECHNOLOGY LICENSING

The microbolometer thermoelastic evaluation (MiTE) technology developed by DST has been licensed to LRM Technologies for production and sale worldwide. MiTE is a breakthrough stress measurement system that uses small, low-cost infrared cameras to capture high-resolution close-up images of structural stress at critical hot spots. It has particular relevance for use on high performance aircraft that are routinely exposed to severe stresses. MiTE has been successfully trialled on full-scale Joint Strike Fighter fatigue tests in the US and UK. The technology can also be used for detecting manufacturing defects and monitoring fatigue cracks in civil and maritime infrastructure.

DST also executed a licence with Daronmont Technologies in 2016 for commercialisation of its passive coherent location radar technology.

Passive radar is a game-changing sensor technology that uses background sources of radio frequency energy, such as broadcast television, radio and geosynchronous satellite transmissions, as the source of radar illumination for detecting moving targets, which can therefore be undertaken covertly. DST's world-class research capability for passive radar research has been used to develop and test a range of experimental passive radar systems.

Another licence agreement was signed with the Adelaide-based Precise Advanced Manufacturing Group, which will commercialise and market a unique drilling tool developed by DST. The hole rework alignment tool drills accurate holes for aircraft repairs, and has great potential for application to work that demands precise hole tolerances or where the costs of rectification are high.

Ivan Cooper
(Chairman, LRM Technologies)

Grant Tinney
(CEO, Precise Advanced Manufacturing)

Mark Grollo
(MD, Grollo Aerospace)

PARTNERING WITH UNIVERSITIES

The Defence Science Partnerships framework (DSP) was set up in mid-2014 to enable Australian universities to partner with DST on research projects under a standardised model of engagement. With James Cook University and the Australian Catholic University having joined in 2016–17, the number of universities currently in the DSP now amounts to 32, and other universities have expressed interest in joining in the near future.

The DSP framework, though predominantly used by DST for partnering, has been set up to enable all of Defence to partner with participating Australian universities for research and collaboration. Facilitated by DST, the Royal Australian Air Force entered into three DSP agreements in 2016–17 valued at $10.8 million. During 2016–17, DST signed 348 agreements through the DSP with a value of $34.9 million. This amounted to $14.5 million more than last financial year, a 71% increase.

UNIVERSITIES IN THE DEFENCE SCIENCE PARTNERSHIPS PROGRAM

NEXT GENERATION TECHNOLOGIES FUND

Under the Next Generation Technologies Fund universities were invited to contribute proposals for small-scale research projects of up to twelve months in duration. Eight themes were selected from the priority areas of work identified in the Defence White Paper:

- Cyber Electronic Warfare
- Integrated ISR
- Space Capabilities
- Trusted Autonomous Systems
- Enhanced Human Performance (in the air domain) and Resilience
- Quantum Technologies
- Advanced Sensors, Hypersonics and Directed Energy Capabilities
- Multidisciplinary Material Sciences.

Of the 428 submissions received, 59 agreements were signed, up to a value of $100,000 each. In total, $5.7 million was committed.

DEFENCE SCIENCE INSTITUTE CONNECTING UNIVERSITY PARTNERS

The Defence Science Institute (DSI) facilitates R&D connections that foster a globally engaged, competitive and innovative defence and national security sector. Founded in 2010 as a joint venture between DST and eight Victorian university partners, and supported by the Victorian State Government, DSI has since gone from strength to strength.

A recent DSI highlight included liaising with Lockheed Martin to showcase Australia as a vibrant Defence R&D ecosystem, resulting in a commitment by Lockheed Martin of $13 million to establish the STELaR Lab in Victoria. DSI also provided support to Lockheed Martin to mount its Meet the Technologist event in December 2016, through which Australian researchers were given the opportunity to pitch their research ideas to senior Lockheed Martin scientists. In another notable development, DSI with the Victorian Government and its Victorian university partners formulated a business plan to establish the Oceania Cyber Security Centre (OCSC). The OCSC is now operational and is bringing industry and academia together to foster training and research needs in the cyber domain.

DSI also held an inaugural DSI symposium and a combined student conference with the Defence Materials Technology Centre and the Research Training Centre for Naval Design and Manufacturing. It has in addition maintained a presence at Australian defence expos, having run the PitchFest event at Land Forces 2016, and supported the development of more than 30 international journal and conference papers published during 2016–17.

OTHER STATE-BASED UNIVERSITY PARTNERSHIPS

During 2016–17, DST worked with South Australian Universities and the SA State Government to form the Defence Innovation Partnership. DST has also been

Launch of Defence Innovation Partnership SA.

working with universities in New South Wales and the state government to form the Defence Innovation Network, which is expected to become operational in late 2017.

DISCIPLINE-BASED UNIVERSITY PARTNERSHIPS

HPRNET

The Human Performance Research Network (HPRnet) was established by DST and Army in 2016. Its purpose is to join leading researchers in Australian academia into cross-disciplinary teams for work that will lead to physical and cognitive improvements in Defence personnel performance. Army funds HPRnet and DST leads the collaborative research projects.

A total of $3.14 million over four years has been committed by the Australian Government to its establishment and operation, and over $1.8 million and $4.4 million of in-kind support have been committed by

partnering universities. Seven universities are currently part of the network, including:

- Curtin University
- Deakin University
- University of Canberra
- University of New South Wales
- University of South Australia
- University of Western Australia
- Victoria University.

CYBER RESEARCH CAPABILITY PARTNERSHIPS

DST and Data61 (CSIRO) have entered into a strategic partnership to jointly accelerate the growth of Australia's national cyber research capacity. Starting with fourteen projects in the first year, DST and Data61 researchers are now working with several Australian universities on future-focused research. The research areas include:

- Influence and analytics
- Sensing to effects
- System design for resilience and autonomous systems
- Trustworthy systems
- Formal methods
- Autonomous cyber systems
- Vulnerability research
- Adversarial machine learning
- Network knowledge reliability and provenance
- Enterprise network security.

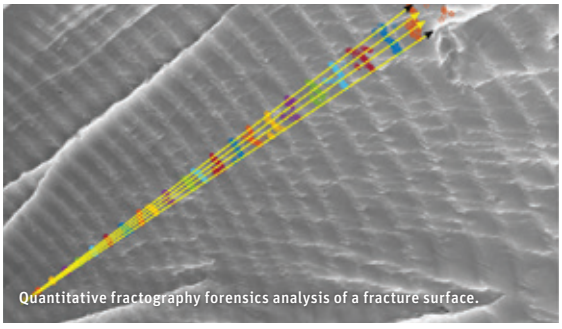
This partnership is supported by the Next Generation Technologies Fund.

TWO RESEARCH PROJECTS WITH UNIVERSITIES

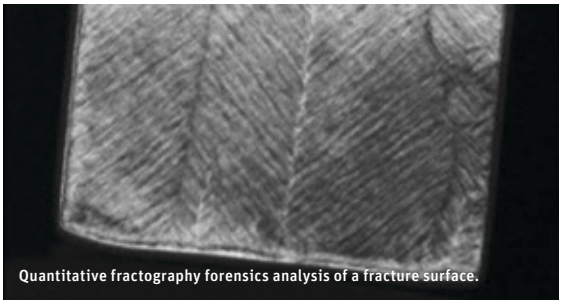
AUTOMATION OF QUANTITATIVE FRACTOGRAPHY FORENSICS TOOL

With the University of Queensland, DST is undertaking work to automate or semi-automate an investigative technique known as quantitative fractography (QF) that is critical for aviation forensic, accident investigations and aircraft structural life assessments.

The challenges of applying QF are that it is time-consuming and labour-intensive, and the results may be affected by the skill, experience and level of attention of the operator.



Quantitative fractography forensics analysis of a fracture surface.



Quantitative fractography forensics analysis of a fracture surface.

The R&D collaboration seeks to overcome these problems by integrating innovations in image processing in the field of medical imaging and handwriting and facial recognition into the QF system. The preliminary results of this work were presented at the 2017 Australian International Aerospace Congress.

FERROELECTRICS

Relaxor ferroelectric single crystals, also known as ternary piezoelectrics, show high promise as materials for the design of next generation sensors, transducers and actuators due to their outstanding electromechanical properties and durability.

DST is leading a relaxor ferroelectrics work program focused in the Defence priority areas of multidisciplinary materials and advanced sensors while also supporting the condition-based maintenance and prognostic health management focus areas in RAAF's Plan Jericho.

The program is drawing on expertise in the University of Wollongong, University of Sydney, Monash University, Thales Australia, the Office of Naval Research Global and the five-Eyes nations. It includes the establishment of a Centre of Expertise in Relaxor Ferroelectrics which has delivered an indigenous crystal manufacturing capability developed by Thales Australia.

PARTNERING WITH OTHER GOVERNMENT ORGANISATIONS

DST maintains strong strategic relationships with publicly funded research agencies including the Australian Nuclear Science and Technology Organisation (ANSTO), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BOM).

This year, DST's Technology Partnerships Office successfully negotiated a MoU for collaboration with the Australian Institute of Marine Science (AIMS). The MoU allows for detailed information, capabilities and resources to be shared in delivering research benefits for Australia.

CROSS DOMAIN DESKTOP COMPOSITOR DEMONSTRATION

The Cross Domain Desktop Compositor (CDDC), which allows the content from multiple computers of different security classifications to be viewed securely on a single screen, was developed by DST in partnership with Data61 (CSIRO). A working prototype of the CDDC was demonstrated at the Avalon International Aerospace and Defence Exposition in March 2017. The technology has since won two national innovation awards from the Australian Information Industry Association.

The CDDC display showing various inputs displayed on a single screen.


Mark Beaumont and Chris North.

INTERNATIONAL ENGAGEMENT

International engagement continued to be a key driver within DST for enhancing defence science and technology capability. Partnerships with allies and regional partners are critical for maintaining Australia's access to world-class technologies, ensuring Defence has advanced capabilities and the ability to operate effectively with its partners. During 2016–17, DST continued to strengthen relationships with its traditional partners.

Additionally, in accord with the 2016 Defence White Paper and the DST Strategic Plan, DST undertook to build and strengthen its relationships in the Indo-Pacific region through various means. One initiative was to host a number of delegations from regional partners to continue discussions on S&T collaboration. Another was by participating in the inaugural Australia-India Joint Working Group on Defence Materiel and Research in New Delhi.

As well, DST participated in the inaugural Australia-Japan Defence Equipment and Technology Cooperation Committee in Melbourne in March 2017 – the first formal dialogue with Japan on S&T and industry issues. As these relationships develop, DST will work with its regional partners to identify and scope potential S&T areas of collaboration that deliver mutual benefit.

DST also hosted the 51st TTCP Principals' Meeting in Sydney in September 2016. TTCP offers the most important means through which Australia can embark on multinational S&T collaborations in Defence science, having involved close partnerships with the US, UK, Canada and New Zealand for several decades already. By fostering cooperation between the S&T organisations of all five nations, TTCP ensures that unnecessary duplication across national programs is avoided and maintains awareness of each other's programs and priorities. The Principals' Meeting provided an excellent opportunity for DST to discuss the valuable work it is doing on capability development in the increasingly important domains of cyber and autonomous systems.

Dr Mark Petrusma with Korean delegates Dr Yong-Woon Park and Dr Inho Kim.

Jeep fitted with DST's Satellite-On-The-Move unit for the TORVICE trial.

INTERNATIONAL TRIAL IN WOOMERA

In September 2016, DST assisted a US Army trial to test the operation of a semi-autonomous land vehicle at the Woomera Test Range guided via satellite link from a control centre half a world away in the United States.

The Trusted Operation of Remote Vehicles in Contested Environments (TORVICE) research program is a major collaborative initiative involving a partnership of DST with the US Army Research, Development and Engineering Command that straddles a range of technology areas. The primary aims were to demonstrate reliable remote operation of a semi-autonomous unmanned vehicle in order to investigate vehicle vulnerabilities that could be exploited by an adversary as well as solutions to those vulnerabilities.

In this Australia-US research partnership, the US Army Tank Automotive Research and Engineering Center provided access to its world-class technologies in vehicle autonomy. DST, meanwhile, served as the red-team adversary seeking to defeat the remotely operated vehicle, pulling together multi-disciplinary teams with expertise in sensor systems, surveillance and reconnaissance, electronic warfare, information architectures, satellite communications capabilities and precision navigation and timing.

The research program is part of a long-term strategy aimed at developing confidence in the use of autonomous vehicles and exploring their utility in human-machine teaming. With the first trial in 2016 having successfully provided insights into the complexities of remotely operating vehicles from the other side of the globe, a follow-on trial towards the end of 2017 will investigate red teaming challenges for vehicle operations posed by electronic warfare and communications disruption capabilities. Further trials will then seek to mitigate any exposed vulnerabilities. The trial series is an excellent opportunity for DST and the Australian Army to form a strong enduring partnership with one of the world's leading military vehicle R&D organisations.

STATE-OF-THE-ART AUSTRALIAN-GERMAN WIND TUNNEL TEST TECHNIQUES

DST engaged with the German Aerospace Center (DLR) to enhance the aerodynamic measurement capabilities of its wind tunnels. A DST staff member was posted to DLR and worked alongside world leaders from its Institute of Aerodynamics and Flow Technology.

DST scientist Peter Manovski (third from left) on posting at DLR with colleagues.

DLR's state-of-the art 4D Lagrangian particle tracking method, called Shake-The-Box, extracts particle trajectories from volumetric flow measurements of complex flow phenomena. The work involved the use of high-speed cameras to capture images of neutrally buoyant helium-filled soap bubbles in flows illuminated by high-powered LEDs.

DLR's novel particle tracking technique tracked up to thousands of bubbles with unprecedented spatial resolution and accuracy, enabling data on their velocity, acceleration and acoustic fields to be extracted. The experience gained by DST will significantly enhance its capabilities to analyse the aerodynamic and hydrodynamic properties of ADF air and maritime vehicles.

Flow of helium-filled soap bubbles being tracked with high-speed cameras in particle trajectory research aimed at enhancing wind tunnel measurement capabilities.

IMPROVING ANALYSIS OF THREAT SYSTEMS

DST has expanded and evolved its collaborative relationship within the international complex-threat modelling, simulation and analysis community and is adopting a sophisticated simulation and analysis environment known as the Integrated Threat Analysis and Simulation Environment. A significant milestone occurred in 2017 with an international red-teaming exercise that brought together representatives from the premier threat modelling and analysis teams of the US, UK and Australia. The discovery and outcomes generated through this collaboration are enabling DST to advance its complex tactical engagement analysis capabilities and strengthen its ability to provide significant advice to the ADF on countermeasures in realistic and complex battlespace problems such as those of integrated air and missile defence.

A Remus 100 AUV owned by DST being retrieved from the waters of Loch Alsh during the multinational 2016 Unmanned Warrior trials.

MULTINATIONAL UNMANNED WARRIOR TRIALS

In October 2016, a DST team travelled to Loch Alsh, Scotland, to participate in the mine warfare component of a UK-hosted multinational exercise called Unmanned Warrior 2016. This was part of a series of exercises called the Hell Bay trials, which have been conducted over the past four years in various parts of the world for TTCP partners.

The Unmanned Warrior participants also included teams from the US, Canada and UK. The DST team took with them a Remus 100 Autonomous Underwater Vehicle (AUV) incorporating a DST-developed autonomy payload. The valuable work carried out by the DST team included benchmarking autonomous target recognition systems for mine counter-measures and developing a universal interface for integration with a high-level command and control system produced through a UK-led R&D program. They also worked with the US team to develop autonomous behaviours and a common communications protocol for enabling a variety of underwater vehicles to collaborate on achieving a goal.

This work culminated in a demonstration in which an Australian AUV autonomously detected an object of interest on the seafloor and then instructed a US AUV to investigate the object, all achieved without any operator intervention. A short-term outcome of this work will be to assist the development of an international standard for AUV interoperability, and in the longer term, it will contribute to the evolution of next-generation autonomous mine countermeasures capability for Navy.

A number of other trials were conducted during the 2016 Hell Bay event, demonstrating state-of-the-art developments in the effectiveness and robustness of unmanned systems for military use. The 2016 trials involved the deployment of unmanned aerial vehicles, unmanned surface vehicles and unmanned underwater vehicles. Future trials will build on this progress towards achieving a goal of end-to-end autonomous systems-of-systems for mine countermeasures.

The next trial called Autonomous Warrior 2018 is to be held next year at Jervis Bay.

DST's low speed wind tunnel in Melbourne.

JOINT AUSTRALIAN-JAPANESE HYDRODYNAMICS RESEARCH PROGRAM

Japan's Acquisition, Technology & Logistics Agency (ATLA) and DST have begun testing a generic diesel electric submarine geometry in support of the Letter of Arrangement regarding Joint Research on Marine Hydrodynamics between the two countries. Comparative experiments have been conducted on the same generic submarine geometry at the DST low speed wind tunnel in Melbourne and ATLA's large towing tank in Tokyo. These experiments will improve understanding of hydrodynamic behaviour of submarines and the surrounding flow structures. The data will also be used to validate comparative computational fluid dynamics simulations. The program offers a valuable opportunity for DST and ATLA to work together to improve their respective experimental techniques and will further develop DST's ability to carry out hydrodynamic design evaluations of the Future Submarine and other platforms.

INTERNATIONAL COLLABORATION FOR AIRCRAFT WEAPONS RELEASE STUDIES

Together with partners from the US (Sandia NL), UK (Dstl) and Canada (NRC), DST has conducted studies using computational fluid dynamics (CFD) analysis and wind tunnel testing to advance knowledge about the behaviour of weapons (called stores) released from aircraft. The work aimed to develop the best means for quantifying and validating some of the factors associated with stores release from weapons bays. In addition, advanced CFD techniques were explored to predict store release trajectory. DST's involvement with this project has enhanced Australia's stores clearance study capability for current and future platforms. This will ultimately enable store trajectory modelling to be undertaken with increased confidence, thereby significantly reducing the cost and risk associated with certifying weapons for safe carriage and release from aircraft.

DST-DSTL COLLABORATION ON LAND COMBAT VEHICLE STUDIES

UK's Dstl and DST are working together to develop, refine and apply methods and techniques for analysing the survivability of land combat vehicles. While future technologies may offer significant potential to mitigate specific threats, those solutions must be investigated for possible negative impacts.

An illustration of threat mitigation solving one problem but exacerbating another is that of adding armour to increase protection, which meanwhile reduces a platform's tactical mobility.

The DST-Dstl collaboration enhances DST's ability to evaluate disparate risk mitigation technologies across all layers of the traditional 'survivability onion'.

The joint work has used the UK-developed Mounted Integrated Survivability Toolkit, which assesses the risk to land platforms when exposed to a wide range of threats and in a variety of contexts. This method complements combat simulation and other operations analysis undertaken by DST, providing an ability to more quickly survey survivability trade-offs and thereby help focus analytical effort.

Outcomes of the study were provided to Army, receiving strong endorsement for the study methods and collaborative approach adopted.

TITANS FATIGUE TESTING COLLABORATION

DST has initiated an international collaboration called the Transglobal Integrated Tests and Analyses Network for Structures (TITANS) that aims to make savings on the cost and time required for the certification of new aircraft types by establishing virtual fatigue testing methods.

TITANS was launched at the 29th International Committee on Aeronautical Fatigue Symposium in June 2017 and has attracted high-level interest from key players in the aircraft structures area.

The US Air Force Research Laboratory, the US Naval Air Systems Command, the US Federal Aviation Authority, Boeing, the National Institute for Aviation Research, the National Research Council Canada, Airbus, the Netherlands Aerospace Centre and the German company, IABG, have agreed to participate.

FULBRIGHT CHAIR IN ADVANCED SCIENCE & TECHNOLOGY

DST sponsors the Fulbright Distinguished Chair in Advanced Science and Technology which brings senior researchers from the United States to Australia for short-term appointments at DST or an Australian research institution linked to DST. A key benefit of the program is the opportunity for the Chair to explore longer-term collaboration and create mutually beneficial links with institutions in Australia.

The 2017 Distinguished Chair was Dr Angus Rupert from the US Army Aeromedical Laboratory in Alabama. Dr Rupert, an expert in spatial disorientation, worked alongside DST researchers for seven months exploring how multi-sensory cueing technology may be used to reduce the spatial disorientation often experienced by pilots when operating in conditions of poor visibility.

Dr Rupert's expertise in the use of tactile cues greatly complemented DST's work in the use of visual guidance.

DST Fulbright Fellow Angus Rupert checks the sensory garment while Maria Gavrilescu trials a tactile belt cueing system.

The Indigenous Garma Festival in Gulkula, North East Arnhem Land, attended by senior DST leadership personnel.

OUTREACH, DIVERSITY AND INCLUSION

DST reaches out to foster the development of new talent, supports the career development of future leaders and helps shape workplace diversity through inclusion. These efforts were increased during the year by engaging with schools, tertiary institutions and community development programs.

During the year, student placements into DST increased to 68, with a record number of 21 STEM cadetships awarded. Of these students, seven graduated to ongoing employment in December 2016 and a further ten the following year. Over a hundred student placements projects will be offered and 36 cadetships will be recruited for the 2017–18 programs.

The second Defence Student Conference was held in February 2017. This served as a finale to the student placement programs, enabling each student to showcase their experience of research work through presentations.

Planning for this year's STEM Day as part of Partnerships Week 2017 drew enormous interest with over 130 attendee registrations. Among those participating were a range of professionals who influence the pathways taken by future talent – tertiary academic advisers, student relationship managers, education and curriculum managers and representatives from publicly funded research organisations and government with career guidance roles. The aim of the day was to enhance partnerships that will foster the development of future STEM talent and attract high-achieving employees who will drive innovation.

Delegates participated in workshops.

Students sample VR technology.

As new partnerships emerge, more opportunities will be provided for scientists to contribute in a greater variety of outreach and engagement activities, which in turn will help build a positive reputation for DST in the community.

As part of its science outreach and inclusion work, DST hosted a visit to its Edinburgh laboratories organised through CSIRO's Aboriginal Summer School for Excellence in Technology and Science (ASSETS) program. Designed specifically for high-achieving Year 10 Aboriginal and Torres Strait Islander students with an interest in science, the ASSETS visit was undertaken to enable them to experience science excellence and to learn about STEM career pathways. In Melbourne, a group of Year 11 and 12 students visited DST's Fishermans Bend laboratory for a tour of activities as part of the Australian & New Zealand Association for the Advancement of Science residential STEM program.

As part of National Science Week 2017, DST participated in the Garma Festival's Youth and Education Forum and Careers Exhibition in order to foster Indigenous student interest in defence science and technology. With more than two hundred students looking on, DST personnel performed interactive experiments and promoted programs designed to build STEM skills and encourage further STEM learning.

In alignment with Defence's Reconciliation Action Plan 2015–2018, DST seeks to attract and develop a strong and capable Indigenous workforce, to foster knowledge of Indigenous culture among all staff and to make advantageous use of their diverse perspectives, experience and knowledge. DST will recruit a further 26 Aboriginal and Torres Strait Islander employees in 2017–18, seeking to provide pathways for them into S&T careers via cadetships, apprenticeships and specialist technical roles.


Cadetship graduation ceremony at the 2017 DST Student Conference (L–R): Jonathan Milford, Ricardo Canizzaro, Joyce Mau, Laura Hodges, Mitchell Cosmo, Dylan Dwyer, Nathan Fisher.

DST scientists Niem Tri and Kasia Krysiak visit Doncaster's Milgate Primary School.

DEFENCE SCIENTISTS IN AUSTRALIAN SCHOOLS

DST staff from a large number of domains and divisions as well as scientific disciplines continued their broad participation in the CSIRO-led STEM Professionals in Schools program. Seven of DST's Aerospace Capability Analysis scientists participated in the program, providing their time and expertise on a voluntary basis to teach at the primary and secondary level. A scientific publication describing particular details of their engagement activities is being produced. For further information see www.scientistsinschools.edu.au

Twelve Alexandria Park Community High School students spent a week with DST scientists learning about DST, Navy and science. Highlights included a wide range of talks from DST Sydney staff and visits to Fleet Base and the Garden Island Dockyard.

DST staff also provided community outreach support via:

- A scientist resident at Canterbury Public School who gave talks and ran workshops with students and teachers
- A stall during Science Week at the Australian Museum on the theme of Droids, Drones and Robots, featuring a drone, infrared camera and various interactive experiences
- Assistance for Canterbury Public School's participation in a national star-gazing event
- Participation in monthly ABC Radio segments and online science communications.

MATHEMATICS ENRICHMENT PROGRAM IN CANBERRA

The Canberra Mathematics Enrichment Program, presented for school students by DST staff and the Australian Mathematics Trust over the past 15 years, doubled the number of participants from 60 to 120 during 2016–17, and now runs for 26 weeks per year.

The program offers extra-curricular enrichment sessions with an emphasis on problem solving in a fun and relaxed atmosphere. It also offers students the opportunity to participate in the International Tournament of the Towns – a Russian-organised international competition in which ACT students have participated many times.

The main Partnerships Week hall in DST Edinburgh.

PARTNERSHIPS WEEK IN ADELAIDE

In August, the third Partnerships Week was held at the DST laboratory in Edinburgh, attracting more than 500 visitors from industry, academia, government, the education sector and the scientific community. This annual event is part of DST's drive to strengthen external engagement with partners and stakeholders.

The event is continually evolving with external partners now playing an increasing role in the program of presentations, demonstrations and workshops. 'Partner and Prosper' was the theme of the 2017 event. Small business was the focus this year and a number of SMEs were keynote speakers. They also had the opportunity to pitch their technical capability to an audience of senior Defence staff.


Small businesses pitch their ideas to senior Defence staff.

Delegates were introduced to the Small Business Innovation Research for Defence program which is being established under the Next Generation Technologies Fund to increase the involvement of SMEs in contributing towards Defence capability.

Signing of new collaboration agreements is an important feature of Partnerships Week. This year DST signed an agreement with DefendTex on researching energetic materials, a three-year agreement with Sonartech Atlas to explore new technologies for ADF naval capability, and a five-year agreement with Chemring Australia to develop advanced techniques for the manufacture of high-performance countermeasures.

Highlighting STEM education is another aspect of Partnerships Week. Vocational education speakers participated in STEM workshops and shared ideas and strategies to drive careers in science, technology, engineering and mathematics, particularly within Defence.

AWARENESS AND REPUTATION

Raising DST's profile and enhancing the reputation of science and technology are central to attracting partners with the most relevant expertise to collaborate on Defence research.

The campaign for the Next Generation Technologies Fund provided a fresh impetus to promote partnerships and collaboration for the Grand Challenge program, the Defence Cooperative Research Centres program and the Emerging Disruptive Technology Assessment Symposiums.

Coverage in mainstream media, Defence-specific publications and social media continued to improve during the year.

Extensive effort was invested in showcasing Defence technologies and collaboration opportunities through participation in high-profile events. These included the Future Land Force Conference, the Australian International Airshow, the International Aerospace Congress, the ADM Congress, Science Meets Parliament, Science Meets Business, D+I Conference, the Clunies Ross annual conference, the National Security Summit, the *Australian Financial Review* Innovation Summit and the Eureka Prizes.

DST's reputation for scientific excellence was further validated by a successful nomination for the highly valued Clunies Ross Award. Darryn Smart, who was the key figure in the development of the Redwing suite of counter-IED equipment which won the 2016 innovation award from the Institute of Public Administration Australia, was also recognised for the same project with a Knowledge Commercialisation Award from the Australian Academy of Technology and Engineering which organises the Clunies Ross Awards. DST proactively competes for prestigious science and innovation awards to benchmark its work against other contenders.

To facilitate internal collaboration among research scientists, DST took a big leap forward by launching the Science and Technology Unified Research Network (SATURN), a one-stop digital workspace with social tools that improve interactions among staff, including communication and the ability to partner on projects, share knowledge and expertise. In the future SATURN could be made available to external networks to enable improved collaboration with industry, academia and international partners.

The Minister for Defence, Senator the Hon Marise Payne at DST's Airshow booth.

S&T PUBLISHING

The major achievement in 2016–17 for S&T Publishing was the implementation of the S&T publication approval workflow in the Objective software application. This is an electronic approval system to automate and streamline the approvals of all S&T publications produced by DST, including external publications and internal reports. Some significant benefits delivered by the system include:

- Solving the problem of tracking the progress of publications
- Being flexible enough to handle the approval requirements of a variety of publications
- Simplifying the processes for archiving and distributing the reports.

Formal training for authors producing S&T publications was also offered during the year. S&T publications in PDF format are being produced to ISO standard PDF/A-1 to meet accessibility and diversity requirements.

4

INVESTING IN OUR PEOPLE, OUR ASSETS, OUR SUCCESS

VALUING OUR PEOPLE

DST places high priority on nurturing career development to ensure personnel achieve their full potential as researchers and future leaders, and deliver outstanding scientific support to Defence. A range of initiatives to promote talent, diversity and career development is yielding results.

LEADERSHIP, ACCOUNTABILITY, LEARNING AND DEVELOPMENT

RECRUITMENT

After a lengthy period of downward pressure on staffing numbers, DST achieved the required levels during 2016–17. The introduction of an agreed recruitment strategy resulted in:

- The successful consolidation of DST's benchmark chief-of-division selection approach
- The identification of 82 priority vacancies requiring the engagement of new skill sets
- The advertising of 75 S&T middle-management roles
- Planned programs of entry-level recruitment for apprentices and cadets
- Five places filled in the new Defence Graduate Research and Innovation Stream pilot program.

Seven chief-of-division roles were filled during the year, including:

- Two level-1 roles, one as Chief of the Science and Technology Program Division and one as Chief Technology Officer, National Security Division (both divisions newly formed)
- One for the enabling division, Science Partnerships and Engagement Division
- Four replacement chiefs for the research divisions of Aerospace Division, Cyber and Electronic Warfare Division, Joint and Operations Analysis Division and National Security and ISR Division.

The chief appointments for three of the divisions – Aerospace Division, National Security and ISR Division and Science Partnerships and Engagement Division – were selected from outside Defence.

With all divisions now having appointed chiefs (some roles during the last period were filled temporarily with acting appointments) DST's leadership team is now set to enjoy a period of consolidation and growth during 2017–18.

DIVERSITY AND INCLUSION

As part of DST's recruitment strategy in 2016–17, a 'blind' recruitment process was applied on a business-as-usual basis. Designed to assist the management of unconscious bias, this approach involves the removal of personal and diversity indicators before employment applications are assessed to ensure selection decisions are made on the basis of merit.

As a follow-on from acceptance in 2015 into the national SAGE Athena Scientific Women's Academic Network (SWAN) program, DST established its SAGE Pilot Self-Assessment Team (SAT) in 2016–17. SAT was formed to gather information and develop an action plan that will facilitate completion of the Athena SWAN Bronze Award application. It consists of four working groups: Data Collection and Analysis, Organisation and Culture, Career Progression and Specific Focus Areas.

PULSE POLL

A Pulse Poll was conducted in September 2016 to gauge continuing trends in DST staff perceptions of progress made towards achieving Strategic Plan objectives. This was undertaken in preparation for a Pathway to Change

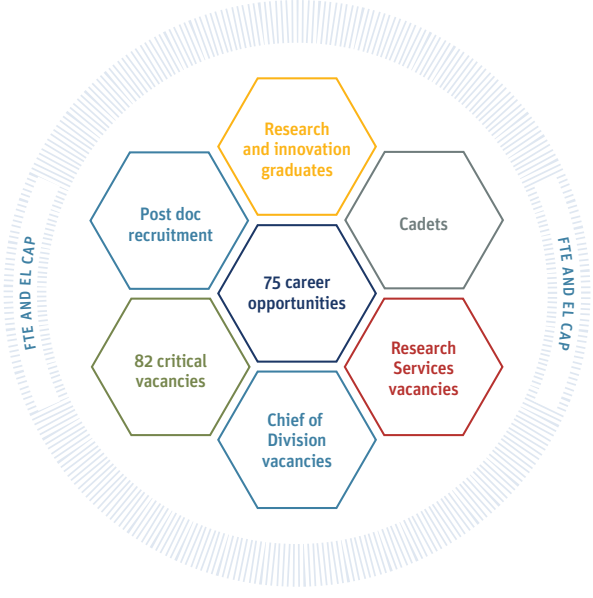
Insights survey to be conducted in July 2017. The results of the Pulse Poll indicated further increases in staff satisfaction regarding opportunities to participate in action planning, and also indicated increased confidence that the Insights program will lead to tangible improvements.

DEVELOPING LEADERSHIP

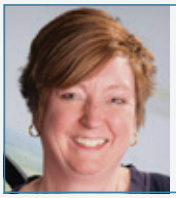
While continuing to offer its suite of Scientific Leadership Development programs, DST in 2017 initiated a set of Leadership Exploration and Development in Science programs. These will bolster scientific management capability and assist with succession planning for future S&T management roles.

In November 2016, the DST Career Development Guide was launched – a new career planning tool created under the auspices of the Talent, Diversity and Career Development (O2) Strategic Initiative. The guide will provide DST staff with a framework for career development that will promote diverse development opportunities, enable lateral movement and identify breadths of development for S&T staff, while also ensuring that staff remain engaged and enthusiastic contributors to high-quality outcomes for ADF.

DST RECRUITMENT PLAN 2017



Promotions



DR LYNN BOOTH

Chief Joint and Operations Analysis Division

DR DALE LAMBERT

Chief Cyber and Electronic Warfare Division

DR MICHAEL DAVIES

Chief Science and Technology Program Division

DR RICHARD DAVIS

Chief Technology Officer, National Security Division

New appointments

DR IAN DAGLEY

Chief Science Partnerships and Engagement Division

DR DONG YANG WU

Chief Aerospace Division

MR ANDREW SEEDHOUSE

Chief National Security and Intelligence, Surveillance and Reconnaissance Division

HIGH ACHIEVERS

2016 MINISTER'S AWARD FOR ACHIEVEMENT IN DEFENCE SCIENCE

Dr Brian Ferguson

MARITIME DIVISION

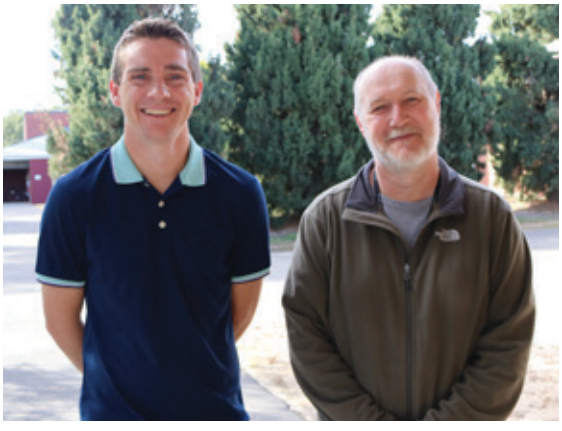
For outstanding achievements in the development of innovative acoustic and signal processing systems that have significantly enhanced ADF capabilities to identify and localise threats. Presented by The Minister for Defence, Senator the Hon Marise Payne.

CLUNIES ROSS KNOWLEDGE COMMERCIALISATION AWARD 2017

Darryn Smart

CYBER AND ELECTRONIC WARFARE DIVISION

For developing unique protection systems to counter improvised explosive devices, these systems having an estimated net benefit of $61 million.



2017 DAVID RIST PRIZE

DST operations staff

Awarded for their Coastal, Littoral, Estuarine and Riverine study, this is the first time a non-American entry has won the prize. The CLEAR study leads were Denis Shine and Nicholas Kempt (pictured) who accepted the award on behalf of the team.

The 2017 Rist Prize was awarded by the US Military Operations Research Society.

Award categories:

- Infrastructure and Platforms Innovation of the Year
- Research and Development Project of the Year

AUSTRALIAN INFORMATION INDUSTRY ASSOCIATION I-AWARDS

Cyber Cross Domain Desktop Compositor team

CYBER AND ELECTRONIC WARFARE DIVISION

Mark Beaumont, Suneel Randhawa, Chris North, Paul Buckland, John Shield, Angela Billard, Brad Hopkins, Sam Chenoweth, Patrick Prendergast.

For developing the Cyber Cross Domain Desktop Compositor, which allows content from multiple computers of different security classifications to be viewed securely on a single screen.

2017 AEROSPACE AUSTRALIA DEFENCE INDUSTRY INNOVATION AWARD

DST and BAE Systems Australia

For the development of a corrosion prognostic health management system for ADF's Hawk Lead-In Fighter, Seahawk Helicopter and F-35 Joint Strike Fighter.

The award was received by Aaron Sudholz of DST and James Waldie of BAE Systems Australia.

ROYAL AERONAUTICAL SOCIETY 2016 AVIATION SAFETY AWARD

Andrew Becker and Peter Stanhope

For the development of a filter screening tool to capture debris in the engine and gearbox oil of RAAF's PC-9/A trainer aircraft.

ORDER OF AUSTRALIA

Dr Alex Zelinsky

CHIEF DEFENCE SCIENTIST

Recognised for distinguished services to defence science and technology, engineering systems and education as an academic and researcher.

Seen here receiving the award from The Governor-General, His Excellency General the Honourable Sir Peter Cosgrove AK MC (Retd).

2017 SURFACE COATINGS OF AUSTRALIA LOU CASH MEMORIAL AWARD

Chris Lyons

MARITIME DIVISION

Awarded for the paper 'A Two-Pack Waterborne Topcoat for Royal Australian Air Force Aircraft'.

CHIEF DEFENCE SCIENTIST FELLOWSHIP

Dr Sanjeev Arulampalam

MARITIME DIVISION

To undertake investigations into multimodal information fusion for the development of new methods of target motion analysis – one of the key functions of submarine combat systems.

DST ACHIEVEMENT AWARDS 2016

SCIENCE AND ENGINEERING EXCELLENCE

Infectious Disease Detection and Forecasting Capability Development Team

LAND DIVISION

Peter Dawson, Branko Ristic, Ralph Gailis, Tony Lau and Alex Skvortsov.

For significant contributions to the establishment of an infectious disease detection and forecasting capability that will assist Defence, national security and public health authorities with disease control and management in the event of an outbreak.

TECHNICAL EXCELLENCE

MH17 Crash Investigation Team

CROSS DIVISIONAL

Dale Quinn, Russell Connell, Kelvin Bramley, Michael Grant, Nicholas Athiniotis, Jeremy Anderson, Andrew Hunt, Neal Winter, Kristian Allison, Simon Ellis-Steinborner, Tristan Goss, Lloyd Damp, Mark Chase, Anna Dostovalova, Daniel Billing and Anthony Travers.

For their tireless support of the Australian Federal Police investigation into the downing of Malaysia Airlines flight MH17 on 17 July 2014 in Ukraine.

SCIENCE AND ENGINEERING EXCELLENCE

Luke Rosenberg

NATIONAL SECURITY AND ISR DIVISION

In recognition of his work in support of the AIR 7000 maritime patrol project including the development of a novel sea-clutter simulation technique and the first-ever demonstration of the application of the velocity synthetic aperture radar algorithm on an airborne platform.

OUTSTANDING CONTRIBUTION TO DEFENCE OUTCOMES

Missile Warning Team

CYBER AND ELECTRONIC WARFARE DIVISION

Shane Kelly, Edward Watts, Bill Field and Victor Florea.

For exceptional work in identifying a capability shortfall arising from the integration of the missile warning sensor to the armed reconnaissance helicopter and multi-role helicopter, and subsequent dedicated and sustained effort in quantifying the impact of the shortfall, identifying the root cause and working to evaluate and refine potential solutions.

OUTSTANDING CORPORATE CONTRIBUTION

Explosives Management System Team

WEAPONS AND COMBAT SYSTEMS DIVISION

Sean Lightowler, Chad Prior and Matthew Smith.

For outstanding contribution, technical leadership and management of the DST Explosive Ordnance Reform Program Phase II over the last twelve months, and specifically, the design, development and delivery of a new DST-wide explosives management system.

OUTSTANDING CONTRIBUTION TO COLLABORATIVE PARTNERSHIPS

Linh Nguyen

CYBER AND ELECTRONIC WARFARE DIVISION

For his highly valued contributions to collaborations in support of Defence capability outcomes with international partners, Australian and US Defence contractors, and continued academic engagement with the University of Sydney.

2016 Achievement Award recipients.

OUTSTANDING EARLY CAREER ACHIEVER

Amir Galehdar

MARITIME DIVISION

In recognition of his scientific skill in the field of radar-absorbing materials, for having developed novel approaches to the design and measurement of radar absorbers, and for successfully transitioning the designs to full-scale industrial manufacture and installation on front-line ADF platforms.

OUTSTANDING COMMUNICATION OF SCIENCE AND TECHNOLOGY

Pina Dall'Armi-Stoks

WEAPONS AND COMBAT SYSTEMS DIVISION

For her passion, enthusiasm and dedication to STEM education in South Australian high schools and universities, and her efforts to promote DST as an active partner in STEM education within the broader scientific and engineering communities.

TTCP AWARDS

TECHNICAL PANEL 9 – LARGE ARRAY SIGNAL PROCESSING TEAM

Chaoying Bao, Derek Bertilone, David Crew and Warren Smith

MARITIME DIVISION

In recognition of the significant contribution made to the development of processing techniques that improve the performance of large passive sonar flank arrays and increase the sensing range of TTCP-nation submarines, current and future. The Large Array Signal Processing team developed and successfully assessed methods to implement computationally efficient and practically implementable adaptive array processing schemes that incorporate knowledge of the ambient noise structure. The work will help fully realise the potential of large aperture flank arrays to achieve undersea acoustic superiority.

TECHNICAL PANEL 3 – WATERSIDE RAPID DEPLOYMENT SECURITY SYSTEM TEAM

Ping Cao, Mark Hallett and Robert Winter

MARITIME DIVISION

In recognition of their timely and important research on harbour force protection. Their work on developing and applying harbour force protection technologies will enable TTCP nations to counter the real and immediate threat posed by terrorists and other asymmetric threats to naval ships and vital maritime infrastructure.

In addition, their efforts have helped to define and validate requirements, established a common baseline across the nations, informed tactics for port security personnel and provided necessary knowledge for future acquisitions.

INVESTING IN ORGANISATIONAL ENABLERS

During the year, investments were made in infrastructure and resources to enhance research capabilities and organisational effectiveness.

ENHANCEMENTS TO SCIENTIFIC ENGINEERING CAPABILITIES

Further investments were made to DST's advanced manufacturing areas, with new multi-axis machining, cutting, bending and inspection equipment being installed. These capabilities will deliver both greater capability and flexibility and will improve DST's ability to design and subsequently manufacture high-complexity high-risk items in a timely manner.

A new automated R&D scale-surface mount assembly and inspection line will allow electronics designs (including secure designs) to be developed and de-risked for more reliable operational deployments and transfer to industry.

SETTING OUR SOFTWARE FREE

The Open Source Our Software project aims to give DST the option and ability to release its software as free and open source. The benefits of doing so for DST and the science community at large are recognised to be improved science outcomes, reduced costs, enhanced reputation and the growth of collaborations.

The project was one of the winning proposals that emerged from DST's 2016 Innovation Day.

During 2016–17, the project developed Version 1 of a DST instruction that authorises staff to release software as open source if certain risk management measures are applied. The instruction is based on a policy that is already in use in another part of Defence. It was endorsed by the DST Leadership Team in March 2017 and is currently in provisional use in a number of divisions.

(L–R) John Taylor, John Henderson, Warwick Bradly, Steve McMahon and Jane Hatton.

ADVANCED S&T COMPUTING SUPPORT TO RESEARCH AND MODELLING

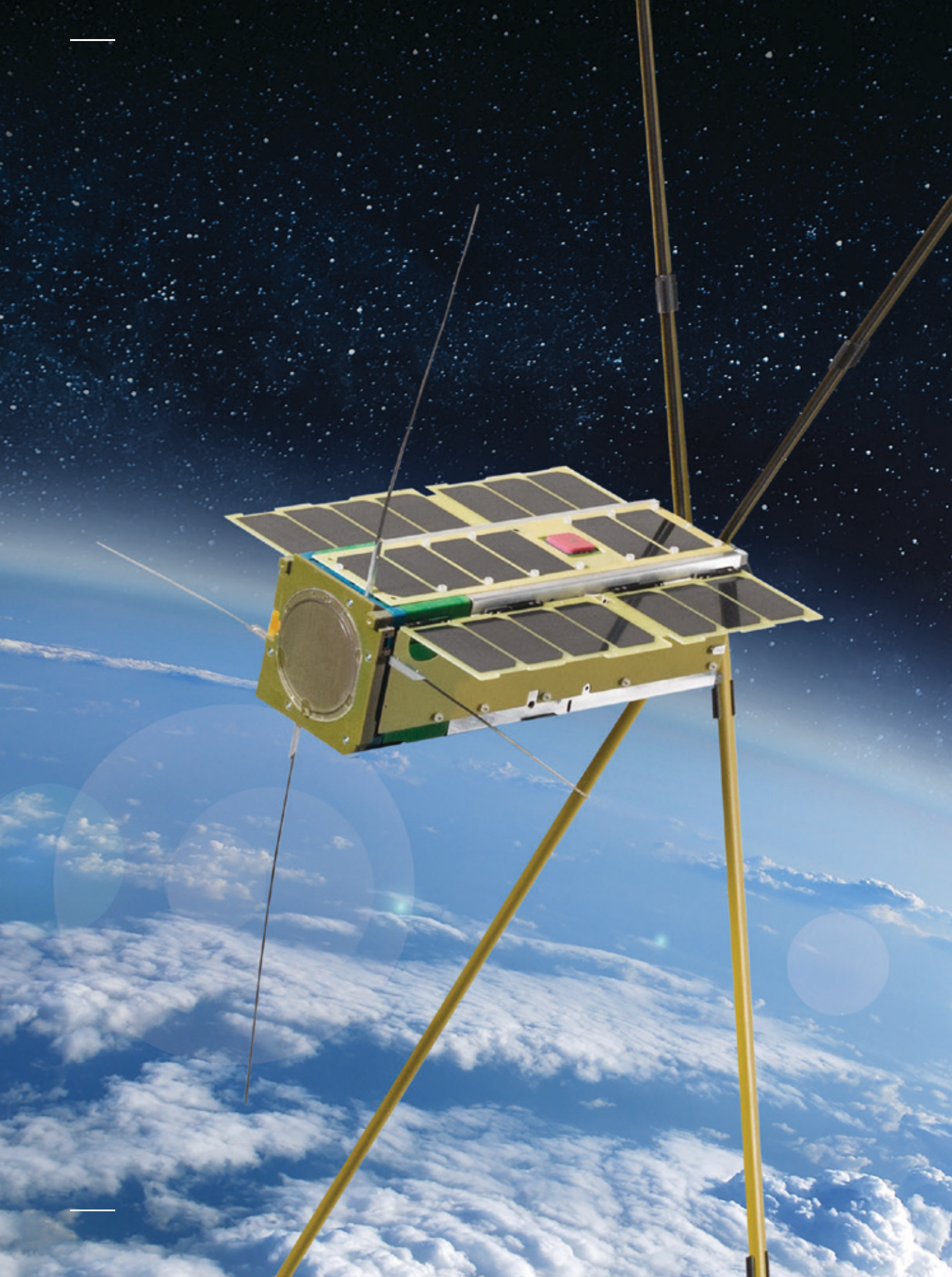
Through the Defence Integrated Investment Program, DST is acquiring a large-scale secure enterprise high-performance computing (HPC) capability to enable advanced S&T research, development, modelling and experimentation across Defence. Once approved, the project is planned to achieve an initial operating capability (IOC) in November 2019 and final operating capability in March 2021.

On 8 December 2016, Project ICT2286-1 received Defence Investment Committee approval to progress to Gate 2, Government approval, in September 2018. The Project Office was established in February 2017 and has commenced the development of the Gate 2 Business Case and supporting documents.

The Project Office has been working with the DST Facilities Team and Defence Estate and Infrastructure Group to ensure that the new centre to house the large HPC capability will be available in mid-2019, ready for equipment installation in advance of the IOC date. The Project Office has also meanwhile been preparing to purchase a pilot HPC system to train DST staff and help them become familiar with HPC-relevant aspects of computational science. The pilot HPC will be available from March 2018 and, together with the Project Office, will provide the support required to help ensure DST makes full use of the large HPC capability.

The benefits of a secure HPC service include:

- World-class computational science capability for defence research
- Faster and lower cost modelling or simulation of complex problems to reduce risk and improve scientific outcomes
- Exponentially improved speed and resolution of simulations leading to improved analysis and enhanced decision making
- Increased flexibility and scalability of computing power as problems become more complex and data availability increases
- Integrated ability to discover and consume data leading to higher value multi-domain data and information-driven decisions
- Modelling and simulation of real-world activities early in the capability life cycle rather than using, modifying or destroying valuable ADF assets in field experiments earlier than necessary
- Improved return on investment for military assets through strengthened design and operating decisions.



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EMERGING FUTURES

SHAPE OF THINGS TO COME

Foresighting studies provide insights into long-term futures and how broader socio-economic trends impact S&T developments. The study of emerging S&T areas enables Defence to avoid strategic surprise as well as exploit opportunities for building capability. DST's assessment of S&T trends was instrumental in shaping the key priority areas identified in the White Paper for further development into game-changing capabilities. These included integrated intelligence, surveillance and reconnaissance, space capabilities, enhanced human performance, medical countermeasure products, multidisciplinary material sciences, quantum technologies, trusted autonomous systems, cyber, advanced sensors, hypersonics and directed energy capabilities.

Chemical, Biological, Radiological and Nuclear (CBRN) training takes place at Royal Australian Air Force (RAAF) Base Amberley.

NANOFIBRE DERMAL PROTECTION

DST and the Defence Materials Technology Centre have produced a proof-of-concept nanofibre composite material to improve dermal protection against aerosol threats. This material has the unique property of providing aerosol protection while offering air permeability – a key requirement of fabrics to minimise the thermal burden borne by personnel when wearing ensembles to protect against chemical, biological, radiological and nuclear hazards.

DST, RAAF and Saab demonstrate AR and VR technology.

ADVANCED VISUALISATION FOR OPERATIONS ANALYSIS

DST has developed a series of prototypes and technology demonstrators that explore the application of virtual and augmented reality to operations analysis.

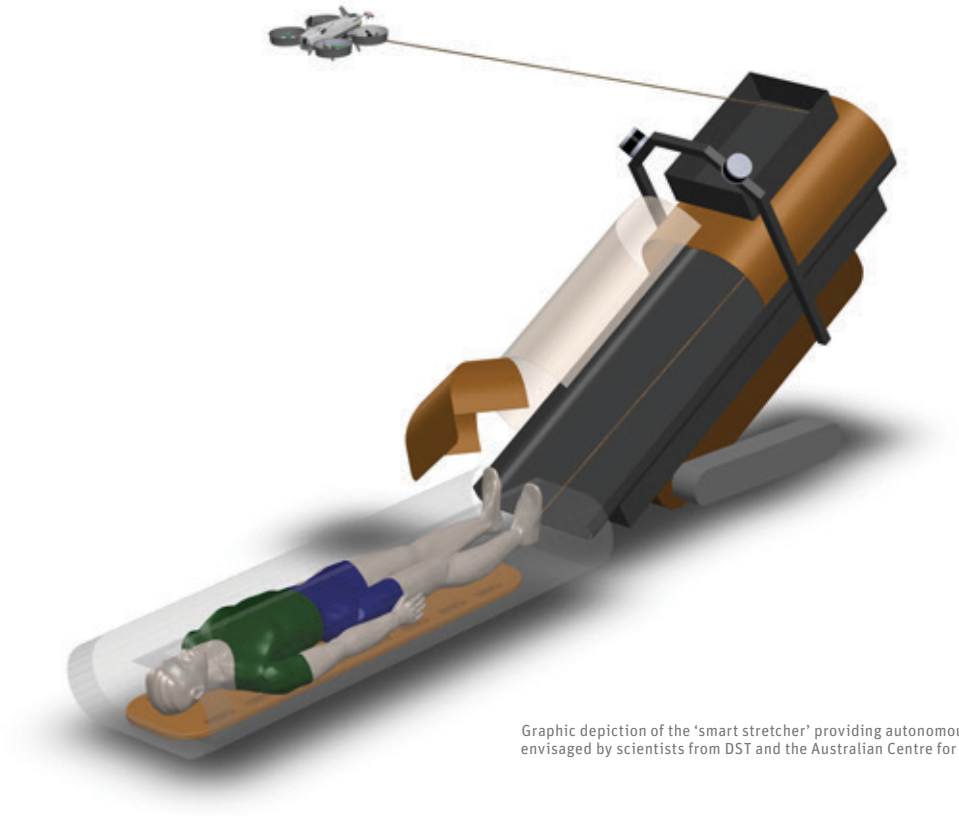
The virtual reality options of smart phones, Oculus Rift and Microsoft HoloLens were investigated to assess developments in advanced visualisation – a technology which, when combined with other data analysis techniques, may have a transformative effect on the levels of understanding that can be drawn from simulations.

Taking the most advanced prototype, a partnership between DST, RAAF and Saab produced a HoloLens-based application for viewing exercise and simulation data. An outcome of the collaboration was a prototype augmented-reality application for RAAF that showcases the potential for visualising the battlespace.

In the process, Saab Australia has strengthened its capability to deliver innovative augmented reality applications for Defence, and DST has better positioned itself to carry out scientific research targeted to RAAF requirements for improved airspace battle management.

‘SMART STRETCHER’ AUTONOMOUS COMBAT CASUALTY CARE

Working with the Australian Centre for Field Robotics at the University of Sydney, DST researchers have put together the initial design considerations for a semi-automated medical assistance system. This system, in terms of design principles, will be deployed autonomously to a casualty. It will provide stabilisation medical care as well as advanced monitoring and initial diagnosis. It will also give powered assistance to a single untrained operator for transport of the victim to a safe site for evacuation by air to hospital-based medical aid. The smart stretcher’s vehicle is envisaged to be an all-terrain ground platform, which would be delivered by helicopter or drone close to the casualty and then navigate to a target location either autonomously or via remote control, with all-around situational awareness aided by a tethered drone system. The platform would also incorporate a telelink for communications between on-site personnel and remote medical experts. The proposed ‘smart-stretcher’ payload would use multi-cell airbag technology to absorb transportation shocks and keep the victim in a prone and temperature-controlled state while on-board medical diagnosis functions are undertaken via embedded imaging technologies. The desirable treatment functions identified include wound stabilisation and compression and the provision of drugs and fluids through advanced auto-cannulation technology. Details of the design proposal were presented at the Future Land Forces Conference 2016.



Graphic depiction of the ‘smart stretcher’ providing autonomous casualty care envisaged by scientists from DST and the Australian Centre for Field Robotics.

DST staff preparaing for HIFiRE's launch.

HIFIRE 4 HYPERSONIC FLIGHT TRIAL

In June 2017, DST in collaboration with the US Air Force Research Laboratory, Boeing, BAE Systems, the German Aerospace Centre and University of Queensland, conducted another successful experimental flight as part of the Hypersonic International Flight Research Experiment (HIFiRE) program. The HIFiRE 4 flight built upon and culminated a decade of flight-testing experience within Defence. The successful test of hypersonic flight vehicles and the complex avionics and flight systems needed to control them has kept Australia at the leading edge of hypersonic research, test and evaluation. The knowledge gained from these experiments has enabled DST to further understand the challenges and opportunities presented by hypersonics.

SPACE RESEARCH WITH MINIATURE SATELLITES

In October 2016, Defence Minister Marise Payne announced a DST-led space research program using miniature satellites (or cubesats) on two missions – Biarri and Buccaneer.

The US cube satellite Biarri Point was successfully launched from Cape Canaveral in April 2017, carrying a Global Positioning System payload developed by the University of New South Wales and integrated into the satellite by DST.

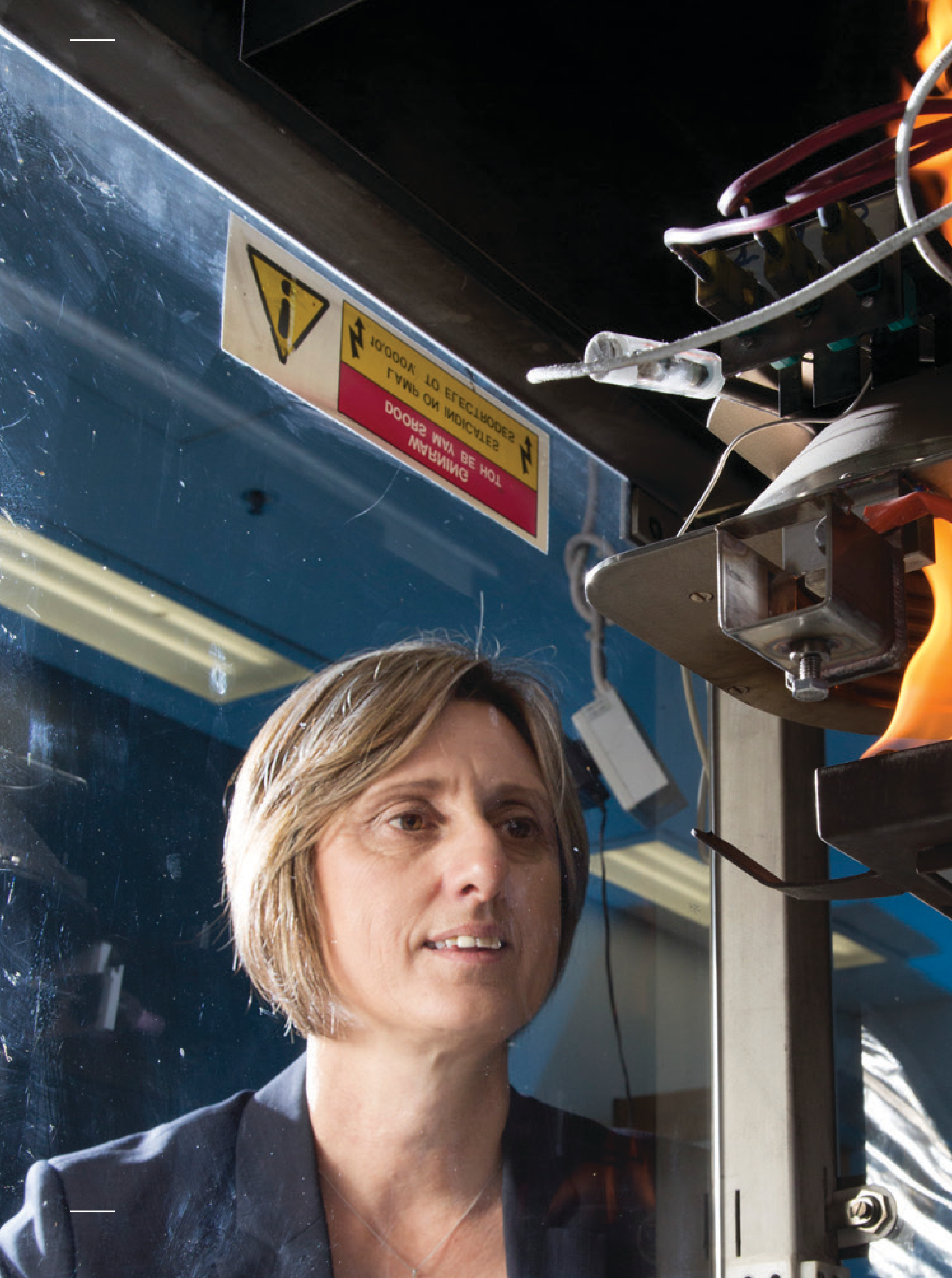
On its year-long mission the satellite will conduct a range of experiments aimed at increasing Defence's understanding of outer atmosphere effects on small satellites and improve situational awareness of space.

Preparations were also completed for the more ambitious Buccaneer mission that is intended to fly an advanced high frequency receiver to calibrate measurements for the Jindalee Operational Radar Network (JORN). Buccaneer was developed in collaboration with the University of NSW in Canberra.

On its first mission Buccaneer is to test key technologies in preparation for the subsequent main mission when it will perform calibration activities for JORN.

In late breaking news, Buccaneer was successfully launched in November 2017 from Vandenberg Air Force Base in California on a Delta-II rocket and had established communications with the ground station.

The Buccaneer and Biarri projects are designed to support the ADF's use of space-based capabilities and provide a catalyst for the rejuvenation of the space industry in Australia.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APPENDICIES

APPENDIX A: PUBLIC RELEASE SCIENCE AND TECHNOLOGY REPORTS

Title	Author/s	Report No.
Development of an aircraft corrosion exposure index	Peter Trathen, Andrew Butler and Jim Bitcon	DST-Group-TN-1630
Text classification of network intrusion alerts to enhance cyber situation awareness and automate alert triage	Iain Dickson	DST-Group-TN-1640
Characterisation of DST delay trigger units	Daniel Birt, Daniel Lamos and Darren Wiese	DST-Group-TN-1645
Technology watch report: Virtual reality and mixed reality head-mounted displays	Sarah J Hibbard, Justin J T Fidock and Susannah J Whitney	DST-Group-GD-0953
Summer vacation placement LD04: Investigating the utility of augmented reality for land logistics	Matthew Howe, Chelsea Fortuna and Guy Edward Gallasch	DST-Group-GD-0964
Signal separation of helicopter radar returns using wavelet-based sparse signal optimisation	Si Tran Nguyen Nguyen, Sandun Kodituwakku, Rocco Melino and Hai-Tan Tran	DST-Group-RR-0436
Beta factors for collinear asymmetrical cracks emanating from an offset circular hole in a rectangular plate	Witold Waldman	DST-Group-RR-0437
A thermally actuated flux pump for energizing YBCO pucks	Kenneth G White and Christopher Halliday	DST-Group-TN-1527
The Vital Planning and Analysis (ViPA) ORBAT data service architecture and design overview	Kyran Lange	DST-Group-TN-1539
Research notes: An introduction to openness and evolvability assessment	Michael Haddy and Adam Sbrana	DST-Group-TN-1541
Research notes: Openness and evolvability – standards assessment	Michael Haddy and Adam Sbrana	DST-Group-TN-1542
Research notes: Openness and evolvability – legal assessment	Michael Haddy and Adam Sbrana	DST-Group-TN-1543
Research notes: Openness and evolvability – interface assessment	Michael Haddy and Adam Sbrana	DST-Group-TN-1544
Research notes: Openness and evolvability – documentation quality assessment	Michael Haddy and Adam Sbrana	DST-Group-TN-1545
Changing coordinates in the context of orbital mechanics	Don Koks	DST-Group-TN-1594
Review of battery technologies for military land vehicles	Brendan Sims and Simon Crase	DST-Group-TN-1597
Optoelectronic assessment of the Estimote Location Beacon	R Bruce Backman	DST-Group-TN-1602
Conversion of DST Group shape optimisation software for increased portability across computing platforms	Robert Kaye and Witold Waldman	DST-Group-TR-3251
A modified constant-stress coupon for enhanced natural crack start during fatigue testing	Witold Waldman, Robert Kaye and Xiaobo Yu	DST-Group-TR-3252
Deflection and supporting force analysis of a slender beam under combined transverse and tensile axial loads	Witold Waldman and Xiaobo Yu	DST-Group-TR-3254

Title	Author/s	Report No.
A systems of thinking approach to engineering challenges of military systems-of-systems	Pin Chen and Mark Unewisse	DST-Group-TR-3271
Discrimination between fatigue cracking and mechanical damage in aircraft fastener holes by eddy-current phase rotation	M E Ibrahim, G D Surtees, G R Hugo, H J Morton and S K Burke	DST-Group-TR-3289
Development of a low strain-rate gun propellant bed compression test and its use in evaluating propellant mechanical response	J R Mortimer, A H Hart and J Huff	DST-Group-TR-3291
A review of sparsity-based methods for analysing radar returns from helicopter rotor blades	Ngoc Hung Nguyen, Hai-Tan Tran, Kutluyil Doganc and Rocco Melino	DST-Group-TR-3292
The mechanical metallurgy of armour steels	Stephen Cimpoeru	DST-Group-TR-3305
Monitoring of viral-induced cell death using real-time cell analysis	David Thirkettle-Watts and Penny Gauci	DST-Group-TR-3315
Investigation of the ElectroPuls E3000 testing machine for fatigue testing of structural materials	Lucy Caine and Emily Frain	DST-Group-TR-3319
Visualising uncertainty for decision support	Jae Chung and Steven Wark	DST-Group-TR-3325
Variable discretisation for anomaly detection using bayesian networks	Jonathan Legg	DST-Group-TR-3328
Radiological modelling of a gamma-ray imaging device	Martin Kocan, Michael Roberts, Arthur Eleftherakis and Alaster Meehan	DST-Group-TR-3329
A simple handbook for non-traditional red teaming	Monique Kardos and Patricia Dexter	DST-Group-TR-3335
Copolymer toughening of epoxy resin systems for low temperature cure bonded composite repair	Andrew D M Charles and Andrew Rider	DST-Group-TR-3344
Finite element modelling of heat exchange with thermal radiation	Leonid K Antanovskii	DST-Group-TR-3345
Sparse reconstruction of a scene and camera poses from the scene images wth MATLAB	Leonid K Antanovskii	DST-Group-TR-3346
Implementation of the scale invariant feature transform algorithm in MATLAB	Leonid K Antanovskii	DST-Group-TR-3347
Event sequencing for situation narratives	Ian Dall and Bradley Donnelly	DST-Group-TR-3351
Evaluation of available software for reconstruction of a structure from its imagery	Leonid K Antanovskii	DST-Group-TR-3356
Characterisation of dirt, dust and volcanic ash: A study on the potential for gas turbine engine degradation	Christopher A Wood, Sonya L Slater, Matthew Zonneveldt, John Thornton, Nicholas Armstrong and Ross A Antoniou	DST-Group-TR-3367

APPENDIX B: PAPERS DELIVERED OR PUBLISHED EXTERNALLY JULY 2016–JUNE 2017

Title	Author/s	Publication
Ground penetrating radar applications in buried improvised explosive device detection	Abeynayake, C. and Tran, M. D.	In: *18th International Conference on Electromagnetics in Advanced Applications, ICEAA 2016*, Institute of Electrical and Electronics Engineers Inc. 2 November 2016
Capacity analysis of zero-forcing precoding in multibeam satellite systems with rain fading	Ahmad, I., Nguyen, K. D., Pollok, A. and Letzepis, N.	In: *27th IEEE Annual International Symposium on Personal, Indoor, and Mobile Radio Communications, PIMRC 2016*, Institute of Electrical and Electronics Engineers Inc. 21 December 2016
Multi-hopping loss in MIMO decode-and-forward cooperative relaying	Ahmad, I., Nguyen, K. D., Pollok, A. and Letzepis, N.	In: *27th IEEE Annual International Symposium on Personal, Indoor, and Mobile Radio Communications, PIMRC 2016*, Institute of Electrical and Electronics Engineers Inc. 21 December 2016
Real time apnoea monitoring of children using the microsoft kinect sensor: A pilot study	Al-Naji, A., Gibson, K., Lee, S. H. and Chahl, J.	*Sensors (Switzerland)* **17** (2) 3 February 2017
Local structural damage evaluation of a C/CSiC ceramic matrix composite	Arhatari, B. D., Zonneveldt, M., Thornton, J. and Abbey, B.	*Microscopy and Microanalysis* **23** (3) 518-526 1 June 2017
OSL dating of individual quartz 'supergrains' from the ancient middle palaeolithic site of Cuesta de la Bajada, Spain	Arnold, L. J., Duval, M., Demuro, M., Spooner, N. A., Santonja, M. and Pérez-González, A.	*Quaternary Geochronology* **36** 78-101 1 September 2016
Flexible field goniometer system: The goniometer for outdoor portable hyperspectral earth reflectance	Bachmann, C. M., Abelev, A., Montes, M. J., Philpot, W., Gray, D., Doctor, K. Z., Fusina, R. A., et al.	*Journal of Applied Remote Sensing* **10** (3) 1 July 2016
Trace isotope analysis of *Ricinus communis* seed core for provenance determination by laser ablation-ICP-MS	Bagas, C. K., Scadding, R. L., Scadding, C. J., Watling, R. J., Roberts, W. and Ovenden, S. P. B.	*Forensic Science International* **270** 46-54 1 January 2017
Nanoparticle doping for high power fiber lasers at eye-safer wavelengths	Baker, C. C., Friebele, E. J., Burdett, A. A., Rhonehouse, D. L., Fontana, J., Kim, W., Bowman, S. R., et al.	*Optics Express* **25** (12) 13903-13915 12 June 2017
Facilitating organizational learning through agent-based modeling and simulation experimentation	Baškarada, S., Chandran, A., Shokr, M. and Stewart, C.	*Learning Organization* **23** (6) 429-443 September 2016
Managing the exploitation-exploration tradeoff: How leaders balance incremental and discontinuous innovation	Baškarada, S. and Watson, J.	*Development and Learning in Organizations* **31** (4) 13-16 July 2016
Leadership and organizational ambidexterity	Baškarada, S., Watson, J. and Cromarty, J.	*Journal of Management Development* **35** (6) 778-788 11 July 2016
Dynamic model for underwater vehicle maneuvering near a free surface	Battista, T., Woolsey, C., Perez, T. and Valentinis, F. A.	*IFAC-PapersOnLine* **49** (23) 68-73 November 2016

Title	Author/s	Publication
The cross domain desktop compositor: Using hardware-based video compositing for a multi-level secure user interface	Beaumont, M., McCarthy, J. and Murray, T.	In: *32nd Annual Computer Security Applications Conference, ACSAC 2016*, Association for Computing Machinery 5-9 December 2016
Modifiable anthropometric characteristics are associated with unilateral and bilateral carry performance	Beck, B., Carstairs, G. L., Billing, D. C., Caldwell, J. N. and Middleton, K. J.	*Journal of Strength and Conditioning Research* **31** (2) 489-494 1 February 2017
Predicting endurance time in a repetitive lift and carry task using linear mixed models	Beck, B., Ham, D. J., Best, S. A., Carstairs, G. L., Savage, R. J., Straney, L. and Caldwell, J. N.	*PLoS ONE* **11** (7) 7 July 2016
A study on the impact of drag reduction technologies on the mission performance of the Boeing C-17 Globemaster III aircraft	Bedwell, K. M., Brian, G. J. and Porter, R. J.	In: *35th AIAA Applied Aerodynamics Conference, 2017*, American Institute of Aeronautics and Astronautics Inc, AIAA 5-7 June 2017
Artificial thickening and thinning of cavitation tunnel boundary layers	Belle, A., Brandner, P. A., Pearce, B. W., de Graaf, K. L. and Clarke, D. B.	*Experimental Thermal and Fluid Science* **78** 75-89 1 November 2016
Physical mechanisms for near-field blast mitigation with fluid containers: Effect of container geometry	Bornstein, H., Ryan, S. and Mouritz, A.	*International Journal of Impact Engineering* **96** 61-77 1 October 2016
On compression and damage evolution in two thermoplastics	Bourne, N. K., Garcea, S. C., Eastwood, D. S., Parry, S., Rau, C., Withers, P. J., McDonald, S. A., et al.	*Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* **473** (2197) 1 January 2017
Target detection in GPR data using joint low-rank and sparsity constraints	Bouzerdoum, A., Tivive, F. H. C. and Abeynayake, C.	In: *Compressive Sensing V: From Diverse Modalities to Big Data Analytics*, SPIE 13 July 2016
In-flight measurements of low-altitude marine atmospheric properties.	Brian, G. J., Dansie, J. L., Newman, D. M. and Gibard, J. P.	In: *55th AIAA Aerospace Sciences Meeting*, American Institute of Aeronautics and Astronautics Inc. 9-13 January 2017
An experimental investigation of additional actuators on a submarine diesel generator	Broomhead, T., Manzie, C., Hield, P. and Brear, M.	*Control Engineering Practice* **55** 26-37 1 October 2016
Economic model predictive control and applications for diesel generators	Broomhead, T., Manzie, C., Hield, P., Shekhar, R. and Brear, M.	*IEEE Transactions on Control Systems Technology* **25** (2) 388-400 2 March 2017
Periodates as potential replacements for perchlorates in pyrotechnic compositions	Brusnahan, J. S., Shaw, A. P., Moretti, J. D. and Eck, W. S.	*Propellants, Explosives, Pyrotechnics* **42** (1) 62-70 1 January 2017
Rolling horizon non-myopic scheduling of multifunction radar for search and track	Byrne, M., White, K. and Williams, J.	In: *19th International Conference on Information Fusion, FUSION 2016*, Institute of Electrical and Electronics Engineers Inc. 1 August 2016
Identification and characterization of a nonlinear aeroelastic system with freeplay and aerodynamic nonlinearities via higher order spectra	Candon, M., Carrese, R., Ogawa, H., Marzocca, P., Mouser, C., Levinskik, O. and Silva, W. A.	In: *58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 2017*, American Institute of Aeronautics and Astronautics Inc, AIAA 9-13 January 2017

Title	Author/s	Publication
Anthropogenic trauma is the most prevalent cause of mortality in little penguins, *Eudyptula minor*, in Perth, Western Australia	Cannell, B. L., Campbell, K., Fitzgerald, L., Lewis, J. A., Baran, I. J. and Stephens, N. S.	*Emu* **116** (1) 52-61 December 2016
Two algorithms for modeling and tracking of dynamic time-frequency spectra	Carevic, D. and Davey, S.	*IEEE Transactions on Signal Processing* **64** (22) 6030-6045 15 November 2016
Aeroelastic response of the AGARD 445.6 wing with freeplay nonlinearity	Carrese, R., Joseph, N., Marzocca, P. and Levinski, O.	In: *58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 2017*, American Institute of Aeronautics and Astronautics Inc, AIAA 9-13 January 2017
A data set for evaluating the performance of multi-class multi-object video tracking	Chakraborty, A., Stamatescu, V., Wong, S. C., Wigley, G. and Kearney, D.	In: *Automatic Target Recognition XXVII 2017*, SPIE 11 April 2017
Prediction of bubble generation based on acoustic emission	Chen, L., Trinh, V., Yang, W. and Mohanangam, K.	*Acoustics Australia* **44** (2) 325-3311 August 2016
SoS thinking: An approach to conceptualising and understanding military systems-of-systems	Chen, P. and Unewisse, M.	*International Journal of System of Systems Engineering* **8** (1) 74-101 January 2017
Achieving distributed decision-making using BDI and Coo^2 for future distributed tactical decision aids	Consoli, A.	*Intelligent Decision Technologies* **10** (4) 453-471 September 2016
Typology dimensions for classifying SoSE problem spaces	Cook, S. C. and Pratt, J. M.	In: *11th Systems of Systems Engineering Conference, SoSE 2016*, Institute of Electrical and Electronics Engineers Inc. 12 August 2016
Metal clad active fibres for power scaling and thermal management at kW power levels	Daniel, J. M. O., Simakov, N., Hemming, A., Clarkson, W. A. and Haub, J.	*Optics Express* **24** (16) 18592-18606 8 August 2016
Effects of coating thickness on high power metal coated fibre lasers	Daniel, J. M. O., Simakov, N., Hemming, A., Clarkson, W. A. and Haub, J.	In: *Fiber Lasers XIV: Technology and Systems 2017*, SPIE 30 January-2 February 2017
Multipath-aware detection and tracking in skywave over the-horizon radar	Davey, S. J., Fabrizio, G. A. and Rutten, M. G.	In: *2017 IEEE Radar Conference, RadarConf 2017*, Institute of Electrical and Electronics Engineers Inc. 7 June 2017
Reliability, durability and packaging of fibre Bragg gratings for use on defence platforms	Davis, C.	In: *Bragg Gratings, Photosensitivity, and Poling in Glass Waveguides, BGPP 2016*, OSA – The Optical Society 29 August 2016
Aeroacoustic analysis of a mach 0.9 round jet using synchronized microphone array and shake-the-box 3D Lagrangian particle tracking measurements	Depuru Mohan, N. K., Manovski, P., Geisler, R., Agocs, J., Ahlefeldt, T., Novara, M., Schanz, D., et al.	In: *23rd AIAA/CEAS Aeroacoustics Conference, 2017*, American Institute of Aeronautics and Astronautics Inc, AIAA 5-9 June 2017
Handling knowledge imperfection in hybrid logic inference	Ding, L. and Tweedale, J. W.	In: *20th International Conference on Knowledge Based and Intelligent Information and Engineering Systems, KES 2016*, Elsevier 5-7 September 2016
A study of fatigue variability in aluminium alloy 7050-T7451	Dixon, B., Molent, L. and Barter, S.	*International Journal of Fatigue* **92** 130-146 1 November 2016

Title	Author/s	Publication
The fabrication and performance of C/C composites impregnated with TaC filler	Djugum, R. and Sharp, K.	*Carbon* **115** 105-115 1 May 2017
The influence of internal resonances from machinery mounts on radiated noise from ships	Dylejko, P. G., Macgillivray, I. R., Moore, S. M. and Skvortsov, A. T.	*IEEE Journal of Oceanic Engineering* **42** (2) 399-409 April 2017
Source parameter estimation of aero-acoustic emitters using non-linear least squares and conventional methods	Ferguson, B. G.	*IET Radar, Sonar and Navigation* **10** (9) 1552-1560 December 2016
Sound radiation from a submerged stiffened cylinder with acoustic excitation	Forrest, J. A.	In: *2nd Australasian Acoustical Societies Conference, ACOUSTICS 2016*, Australian Acoustical Society 9-11 November 2016
A new family of single frequency Bragg grating fiber lasers	Foster, S.	In: *Bragg Gratings, Photosensitivity, and Poling in Glass Waveguides, BGPP 2016*, OSA – The Optical Society 29 August 2016
Improving Air Force operator performance through synthetic mission rehearsal	Francis, C., Best, C. and Yildiz, J.	In: *1st Simulation Innovation Workshop, SIW 2016*, SISO – Simulation Interoperability Standards Organization 16 September 2016
Evaluation of military helmets and roof padding on head injury potential from vertical impacts	Franklyn, M. and Laing, S.	*Traffic Injury Prevention* **17** (7) 750-757 2 October 2016
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Title	Author/s	Publication
GPR signal classification with low-rank and convolutional sparse coding representation	Tivive, F. H. C., Bouzerdoum, A. and Abeynayake, C.	In: *2017 IEEE Radar Conference, RadarConf 2017*, Institute of Electrical and Electronics Engineers Inc. 7 June 2017
Time changes in the body dimensions of male Australian Army personnel between 1977 and 2012	Tomkinson, G. R., Daniell, N., Fulton, A. and Furnell, A.	*Applied Ergonomics* **58** 18-24 1 January 2017
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OMP-based translational motion estimation for a rotating target by narrowband radar	Tran, H. T., Heading, E. and Melino, R.	*IET Radar, Sonar and Navigation* **11** (5) 854-860 1 May 2017
Phlebotomists do it better: Exploring soft interaction in the medical domain	Tsimeris, J., Stevenson, D. R., Gedeon, T. D. and Broughton, M.	*In: 2017 ACM SIGCHI Conference on Human Factors in Computing Systems, CHI EA 2017, Association for Computing Machinery 6-11 May 2017*
Dual estimators for clutter-map CFAR detection on non-Gaussian background	Van Cao, T. T.	*In: 18th International Radar Symposium, IRS 2017, IEEE Computer Society 28-30 June 2017*
Guidelines and best practices for using Docker in support of HLA federations	Van Den Berg, T., Cramp, A. and Siegel, B.	In: *1st Simulation Innovation Workshop, SIW 2016*, SISO – Simulation Interoperability Standards Organization 12-16 September 2016
RAPID: Real-time analytics platform for interactive data-mining in a decision support scenario	Vanni, M., Kase, S. E., Karunasekara, S., Falzon, L. and Harwood, A.	In: *5th Conference on Next-Generation Analyst*, SPIE 10-11 April 2017
An experimental study on the scattering of edge guided waves by a small edge crack in an isotropic plate	Vien, B. S., Francis Rose, L. R. and Chiu, W. K.	In: *8th European Workshop on Structural Health Monitoring, EWSHM 2016*, NDT.net 5-8 July 2016
Energy-based localized anomaly detection in video surveillance	Vu, H., Nguyen, T. D., Travers, A., Venkatesh, S. and Phung, D.	*21st Pacific-Asia Conference on Knowledge Discovery and Data Mining, PAKDD 2017*, **10234 LNAI** 641-653 April 2017
Size estimation for naturally occurring bearing faults using synchronous averaging of vibration signals	Wang, W., Sawalhi, N. and Becker, A.	*Journal of Vibration and Acoustics, Transactions of the ASME* **138** (5) 1 October 2016
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Oxidised compounds in aviation fuels using Nafion fibre solid phase microextraction	Webster, R. L., Mete, J. B., Rawson, P. M., Evans, D. J. and Marriott, P. J.	*Fuel* **197** 226-231 June 2017
Quantification of trace fatty acid methyl esters in diesel fuel by using multidimensional gas chromatography with electron and chemical ionization mass spectrometry	Webster, R. L., Rawson, P. M., Evans, D. J. and Marriott, P. J.	*Journal of Separation Science* **39** (13) 2537-2543 1 July 2016

Title	Author/s	Publication
Investigation of the thermal oxidation of conventional and alternate aviation fuels with comprehensive two-dimensional gas chromatography accurate mass quadrupole time-of-flight mass spectrometry	Webster, R. L., Rawson, P. M., Kulsing, C., Evans, D. J. and Marriott, P. J.	*Energy and Fuels* **31** (5) 4886-4894 April 2017
Analysis of a dual order statistic constant false alarm rate detector	Weinberg, G. and Alexopoulos, A.	*IEEE Transactions on Aerospace and Electronic Systems* **52** (5) 2567-2574 October 2016
On the construction of CFAR decision rules via transformations	Weinberg, G. V.	*IEEE Transactions on Geoscience and Remote Sensing* **55** (2) 1140-1146 February 2017
Asymptotic performance of the geometric mean detector in Pareto distributed clutter	Weinberg, G. V.	*IEEE Signal Processing Letters* **23** (11) 1538-1542 November 2016
Enhancing Goldstein's Log-t detector in Pareto-distributed clutter	Weinberg, G. V. and Glenny, V. G.	*IEEE Transactions on Aerospace and Electronic Systems* **53** (2) 1035-1044 April 2017
Optimal Rayleigh approximation of the K-distribution via the Kullback-Leibler divergence	Weinberg, G. V. and Glenny, V. G.	*IEEE Signal Processing Letters* **23** (8) 1067-1070 August 2016
Hydrogen induced amorphisation around nanocracks in aluminium	White, P. D., Barter, S. A. and Medhekar, N.	*Engineering Fracture Mechanics* **161** 40-54 1 August 2016
Understanding data augmentation for classification: When to warp?	Wong, S. C., Gatt, A., Stamatescu, V. and McDonnell, M. D.	In: *2016 International Conference on Digital Image Computing: Techniques and Applications, DICTA 2016*, Institute of Electrical and Electronics Engineers Inc. 22 December 2016
Measurement of pressure fluctuations inside a model thrust bearing using PVDF sensors	Youssef, A., Matthews, D., Guzzomi, A., Sun, H. and Pan, J.	In: *2nd Australasian Acoustical Societies Conference, ACOUSTICS 2016*, Australian Acoustical Society 9-11 November 2016
Fatigue crack growth of aluminium alloy 7075-T651 under proportional and non-proportional mixed mode I and II loads	Yu, X., Li, L. and Proust, G.	*Engineering Fracture Mechanics* **174** 155-167 April 2017
Fatigue crack growth of aluminium alloy 7075-T651 under non-proportional mixed mode I and II loads	Yu, X., Li, L. and Proust, G.	*Frattura ed Integrita Strutturale* **10** (38) 148-154 October 2016
Cooperative localisation of UAVs in a GPS-denied environment using bearing measurements	Zhang, L., Ye, M., Anderson, B. D. O., Sarunic, P. and Hmam, H.	In: *55th IEEE Conference on Decision and Control, CDC 2016*, Institute of Electrical and Electronics Engineers Inc. 27 December 2016
Pulse spreading and correlation loss in shallow water environments with rough sea surfaces and bottoms	Zhang, Z. Y. and Bartel, D.	In: *2nd Australasian Acoustical Societies Conference, ACOUSTICS 2016*, Australian Acoustical Society 9-11 November 2016
Easy-to-use closed-form equations for modal cut-on frequencies of a surface duct with an exponential sound speed profile	Zinoviev, A.	In: *2nd Australasian Acoustical Societies Conference, ACOUSTICS 2016*, Australian Acoustical Society 9-11 November 2016

APPENDIX C: PATENTS (PENDING OR GRANTED)

Country	Application number	Filing date	Priority date	Granted number	Type	Patent status	Granted
AERIAL DEPLOYABLE RESCUE PACKAGE							
David Cole							
Australia	2015240411	19 Oct 16	31 Mar 14	N/A	Regional	Filed	N/A
Canada	2943145	19 Sep 16	31 Mar 14	N/A	Regional	Filed	N/A
Europe	15773561.4	24 Oct 16	31 Mar 14	N/A	Regional	Filed	N/A
India	201617036484	25 Oct 16	31 Mar 14	N/A	Regional	Filed	N/A
Iran	1395 5014 0003 0081 56	27 Sep 16	31 Mar 14	N/A	Regional	Filed	N/A
New Zealand	725436	31 Mar 15	31 Mar 14	N/A	Regional	Filed	N/A
USA	15/128790	23 Sep 16	31 Mar 14	N/A	Regional	Filed	N/A
ALIGNMENT DEVICE FOR DRILLING OR REAMING AN OPENING IN A STRUCTURE							
Peter Anson							
USA	14/378590	12 Feb 13	13 Feb 12	TBC	Regional	Allowed	TBC
BALANCE DEVICES							
David Clarke							
Australia	2015240427	12 Sep 16	31 Mar 14	N/A	Regional	Filed	N/A
Europe	15773677.8	14 Sep 16	31 Mar 14	N/A	Regional	Filed	N/A
USA	15/301271	30 Sep 16	31 Mar 14	N/A	Regional	Filed	N/A

Country	Application number	Filing date	Priority date	Granted number	Type	Patent status	Granted
CARTRIDGE AND SYSTEM FOR GENERATING A PROJECTILE WITH A SELECTABLE LAUNCH VELOCITY							
Stephen Forbes, Edmond Almond, Shaun McCormack, Jeffrey Ackers, Robert Reichstein, Michael Chatwin							
USA	14/351724	15 Oct 12	14 Oct 11	9534858	Regional	Granted	3 Jan 17
Australia	2012323776	15 Oct 12	14 Oct 11	2011904179	Regional	Granted	6 Apr 17
EXOSKELETON SYSTEM FOR LOAD CARRYING							
Thomas Chapman							
Australia	2015246634	11 Oct 16	16 Apr 14	N/A	Regional	Filed	N/A
Canada	2945827	24 Oct 16	16 Apr 14	N/A	Regional	Filed	N/A
Europe	15779491.8	16 Nov 16	16 Apr 14	N/A	Regional	Filed	N/A
Israel	248233	6 Oct 16	16 Apr 14	N/A	Regional	Filed	N/A
Japan	2016 562012	11 Oct 16	16 Apr 14	N/A	Regional	Filed	N/A
New Zealand	725179	12 Oct 16	14 Apr 14	N/A	Regional	Filed	N/A
USA	15/303463	11 Oct 16	16 Apr 14	N/A	Regional	Filed	N/A
IMAGING SYSTEM							
Mike Roberts							
AU Complete application	2016277736	23 Dec 16	23 Dec 16	N/A	Australia Complete	Filed	N/A
IMPROVED EXOSKELETON SYSTEM FOR LOAD CARRYING							
Thomas Chapman							
Australia	2017901400	18 Apr 17	18 Apr 17	N/A	Australia Provisional	Filed	N/A

Country	Application number	Filing date	Priority date	Granted number	Type	Patent status	Granted
METHODS AND SYSTEMS FOR CHEMICAL VAPOUR SENSING							
Karl Pavey, Nicholas Fitzgerald, Craig Stevens, John Huberts, Anthony Pahl, Igor Van de Griendt							
Australia	2014405050	20 Feb 17	27 Aug 14	N/A	Regional	Filed	N/A
Canada	2959075	20 Feb 17	27 Aug 14	N/A	Regional	Filed	N/A
Europe	14900380.8	23 Feb 17	27 Aug 14	N/A	Regional	Filed	N/A
New Zealand	729244	20 Feb 17	27 Aug 17	N/A	Regional	Filed	N/A
USA	15/507170	27 Feb 17	27 Aug 17	N/A	Regional	Filed	N/A
PYROTECHNICS METHODS OF MANUFACTURE (PYROFILM)							
Ken Smit							
PCT	PCT/ AU2017/000041	10 Feb 17	11 Feb 16	N/A	PCT Complete	Filed	N/A
VIBRATION ENERGY HARVESTING USING CYCLOIDAL MOTION							
Scott Moss							
USA	14/265,005	29 Apr 14	7 Nov 13	9484795	Regional	Granted	1 Nov 16

ABBREVIATIONS AND ACRONYMS

ADF	Australian Defence Force
AMC	Australian Maritime College
Bilats	Bilateral agreements
CDS	Chief Defence Scientist
CTD	Capability and Technology Demonstrator
Defence	The Defence Organisation, including the Department of Defence and the Australian Defence Force
DOSC	DST Group Operations Support Centre
DMTC	Defence Materials Technology Centre
DSI	Defence Science Institute
DSP	Defence Science Partnership
Dstl	Defence Science and Technology Laboratory (UK)
DST	Defence Science and Technology Group
EDTAS	Emerging and Disruptive Technology Assessment Symposium
ICT	Information and Communication Technology
IED	Improvised Explosive Device
IEP	Industry Experience Placement
ISR	Intelligence surveillance and reconnaissance
JSF	Joint Strike Fighter
JTF	Joint Task Force
LHD	Landing Helicopter Dock
MoU	Memorandum of Understanding
MSTC	Major Science and Technology Capabilities
NATO	North Atlantic Treaty Organization
NICOP	US Naval International Cooperative Opportunities in Science and Technology Program
NSSTC	National Security Science and Technology Committee
PA	Project Arrangement
RAN	Royal Australian Navy
RAAF	Royal Australian Air Force
R&D	Research and Development
SAGE	Science in Australia Gender Equity
S&T	Science and technology
SME	Small to medium enterprises
STC	Science and Technology Capability
STEM	Science, Technology, Engineering and Mathematics
SVS	Summer Vacation Scholarship
TPO	Technology Partnerships Office
TTCP	TheTechnical Cooperation Program
TTCP CP	TTCP Collaborative Project
TTCP SA	TTCP Study Assignment
UAV	Unmanned aerial vehicle
UAS	Unmanned aerial system

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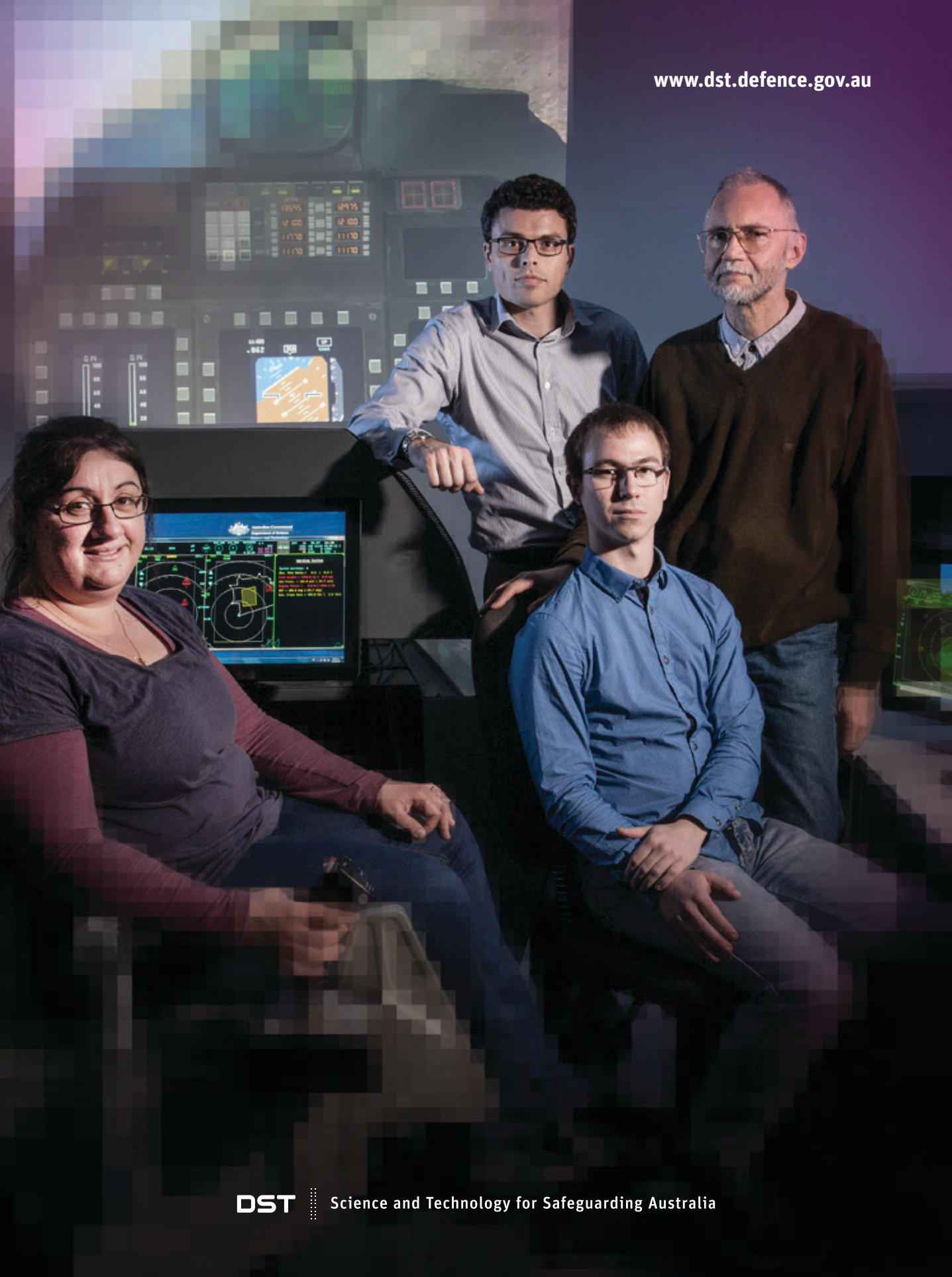

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