Defence Science and Technology

OUTLOOK 2024

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Hon Richard Marles MP

Deputy Prime Minister and Minister for Defence

OPENING INTERVIEW

Professor Tanya Monro

Chief Defence Scientist

Advanced Strategic Capabilities Accelerator

Professor Emily Hilder, Head ASCA

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Jericho Disruptive Innovation

Trusted Autonomy

Nuclear-powered Submarines and DSTG

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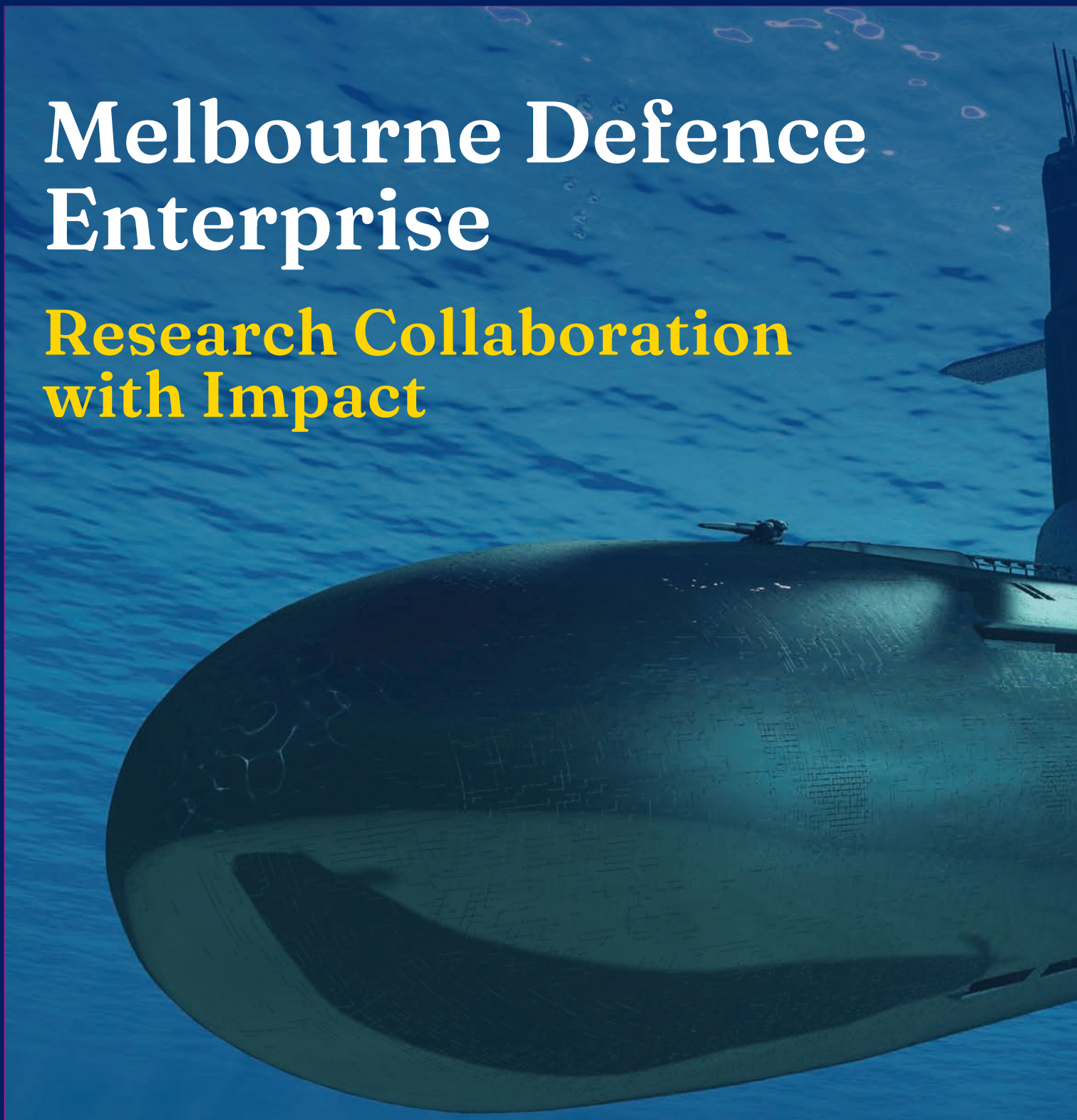

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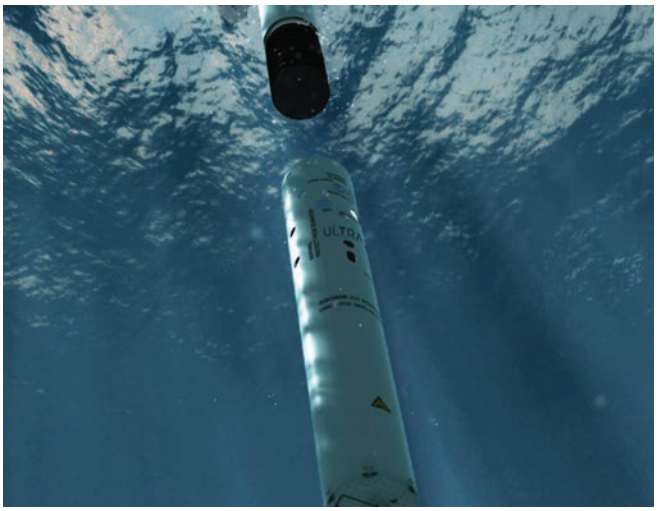

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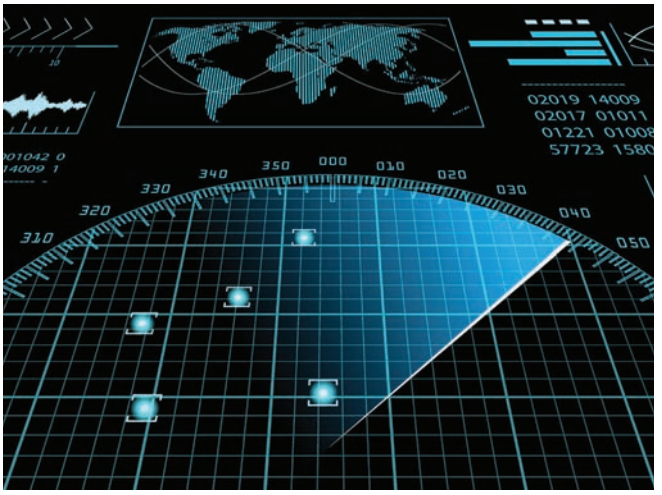

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The Hon Richard Marles MP
Deputy Prime Minister
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A strong defence science and technology ecosystem is essential to Australia's national security. By integrating defence science and technology into our National Defence Strategy, delivering record levels of funding and driving historic partnerships with our international partners, the Australian Government has assured the Defence science and technology enterprise is positioned to rapidly deliver scientific and technological progress on Defence's most difficult and challenging problems.

For 50 years, Defence Science and Technology Group (DSTG) has been the engine room for critical military technologies that are at the heart of Australia's competitive advantage. Today, it is a global leader in a range of emerging technologies; an innovator and a disruptor in fields that span the scientific spectrum. Its expertise in hypersonics and quantum technology are renowned.

DSTG is integral to an ecosystem of Australian organisations, including industry partners, small to medium enterprises and academia who are working together on cutting-edge research and development. That ecosystem is critical to our national security, a key element of the sovereign defence industrial base and essential to the effectiveness and resilience of the Australian Defence Force.

To innovate, you must invest. Through our 2024 Integrated Investment Program the Government is making a record investment in innovation, science and technology because we recognise it is fundamental to properly equipping and preparing a modern fighting force in a technology dominated world.

We are transforming the way Australia approaches the challenges of defence science and technology to make it faster, focused and more agile. The Advanced Strategic Capabilities Accelerator (ASCA) is innovative by design and integrated into the Defence enterprise to ensure that technology is transitioned through at speed into capability and placed in the hands of our warfighters.

The Government is also working even more closely with our partners to drive scientific discovery and development. Our Alliance with the United States is delivering unprecedented levels of scientific, technological and industrial collaboration. At the recent Australia-United States Ministerial Consultations we committed to greater collaboration between the US Defense Innovation Unit and ASCA. We also agreed to streamline cooperation on missile and uncrewed aerial vehicle technologies, particularly for the Guided Weapons and Explosive Ordnance Enterprise and AUKUS Pillar II. Earlier this year, the Government established the first research project between DSTG and Japan's Acquisition, Technology and Logistics Agency to enhance strategic capabilities in robotic and autonomous systems for undersea warfare.

Our AUKUS technology sharing partnership is key to accelerating the delivery of asymmetric capabilities to all three partners. Collaboration under AUKUS Pillar II is unlocking new networks and ecosystems of innovation across our three industrial and research bases. AUKUS partners have already trialled a number of classified cutting edge technologies, including artificial intelligence in robotic vehicles. As we move forward, we need to look at new ways of integrating our innovation, research and industrial systems so we are maximising the potential of AUKUS Pillar II.

Showcased in the pages of this edition of *OUTLOOK* you will see many examples of the work that has led Chief Defence Scientist Tanya Monro to describe DSTG as "the most impactful place to work in the world". Whether you are working within the Defence ecosystem or simply interested in the exciting and evolving world of Australian defence science, I commend to you the 2024 edition of *Defence Science and Technology OUTLOOK*.

Defence Science and Technology
OUTLOOK

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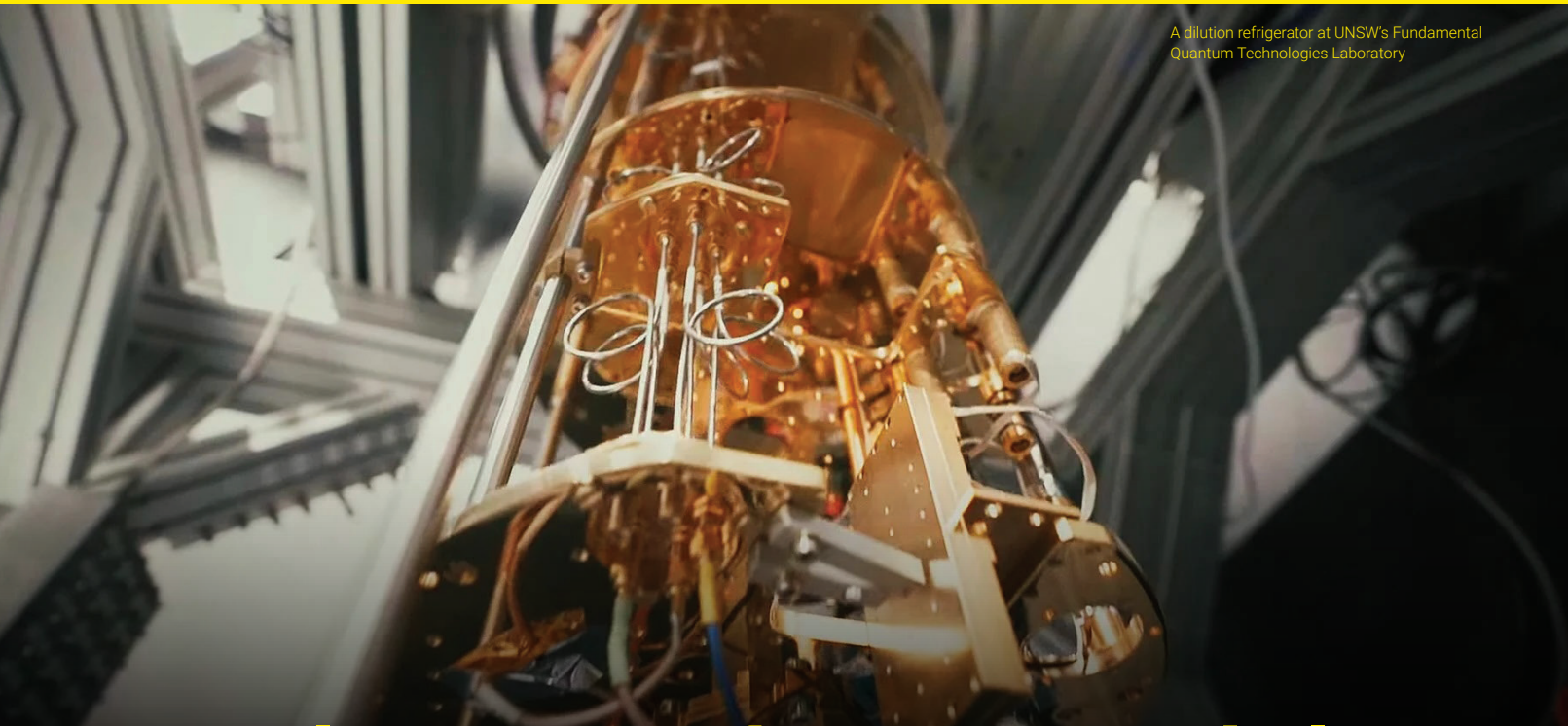

A dilution refrigerator at UNSW's Fundamental Quantum Technologies Laboratory

Developing defence capability starts with exceptional research

The Defence Research Institute enables UNSW's world leading research, education, and workforce development initiatives by building trusted partnerships with defence and industry.

We connect researchers and their research, to defence and national security requirements, to funding pathways, and industry partners.

Striving to secure an advantage that will contribute to our nation's ongoing and future prosperity in this important time can only be made more effective when defence research and education intensive universities like UNSW are part of the solution.

UNSW Defence Research Strengths include:

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- Nuclear science engineering
- Strategic studies

Forging tomorrow's defence capabilities through research and trusted partnerships

By Chris Mills AM, CSC

My recent appointment to the University of New South Wales (UNSW) as Director of the Defence Research Institute (DRI) comes at a time when the collective endeavour to work on Australia's complex future defence and national security challenges is so critical. Striving to secure advantage that will contribute to our nation's ongoing and future prosperity, at this important time, can only be made more effective when defence research and education intensive universities like UNSW are part of the solution.

The DRI enables UNSW's world leading research, education, and workforce development initiatives by building trusted partnerships with Defence and industry. We connect researchers and their research, to defence and national security requirements, to funding pathways and industry partners. Our mission is to bridge the gap between cutting-edge research and the pressing needs of Defence and national security.

Currently, there is an immediate necessity to rapidly expand Australia's skilled workforce to ensure Australia's future security and prosperity. In response, UNSW is actively involved in several key workforce development initiatives, including efforts to harmonise the tertiary sector. The government's recent announcement of $128.5 million of new funding, as part of the AUKUS agreement, creates 4,000 student places over the next four years. This growth represents an important opportunity to help address the skilled workforce needs of Australia's future submarine enterprise and defence more broadly.

UNSW's role as the education partner for the Australian Defence Force Academy through UNSW Canberra further underscores the University's ongoing commitment to Defence education. In addition to UNSW Canberra's traditional degree programs, UNSW offers a range of professional short courses, including ones tailored to the needs of individual groups. Course topics include nuclear engineering, systems engineering, information and cybersecurity, mission engineering and maritime security. These programs provide flexible learning options, allowing defence and industry professionals to enhance their skills while continuing their service.

UNSW's impact on the defence sector is amplified through strategic partnerships and industry collaborations including the Defence Trailblazer, Security & Defence PLuS and the Defence 10x Accelerator.

The Defence Trailblazer focuses on removing barriers for university-industry collaborations. It drives stronger commercialisation activities, paving the way for long-term impact to accelerate delivery of defence capabilities.

Chris Mills AM, CSC

The Security and Defence PLuS Alliance is a global partnership which combines the strengths of three leading research universities on three continents—Arizona State University, King's College London and UNSW—to solve global challenges.

UNSW's Defence 10x Accelerator is the nation's sole accelerator exclusively servicing Defence-focused startups.

These initiatives ensure that innovations developed at UNSW are swiftly integrated into defence capabilities, overcoming the divide between research and practical application.

I am thrilled to be joining the UNSW DRI as its new Director. It is a privilege to be able to work alongside UNSW's world-leading researchers and academics as we partner with industry and Defence. Contact us to learn more and to be part of our exciting next chapter. ●

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IMAGE: Supplied

Professor Tanya Monro AC

CHIEF DEFENCE SCIENTIST

In 2024, the government published its National Defence Strategy (NDS) and Defence published its Integrated Investment Program (IIP), Defence Science and Technology Group (DSTG) turned 50, the Advanced Strategic Capabilities Accelerator (ASCA) turned one, and DSTG published a new innovation, science and technology (IS&T) strategy. The Chief Defence Scientist spoke to *DSTG OUTLOOK's* **Gregor Ferguson.**

How has DSTG changed as a result of the Defence Strategic Review [DSR] and NDS?

The biggest change is that IS&T now is central to Defence's thinking on capability. There's a visceral shift from seeing IS&T as a longer-term thing to it now being a way of accelerating and delivering minimum viable capability.

As you go from peacetime to contest and then (hopefully not) into conflict, you use what you have at hand. It is a shift that is driven by that narrowing of the window of warning. We no longer have a 10-year warning time and we need to be able to make sure we're getting after the things that will make the biggest difference now and in the short term.

Why does DSTG's job description now include innovation as well as science and technology?

Innovation is important because you're creating and applying knowledge, but it doesn't always have to be new-to-the-world knowledge. You can take existing technologies and apply them in different ways. So, I'd say where all R&D is innovative, not all innovation is R&D.

Some of the innovation ASCA is driving is opening access to emerging disruptive technology for our warfighters and prompting them to think differently about novel concepts of use. We're also driving *process* innovation within the Department, challenging how our system works and how we procure things.

Why has ASCA been established?

ASCA came from deep reflection about what needed to change; everything from how we connect R&D and the research ecosystem and industry, right through to how we procure and transition to capability.

IMAGE: Rodney Braithwaite

Ghost Shark 'Alpha' the first prototype co-developed by DSTG, the Royal Australian Navy and Anduril Australia was unveiled. Ghost Shark Program is Mission Zero for ASCA.

> We realised that because a lot of the innovation we need is about how we work internally within the department, it didn't make sense to have ASCA as an external agency. It has to do work on the system, which it can't do from outside.

We realised that because a lot of the innovation we need is about how we work internally within the department, it didn't make sense to have ASCA as an external agency. It has to do work on the system, which it can't do from outside. But it has to sit somewhere for reporting and accountability and so it sits within Defence organisationally and reports through to me, to have the fewest barriers to accessing our scientists' and technologists' deep subject matter expertise.

ASCA isn't an S&T organisation. It draws on the experts in DSTG for scientific and technical advice, works closely with the Capability Acquisition and Sustainment Group to enhance contracting process and capability pathways, and with our Services to ensure we are working on the problems they need solved. The way I'd describe it is that it's a One Defence organisation that brings all the key decision makers at the 3-star or 4-star level who can remove the barriers that stop us doing the right thing the right way.

What does ASCA do that the NGTF [Next Generation Technologies Fund] and the Defence Innovation Hub did not?

It was critical to dismantle the structural barriers between those two initiatives. While the NGTF could get something to the proof of concept stage, say in a laboratory, the Hub was an unsolicited proposal mechanism where, even if you found a Capability Sponsor from Defence, it was difficult to pull the technology through. And that defied the purpose of trying to get things through to the warfighter quickly. It propagated a proliferation of proofs of concept, many with no real prospect of pull through. And that actually created more problems than it solved because I don't think Australia has a problem in developing proofs of concept. Where Australia has a problem is in getting pathways through the valley of death into use and into production and export.

You have spoken in the past about 'speed to capability' and that is obviously part of ASCA's brief. But is that now a whole of DSTG or a whole of Defence goal?

It applies to much more than just ASCA. It's about us doing things like bringing in industry partners early in the process and establishing value for money up front. That's one element.

It is also reflected in DSTG being a more agile organisation. We responded to the DSR by shifting a quarter of our workforce to the DSR IS&T priorities within the first six months of the Review being published. That's a magnificent response when you consider DSTG is a large organisation where people have very specialised skills. We were able to do that because we've introduced a new networked operating model that takes Defence's priority problems and uses them to define our programs of work.

DSTG does have a significant role to play. Our role is to be more agile, as I've just described, but it's also about doing the science, the R&D, in the timeframe that the ADF [Australian Defence Force] needs us to do it so that we can shape and impact decisions.

'Asymmetric Advantage' is highlighted in the NDS—why is this and what is your definition of Asymmetric Advantage?

I'm really pleased the NDS embraced this concept, because we're a small population with a lot of territory to protect and we need to shift from talking about capability gaps to asymmetry. Asymmetry is essentially any decision or capability that you have, or that an adversary thinks you might have, that disrupts their decision calculus.

There are seven different types of asymmetry. They can be everything from technology right through to organisational asymmetries. Asymmetry is something that an adversary can't just counter via the application of scale. So, asymmetries can be things like sending swarms of drones to attack a large platform. Having two or three of those platforms doesn't make them less resistant to a swarm of drones.

Or it can be something that upsets the decision calculus of an adversary when they ask, 'Well, should today be the day?' Asymmetry is what seeds that uncertainty.

A perfect example is something like an uncrewed submarine. An uncrewed submarine can lurk in the depths and conduct anything from a missile strike to an ISR [intelligence, reconnaissance and surveillance] mission at an unknown time in an unknown location, because it's no longer reliant on having to keep a bunch of humans alive. That acts as a deterrent, which is a key shift in emphasis in the DSR and NDS.

That is pure asymmetry working.

Often when you start to talk about asymmetry, it's about harnessing a technological edge and often that technological edge won't be mature or fully extant in terms of an industrial capability. Something you might take to an exercise and demonstrate as a prototype may be exactly what you need to deliver that asymmetric, deterrent effect.

There are six key priorities for Defence: trusted autonomy, quantum technology, information warfare, long-range fires, hypersonics and directed energy. Why have these priorities been selected? Are they areas where Australia has technological mastery, or are they areas where the ADF and Department want to achieve mastery?

It's an interesting one. What I would say is we've got those six areas of IS&T priority and they're priorities for the IS&T ecosystem nationally, including for DSTG. They're a mixture of areas that currently have acquisition paths where it's been recognised that IS&T can make a significant difference. That's either because we're really good at it or because there's a significant role for IS&T to play. In those areas, there may be asymmetric disruption where we don't currently have an acquisition path but where really good IS&T could get government to a position where it can make decisions to change that.

The six advanced capabilities under AUKUS Pillar II—undersea technologies, quantum technologies, artificial intelligence and autonomy, advanced cyber, hypersonic and counter-hypersonic capabilities, and electronic warfare—overlap with IS&T priorities, but not completely. Why is this?

AUKUS Pillar II is about leaning into asymmetry because one of the most

A Trusted Operation of Robotic Vehicles in a Contested Environment (TORVICE) trial was held in South Australia in late 2023. The live trial involved personnel from Australia, the US and UK testing autonomous ground vehicles in a contested electronic warfare environment. TORVICE is part of Australia's commitment to AUKUS Pillar II Advanced Capabilities.

IMAGE: Defence database

IMAGE: Jay Cronan from Defence database

We are committed to updating our strategy every two years to align with the NDS and IIP updates. We're anticipating being able to launch the refresh of our IS&T strategy in September at our ADSTAR Summit and that will be the start of a regular two-year refresh cycle.

asymmetric things we can do is show that we can work effectively with our allies, not just in warfighting but in capability development. Our scientists have been collaborating for a long time but it's not usual practice for our industrial bases to, not just co-develop, but co-produce and co-sustain. That's now starting to change.

Two things always intrinsically sit in tension in this system. One is priorities (like the ones you just flagged and some more classified priorities). The other is Defence problems. And they're kind of chicken and egg: unless you do the R&D that opens up what is possible, at times you don't know how IS&T can best solve Defence's problems. If we just have a bunch of knowledge and solutions in our hands now, but we've developed them without thinking of our problems, we won't come up with the best solutions. It's a bit like you've got a hammer and every problem looks like a nail.

It is early days yet, but are there specific wins or activities you can point to that result from the NDS changes the organisation has undergone?

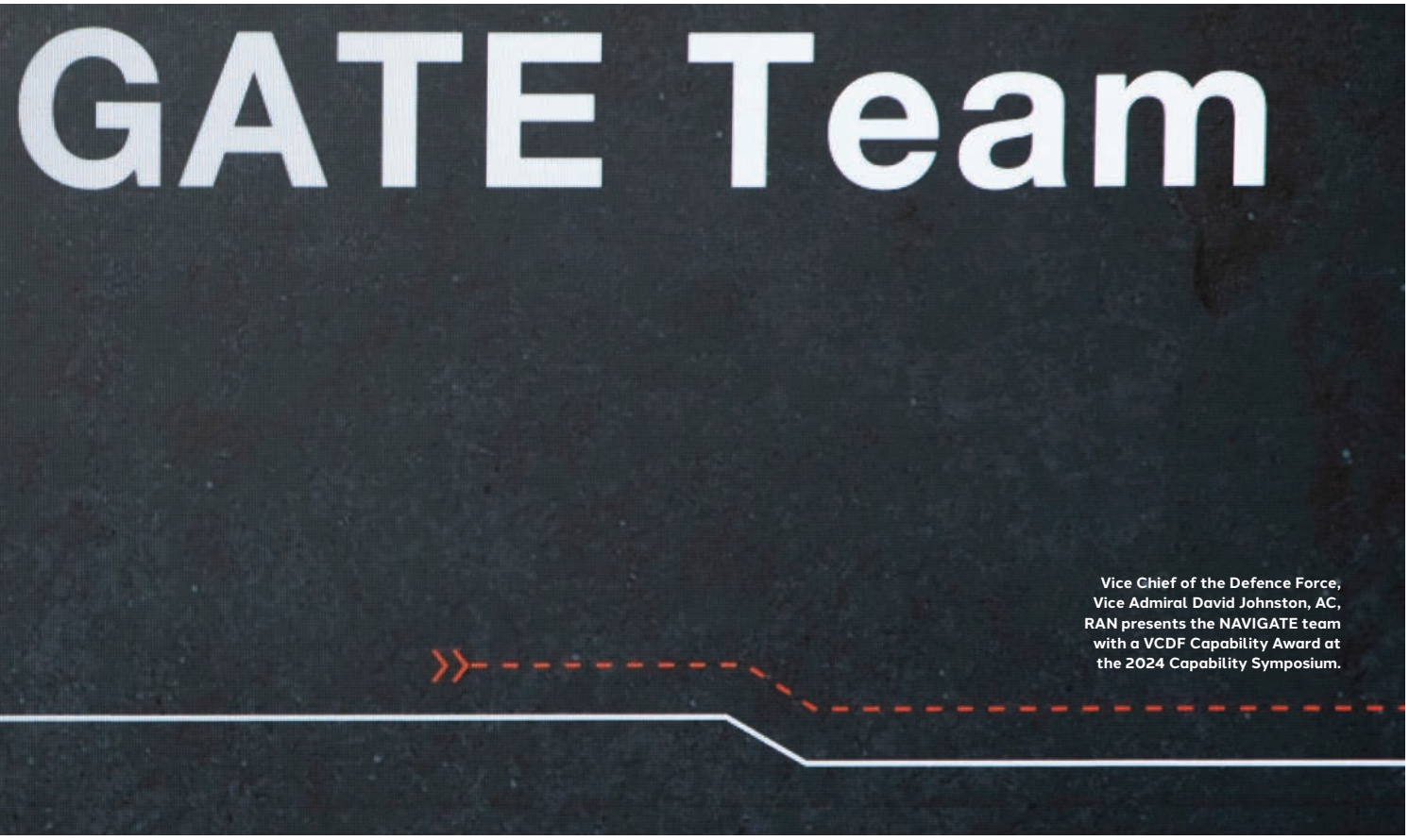
Firstly, the way the Defence IS&T ecosystem engages with industry and how it acquires capability has been restructured, and ASCA is an exemplar of this new approach. We've also pivoted more than half of our workforce to focus on the six Defence IS&T priorities. The implementation of DSTG's new networked operating model and restructure has been driving a culture change and shift in the way we work, which allows the DSTG leadership team to better drive the demand signals through our organisation.

Making sure the science we do and the way the capability the Department acquires is tested and evaluated in terms of the degree of asymmetry it gives to Australia, that's a shift.

That means having quite significant and sophisticated test and evaluation capabilities as well.

It does. And if I reflect on the *More, together* strategy that we published in May 2020, it set us on a path to focusing on fewer, bigger things, focusing on where we can have capability impacts. Having less focus on advice to acquisition and more ambition around what we can do nationally and with our partners.

We are committed to updating our strategy every two years to align



Vice Chief of the Defence Force, Vice Admiral David Johnston, AC, RAN presents the NAVIGATE team with a VCDF Capability Award at the 2024 Capability Symposium.

with the NDS and IIP updates. We're anticipating being able to launch the refresh of our IS&T strategy in September at our ADSTAR Summit and that will be the start of a regular two-year refresh cycle.

What is DSTG's workforce at present? And how are the cultural changes and NAVIGATE Programs that you have initiated going?

Our workforce, without contractors, is sitting at about 2,300. With contractors, it's sitting just shy of 3,000. We've been achieving some modest growth but always have struggles trying to stay to our Average Staffing Level allocation because of the broad range of things we have to cover.

The NAVIGATE Program is really exciting and we're reviewing the program right now so we can continue to improve it. We have three intake programs—our cadets, our R&I (research and innovation) graduates and our Navigators at mid-career. So, essentially student level, graduate level and mid-career professionals. Last year the Assistant Minister for Defence, Matt Thistlethwaite announced that all three of those programs would target having 50% female participation after we discovered with the NAVIGATE Program that signalling to the applicant community that we were seeking a certain proportion of females boosted the number of female applicants.

What we've learnt over the years is that if we aren't explicit in our messaging, we find about 20% of our technical workforce is female and that figure just doesn't shift. But with NAVIGATE, in the first round, we went out and said we wanted at least 40% women, and we got 43%. And in the next round of NAVIGATE we've exceeded 50% female, which is just brilliant.

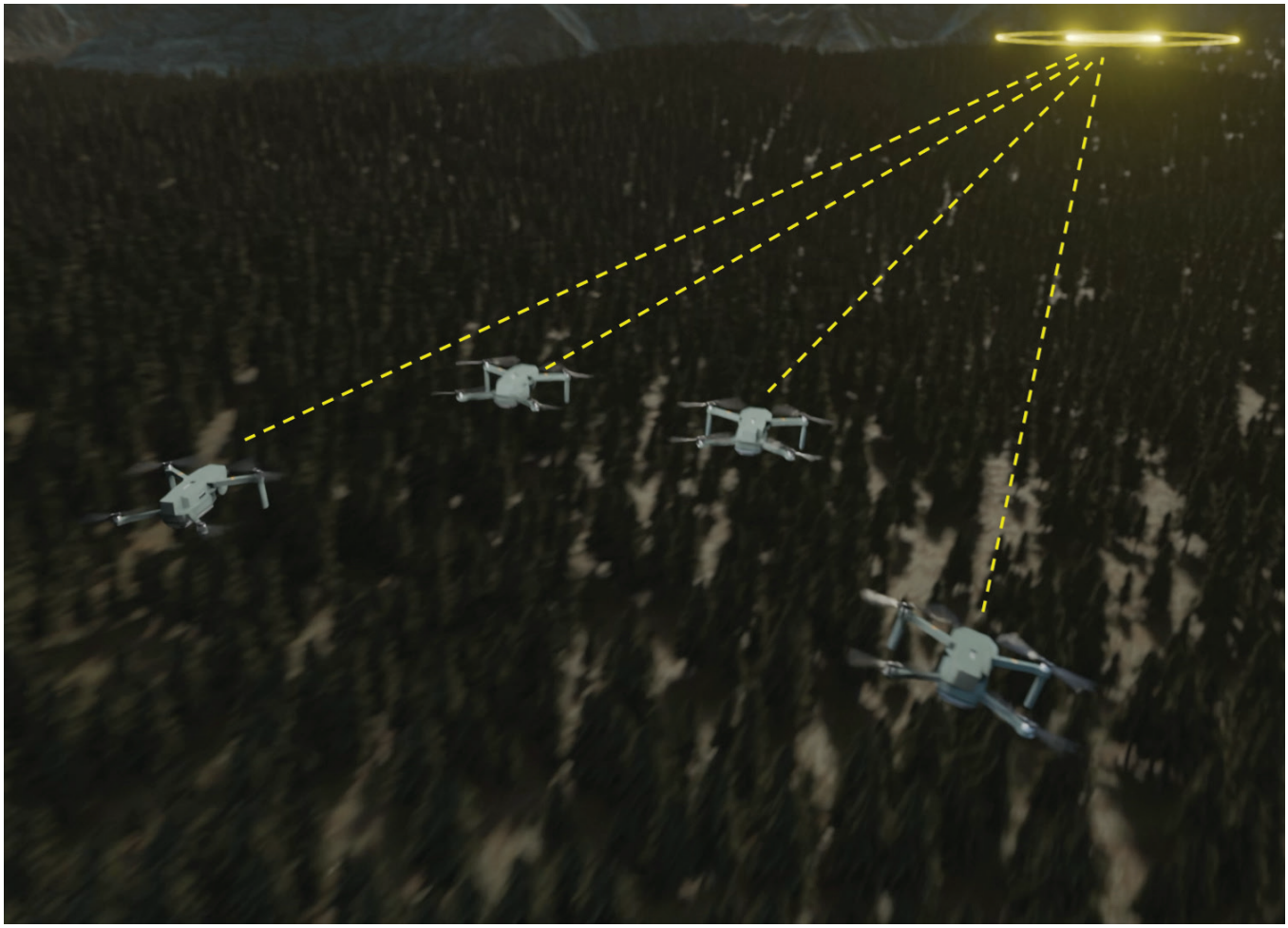
What about funding? The DSTG total funded expenditure budget for 2024-25 is $677.6 million. It will rise in 2025-26 to $744.4 million and then rises to $803.9 million and $964.4 million in 2027-28. What is behind this?

Our actual budget is just north of $1 billion, spread across a number of areas. First, the group budget covers salaries and operating expenses. Then there is funding for ASCA programs and there is some budget that comes into the group for projects where we are the nominated lead in the IIP or where we deliver IS&T plans for IIP programs led by others.

So, that shows a couple of things. The increasing confidence of government and the Department that Defence IS&T is pivotal to future advantage; that it's not just R&D in a lab but it's about getting proofs of concept into the hands of the warfighter and out into capability; and about partnerships with industry. It's representative of a shift of the overall balance of activity to be more focused on higher-risk accelerated programs, such as autonomous systems.

Is it enough?

It's never enough, but it's not just a matter of making an ambit claim. This is a matter of delivering and this funding trajectory is based on increased confidence and trust in our ability to deliver to the ADF. ●



Enhancing asymmetric effect through battlespace control

As adversaries adopt more sophisticated tactics, military strategists and technologists must leverage advancements in technology and innovative methodologies.

The landscape of modern warfare is becoming more complex due to an intricate interplay of sensors, communications and battlespace effects. The ability to manage assets in a complex environment will give us an asymmetric advantage.

Asymmetric effect can have disproportionate impact with relatively few resources. It offsets an opponent's advantages through tactical surprise, sensor and effect agility and unconventional weapons, including cyber-attacks. But to achieve asymmetric effect, we must change how we approach battlespace management.

With our defence industry partners, the University of Melbourne is developing new techniques for battlespace resource management. Our approach incorporates sensor adaptability, tactical communications and autonomous systems to achieve asymmetric effect.

Complex sensors and information systems must be guided by Commander Intent

The integration of sensors, communications, and battlespace effects represents a pivotal advancement in military operations.

Sensors, once limited in scope, are becoming adaptable. Many are

> The evolution of control and battlespace management is essential for achieving asymmetric effect in modern warfare. By harnessing the synergies between sensors, communications and autonomous systems, military forces can gain a decisive edge over adversaries. They can adapt to dynamic threats and seize opportunities on the battlefield.

equipped with multifunction apertures capable of utilising a broader spectrum. Sensors can be interconnected through sophisticated networking systems.

This enhanced sensor capability facilitates real-time data collection and analysis, providing commanders with unprecedented situational awareness. But humans play an important role in ensuring Commander Intent is followed. Technology should facilitate battle management and not direct it.

And the sheer volume of data generated by interconnected sensors necessitates meticulous information management for mission success. Despite technological advancements, communication limitations persist as a critical challenge. Effectively managing this influx of information requires precise control over sensor deployment and utilisation.

By aligning battlespace management systems with Commander Intent, military leaders can streamline decision-making processes and optimise resource allocation.

A battlespace control system helps achieve strategic objectives

To balance these requirements, we need spectrally aware battle management systems. In an environment characterised by increased electromagnetic effects, the ability to adapt and operate across multiple frequencies is paramount. Stochastic control systems and artificial intelligence will enable commanders to exert control over complex, uncertain environments, mitigating risks and maximising operational efficiency.

Just as a control system in engineering regulates the behaviour of a dynamic system, a battlespace control system orchestrates the actions of diverse military elements to achieve strategic objectives. It can do this using algorithms based on the optimisation of key performance criteria.

The University of Melbourne with its partners Australian Systems Research Pty Ltd and AOS Group have developed tools for commanders to better manage sensors, communications and assets in dynamic and contested battlespace conditions.

One of these tools developed for Integrated Air and Missile Defence, Battlespace Aspect Design, emphasises tactical placement of weapons and sensor assets to enhance mission performance. By carefully orchestrating the spatial distribution of resources, military planners can maximise sensor and weapon performance of a battlespace, thereby gaining an advantage on the battlefield.

Achieving asymmetric effect through autonomous systems

Apart from improved battlespace control, autonomous systems hold tremendous potential for achieving asymmetric effect. By augmenting traditional capabilities with autonomous platforms, military forces can operate with greater agility and flexibility, disrupting enemy strategies and outmanoeuvring adversaries.

The building blocks of a successful autonomous system are:

1. **Low-bandwidth communication links**: Efficient low-bandwidth communication channels enable seamless coordination between disparate assets, even in austere environments or contested airspace.
2. **Adaptive sensor technologies**: Sensors, particularly radars, must evolve to track targets with varying signatures, adapting to dynamic threats and changing battlefield conditions.
3. **Spectrum utilisation**: Optimisation of communication links across the electromagnetic spectrum enhances resilience and throughput, enabling rapid information exchange and response.
4. **Electronic warfare innovation**: Advanced electronic warfare capabilities play an important role in countering enemy defences and disrupting adversary communications, confounding their ability to operate effectively.

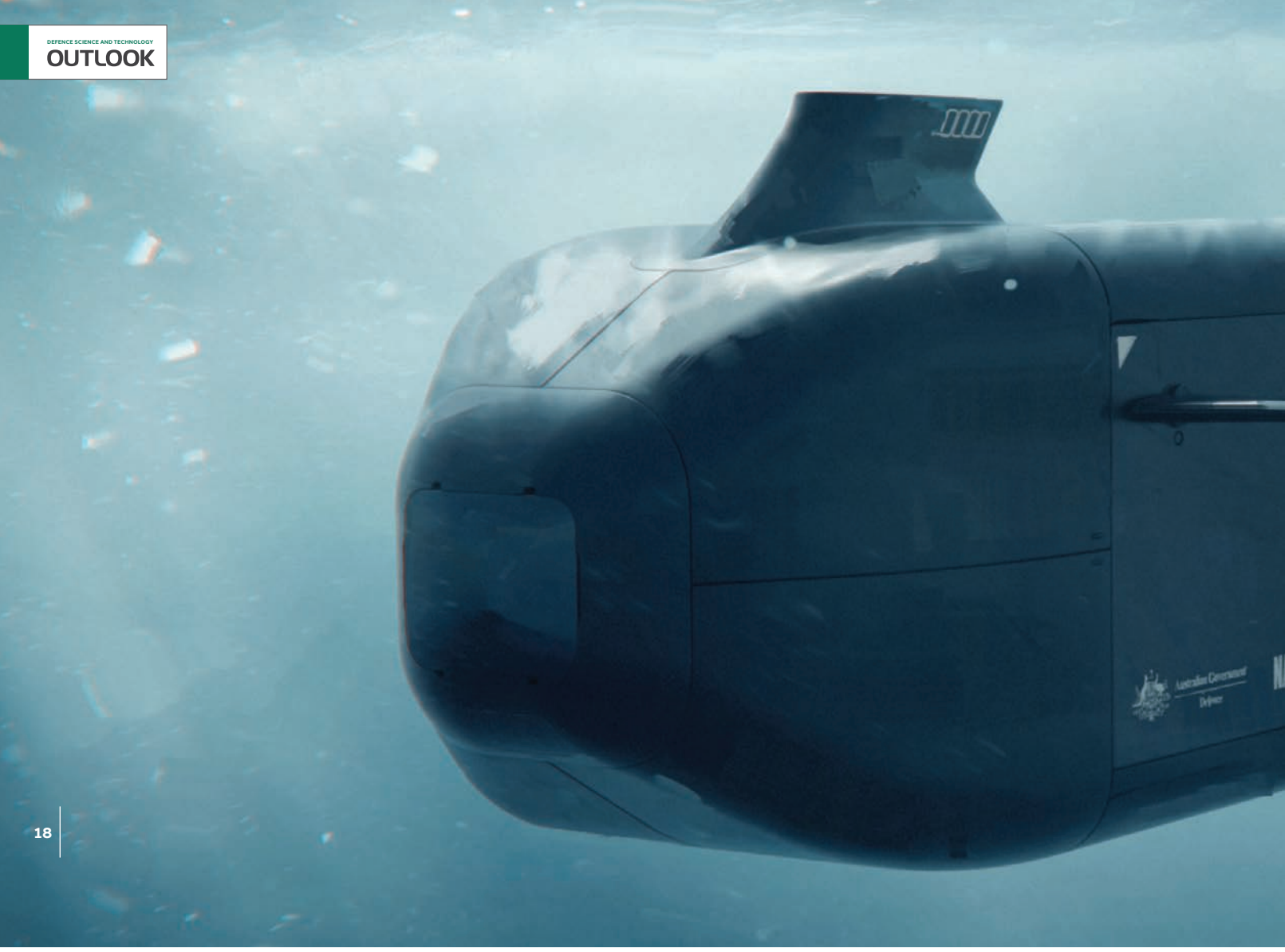
The University of Melbourne, in collaboration with industry partners, is at the forefront of integrating autonomous systems in electronic warfare. From suppression of enemy defence systems to countering Uncrewed Aerial Systems, these initiatives integrate autonomous and semi-autonomous platforms with human oversight.

Additionally, the University's advancements in underwater sensing technologies are enhancing situational awareness in maritime operations and expanding the reach of military forces.

The evolution of control and battlespace management is essential for achieving asymmetric effect in modern warfare. By harnessing the synergies between sensors, communications and autonomous systems, military forces can gain a decisive edge over adversaries. They can adapt to dynamic threats and seize opportunities on the battlefield.

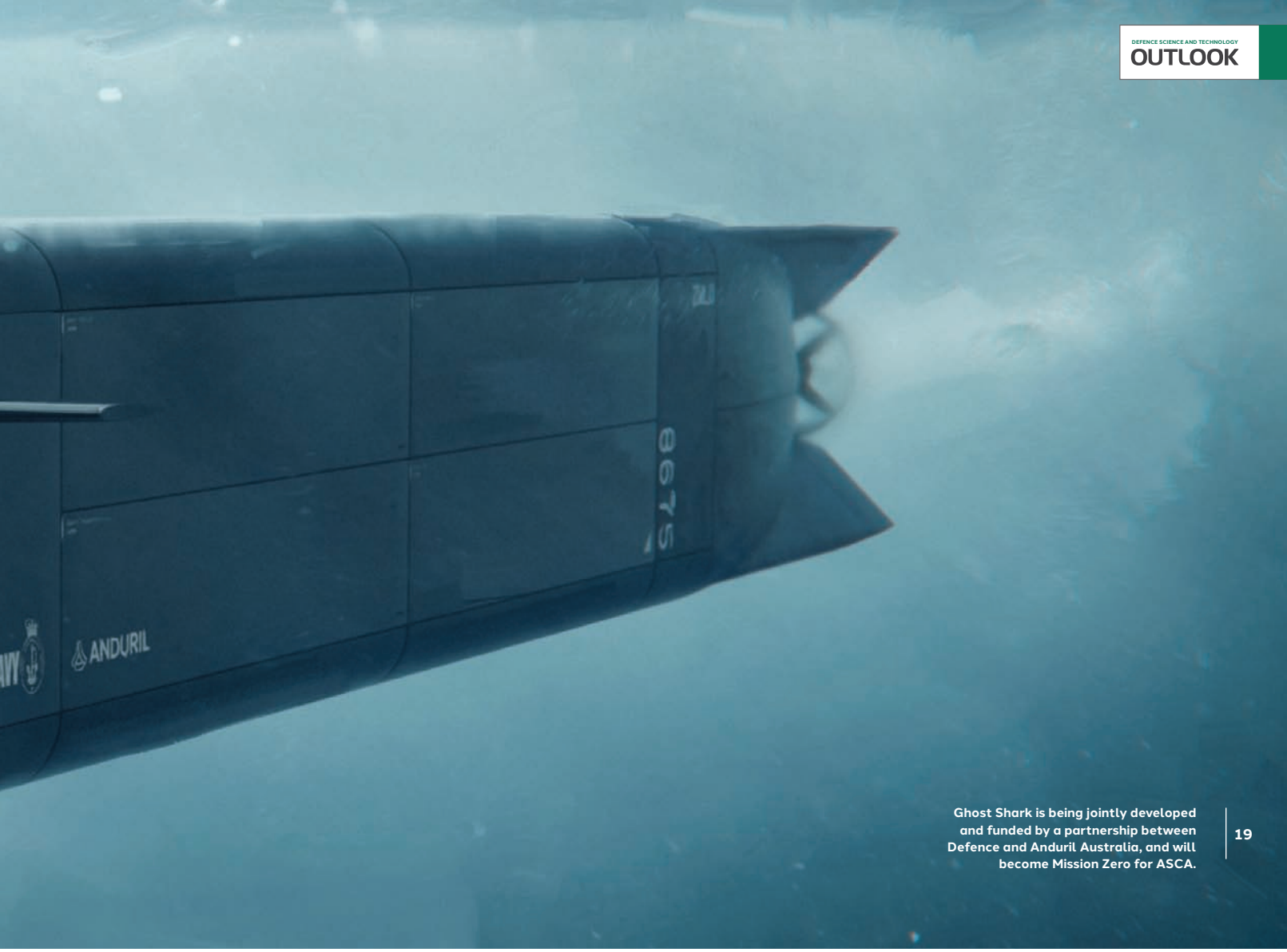
Through strategic innovation and government, industry and university collaborations, we can navigate the complexities of contemporary conflict and secure victory. ●

IMAGE: Supplied



Advanced Strategic Capabilities Accelerator is still accelerating

The Advanced Strategic Capabilities Accelerator (ASCA) has come a long way quickly since it was formed on 1 July 2023. And it is still accelerating to its planned cruising speed. **By Gregor Ferguson**



Ghost Shark is being jointly developed and funded by a partnership between Defence and Anduril Australia, and will become Mission Zero for ASCA.

ASCA celebrated its first birthday in July. Until ASCA was formed, no acquisition transition path existed into operational service for projects such as the $140 million Ghost Shark Extra-Large Autonomous Undersea Vehicle. Defence and Anduril Australia have been developing this since 2022. This was part-funded originally under the DSTG-administered Next Generation Technologies Fund (NGTF) and the formation of ASCA aided in giving Ghost Shark a clear and rapid acquisition pathway to operational service.

The example of Ghost Shark has resonances right across ASCA, says Professor Emily Hilder, who was confirmed in her role as Head of ASCA in February this year. "You'll notice we were very quiet on that in the beginning. We don't start something that we would call a mission, or of that scale, without having an identified transition pathway," she explains. "We didn't want to break our rules before we started. The Ghost Shark Program only became an ASCA mission when we had a viable pathway, and you'll see in the new Integrated Investment Program that there is a commitment to acquire things like Ghost Shark and other underwater capabilities.

"No matter how great the program is, if it doesn't have a transition pathway [to operational service] then the activity should stop."

The aim of ASCA, put simply, is to dramatically accelerate delivery of new technologies and equipment and to seek an asymmetric advantage. It does not do research and development and manufacturing but, instead, is developing the systems and processes that enable others to do them at an accelerated pace. ASCA has access to the DSTG's deep technical expertise when it is needed but is designed to achieve rapid impact.

Professor Emily Hilder FTSE

"Our success will be measured by what we're able to transition to capability for the Australian Defence Force [ADF]," Professor Hilder says. "Part of that success is putting up the systems and processes that allow us to do it again, and again, and again."

At the public unveiling of Ghost Shark in April this year, just 18 months after design and construction began, the

IMAGE: Supplied

I think the first really valuable lesson for us is that the fastest way to learn and to shape something new is, as much as possible, to learn by doing: not being afraid to try something, even if it doesn't work or it's not exactly as we planned, and to modify and adjust along the way.

Minister for Defence Industry, Pat Conroy, emphasised the importance of that transition pathway. He said Australia would acquire Ghost Shark to provide Navy with a stealthy, long-range autonomous undersea warfare capability that can conduct persistent intelligence, surveillance and reconnaissance and strike.

"ASCA is focused on speeding up the transition of innovation into capability that will give our ADF an edge, while creating more jobs for Australians commercialising the technology."

Now ASCA is working with Navy, as the capability manager, and Defence's Naval Shipbuilding and Sustainment Group as the delivery manager for Ghost Shark. "That's the other thing as well," she adds. "We can deliver the innovation acceleration component but we're not the right people to deliver an operational capability. So it's really important that we're working very well with both the capability managers and the delivery managers."

'Speed to capability' is the big difference between ASCA and the two bodies that it has subsumed, the Next Generation Technologies Fund (NGTF) and the Defence Innovation Hub. The NGTF might get something to the proof of concept stage; but the Defence Innovation Hub, as an unsolicited proposal mechanism, did not commit defence sponsors to bring an innovation into service. Between them, neither was designed to get innovations into frontline service quickly.

ASCA is designed to change this by working with the ADF's capability managers and getting innovations—primarily minimum viable capabilities—into operational use. It has moved fast in its first year, says Professor Hilder, and learned some lessons as well. She adds, "I think the first really valuable lesson for us is that the fastest way to learn and to shape something new is, as much as possible, to learn by doing: not being afraid to try something, even if it doesn't work or it's not exactly as we planned, and to modify and adjust along the way.

Minister for Defence Industry, The Hon Pat Conroy MP announced at Garden Island, Sydney that the Government will deliver a sovereign, autonomous undersea capability for the Royal Australian Navy, through the Ghost Shark Program. Ghost Shark 'Alpha', the first prototype co-developed by DSTG, the Royal Australian Navy and Anduril Australia was unveiled. Ghost Shark Program is Mission Zero for ASCA.

"We've learnt too that our external partners—industry and academia—are very understanding of that approach and, in fact, that's helped us to be able to move further and faster." In fact industry, especially, and academia are used to making decisions quickly on sometimes ambiguous or incomplete information. The inevitable risks are mitigated by their expertise in the domain concerned. ASCA is learning from them.

As an example, back in April, ASCA ran a trial of 10 sovereign manufacturers of lightweight Uncrewed Air Systems. Now, it is in contract with three of them.

"We hope that by early next year they will have delivered 100 prototypes each to Defence. But the contract, of course, is for more than that—to help them do the development piece they need and then be able to set up a standing offer panel early next year which would allow anyone across government to go to them," she says.

In its first 12 months ASCA has put out two Innovation Challenges, one of those being the AUKUS Electronic Warfare (EW) Innovation Challenge, and one call for Emerging and Disruptive Technologies (EDT). All of these have multiple facets. A new technology or product may not work, in which case the project can be terminated quickly. But a successful project will result in service entry because it is designed to solve an actual Defence problem, or to offer Defence some form of asymmetric advantage.

In July this year, ASCA put out its first call for pitches to be delivered during the ADSTAR Summit in September. The theme of this first Pitch Day is 'Innovative Asymmetric Advantage'.

Going forward, ASCA aims to put out a single call for an EDT each year, at least two Innovation Challenges a year, and it intends to run more missions, says Professor Hilder. "Our aim, once we get to a steady state, after three years or so, is to have eight or nine missions running in parallel.

"So there's quite a ramp-up there that's reflected in our funding profile."

The AUKUS Electronic Warfare Innovation Challenge addresses one of the advanced technologies identified under AUKUS Pillar II. It is run by each of the three AUKUS partners, the UK, US and Australia, and is aimed at developing a competitive advantage in both targeting and counter-targeting EW.

Leading the challenge for Australia's researchers and industry is ASCA. The release of this challenge creates an opportunity for Australia's defence industry and academia to address a problem faced by all trilateral nations. And, again, the emphasis is on speed to capability as well as greater alignment and integration between the innovation systems of AUKUS nations.

The relationships ASCA is building with Defence's capability and delivery managers is vital, Professor Hilder says.

IMAGE: Supplied

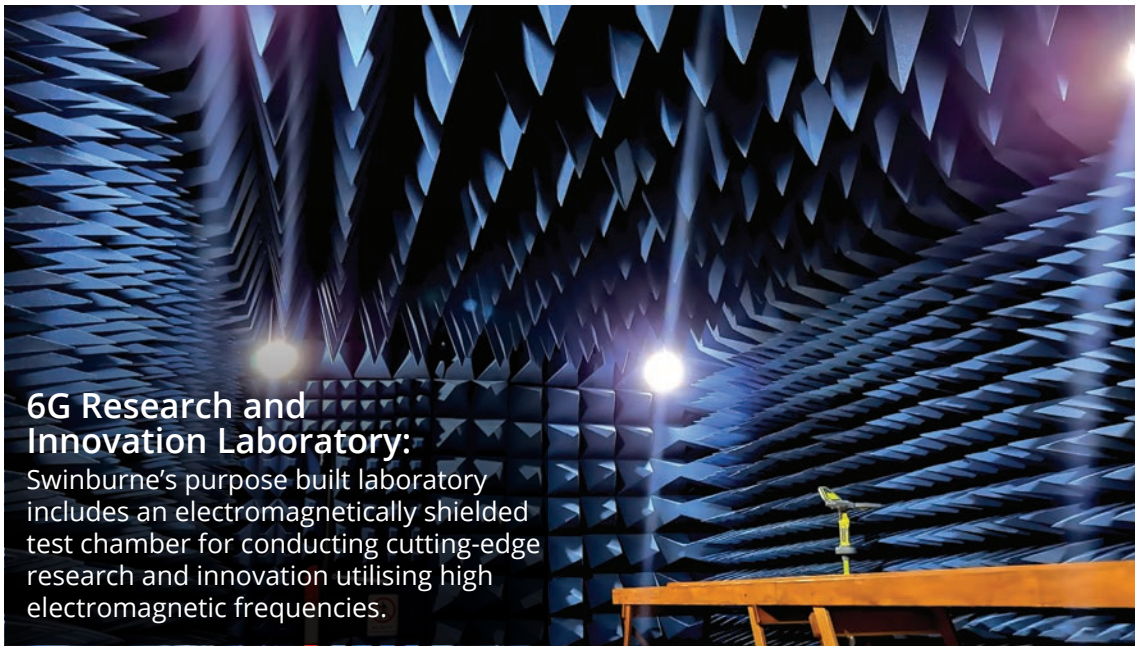


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IMAGE: Supplied

"Capability managers are absolutely key stakeholders for us. It brings a degree of contestability into what we do, which I think is really important. We generate some really healthy friction because everyone is coming at it from different perspectives. It forces us to be really deliberate about our decisions, to understand why we're making decisions and to get after the right problems.

"ASCA doesn't determine the problems we should get after, and we're not the ones who are ultimately going to deliver and manage the capability," she adds. "As I say to the team, we're not the owners of any of this. While something's in our hands, we must be good custodians and do everything we can to accelerate it into the hands of those who are going to use it and deliver it as capability for Australia."

In a sense, ASCA is the result of Australia's deteriorating strategic circumstances and some inspired Defence leadership appointments over the past four or five years. Professor Hilder acknowledges, "But I think the other thing, too, is that we've tried really hard through DSTG, in general, to lean in and to demonstrate where innovation, science and technology [IS&T] can shape future capability and allow Australia to have better asymmetric options, and also to deliver new capability more quickly. And that is a definite shift."

The new Defence IS&T Strategy, which is due out in September, builds on that and the changes in DSTG. She emphasises, "It's really important, because the closer we are to the problem the better we understand the problem; and so the more we can look at where we can bring in innovation and new and emerging technologies to deliver a better and faster outcome for our ADF."

ASCA is within the remit of CDS, sitting alongside DSTG for good reasons. "It is really important that we are close to the ADF and Defence's problems, to be able to co-create with them and to deliver for them rather than being in any way disconnected," says Professor Hilder. "The ability also to draw on those decades of experience in Defence S&T can't be overestimated, and it's been critical to our success to date."

ASCA exists to challenge the status quo and ask how things can be done differently and better. But it also needs repeatable processes and a corporate memory. It needs those processes for applying the lessons it has learned, otherwise ASCA would be constantly relearning how to do its job.

"One of the things that's been really important for us in 'learning by doing' is that we're really focusing on the lessons learnt and the changes we would make to reduce the drag next time," points out Professor Hilder. "We're still on that journey."

The journey involves co-creation, constant reflection and feedback. How could we do that more quickly, or more easily or with less of a burden on ASCA's people?

Renowned former Australian Defence leaders make up Swinburne's Defence Advisory Board

The Swinburne Defence Advisory Board will contribute to the work of Swinburne University of Technology's defence-related research and innovation by offering critical advice, expertise and experience around the university's 'Detect and Protect' mission.

This includes matters relating to defence industry trends, challenges and opportunities, and research.

Board members Kathryn Toohey AM CSC (Major General Retired), Mel Hupfeld AO DSC (Air Marshal Retired), Michael Noonan AO RAN (Vice Admiral Retired) and Professor Gary Hogan AM CSC (Brigadier General Retired) bring a range of industry expertise from the Australian Army, Royal Australian Air Force, Royal Australian Navy and Defence Intelligence Organisation, respectively.

Associate Deputy Vice-Chancellor, Research and Chief of Defence Innovation, Distinguished Professor Saeid Nahavandi says he is thrilled to be working with a range of industry leaders who will bring valuable knowledge and guidance to how Swinburne approaches critically important areas such as aerospace, digital capability, manufacturing, and education and training.

"I am excited to be working with such distinguished and experienced industry trailblazers who will provide a wealth of insights into how we support Australia's national security through a holistic, dual-layer approach," Professor Nahavandi says.

"Swinburne is dedicated to future-focused research that combines science, technology and innovation with humanity to deliver real-world social, environmental and economic impact.

"The Swinburne Defence Advisory Board highlights our commitment to undertaking defence-related research and innovation, aligned with our flagship research areas, to improve defence sovereign industrial capability and advance national security for all Australians."

SWINBURNE UNIVERSITY OF TECHNOLOGY

Ghost Shark 'Alpha' the first prototype co-developed by DSTG, the Royal Australian Navy and Anduril Australia was unveiled. Ghost Shark Program is Mission Zero for ASCA.

Ghost Shark is being jointly developed and funded by a partnership between Defence and Anduril Australia, and will become Mission Zero forASCA.

"So, we are focusing very much on building that methodology which allows us to do things more quickly. The Ghost Shark program, again, provides a classic example. We've learnt some incredible things in working through how we're going to transition it, and some of that will be really important in how we approach that for future missions."

Earlier this year Professor Hilder spoke about venture capitalists and private capital in the defence market. The Ghost Shark is being developed on a 50:50 basis by Defence and private sector firm Anduril Australia, which is a major departure for Defence. Additionally, Sydney company Arican Advisory, saw the opportunity early and established its Periscope National Security Growth Fund in April to focus on the opportunities thrown up by AUKUS Pillar II, and has already had more than $100 million committed. It aims to help companies go from early stage start-ups right through to maturity.

One of the recommendations in February's Defence Industry Development Strategy, she points out, was for Defence to engage with the private finance sector to identify opportunities to increase their participation in the defence industry. This is important to help support some of the small to medium enterprises (SMEs) to get the financial backing they need to scale in order to support Defence's needs.

In early July, Defence published an Expressions of Interest (EOI) via AusTender aimed at seeking venture capital fund managers, investors and industry's views on the establishment of a pilot fund project. The intent of the EOI is to identify whether there is a gap in the market where small business cannot readily and economically access equity or debt products to enable participation in the delivery of Defence capability.

"We know that we have many SMEs that have the skills and the capabilities and the technology to contribute to Defence," she says, "but how do we support them and encourage an ecosystem that supports them to scale and become more resilient?"

Helping develop a robust, innovative, resilient and competitive sovereign defence industrial base will be an important demonstration of ASCA's success. This is a strategic goal of Defence and an innovative industrial base will hasten the delivery of new technology and asymmetric advantage to the ADF. Twelve months on, ASCA is still accelerating and shows no sign of slowing down.

IMAGE: Supplied

Research and innovation drives Australian manufacturing capabilities

Dr John Best, Chief Technical Officer, Thales Australia

By Dr John Best, Chief Technical Officer, Thales Australia

In a world that is progressively interconnected, the systems used by defence and commercial enterprises to deliver outcomes are increasingly complex. With a global workforce of more than 81,000 employees across five continents, Thales has a proud history of delivering these systems internationally across the markets of aerospace, defence and security, digital identity and cybersecurity and space.

Domestically, Thales is a trusted partner of the Australian Defence Force (ADF) and has a workforce of over 4,300 people across 35 sites around the country. As a sovereign manufacturing entity, Thales in Australia has a strong track record of designing, manufacturing and exporting solutions for various sectors including defence, security, transport and aerospace.

Thales has a presence in regional areas, with several of its sites located outside major cities, all of which employ a significant number of Australians. For example, the Lithgow Small Arms Factory in regional New South Wales

plays a crucial role in Australia's national defence, manufacturing the small arms used by Australian soldiers in all conflicts since WWI.

Additionally, the Bushmaster Protected Mobility Vehicle, designed and manufactured in Bendigo, regional Victoria, has saved the lives of Australian and coalition soldiers on operations over the last two decades.

At the core of the Thales ethos lies a commitment to customer success, supported by a dedication to innovation, and research and development (R&D). These pillars are fundamental to mastering the complexity of the systems and solutions Thales provides. In light of this, Thales globally invests around $1.6 billion annually in R&D activities with the objective of creating next generation technologies and solutions.

One of the ways in which we support and sustain our extensive and diverse supply chains is by actively engaging with Australian small to medium enterprises (SMEs) and start-ups. By leveraging their unique skills and technologies, we can collectively deliver leading solutions to the ADF. Thales takes this a step further through its contribution to the Defence Global Supply Chain Program, which links highly innovative Australian companies with opportunities to supply into the broader Thales Group.

Central to Thales' breadth of manufacturing capabilities is our approach to product development and innovation—the 'Thales Innovation System'. This system is realised through the deployment of a number of core processes, practices and methods that assure systematic scanning of the environment, strategic impact assessment, and deployment of actions to develop and implement the technologies and capabilities that will underpin the creation of next generation solutions.

Any successful product innovation and development process is underpinned by:

1. A deep understanding of customers and the challenges they face.
2. Mastery of core enabling technologies.
3. A risk-based deployment of emergent technology.
4. Access to the technologies of tomorrow.

Thales' approach to research and innovation is centred on collaboration with the local research ecosystem, which includes universities, public sector research organisations and research consortia.

A great example of this is Trusted Autonomous Systems (TAS), established as a Defence Cooperative Research Centre through the former Next Generation Technologies Fund. Thales conceived and led the TAS-funded 'Mine countermeasures in a day' project, that aimed to enhance detection and clearance of underwater mines close to shore, while simultaneously improving safety for Navy personnel. The project has designed, developed and tested teams of collaborating autonomous underwater and surface vehicles to provide a mine clearance capability that operates in the amphibious zone close to shore. On this project, Thales worked closely with four leading Australian universities and two innovative SMEs.

This case additionally demonstrates the value of research consortia as a mechanism to pursue innovation in cases where capabilities from multiple parties are required to deliver a complex solution, and when there is an intention to build a supply chain to deliver the solution at industrial scale. The project team members bring different yet complementary perspectives, while end users or their representatives provide the use case. Moreover, universities and public laboratories contribute basic research expertise and infrastructure, and industry adds the rigour of formal engineering and manufacturing processes to realise solutions.

A further example of this is the Advanced Strategic Capabilities Accelerator funded, and DMTC managed, Advanced Piezoelectric Materials and Applications Program. As the lead industry participant in the program, Thales is developing the capability to manufacture single crystal piezoelectric materials to deliver next generation undersea sensing solutions. Single crystal piezoelectric materials hold the prospect for creating sonar transducers with enhanced sensitivity and bandwidth. These features will enable delivery of superior performance in traditional sensing payloads, or optimisation of payload SWAP (space, weight and power) for unmanned surface or underwater vehicles.

Current strategic circumstances demand that we align our innovation, research and industrial activities with the objective of rapidly delivering minimum viable capabilities that support ADF preparedness and asymmetric advantage. To achieve this, we engage collaboratively with SMEs, academia, public sector research organisations, research consortia and our wider supply chain. By leveraging collective expertise and resources, we can ensure that our solutions are agile, adaptable, and aligned with the evolving needs of our customers and end-users. This collaborative effort reinforces our commitment to innovation, excellence, and the delivery of effective, tailored capabilities that contribute to overall mission success.

IMAGES: Supplied

The nuclear-powered, conventionally-armed submarine USS Annapolis (SSN 760) is at HMAS Stirling for the second visit by a fast-attack submarine to Australia since the announcement of the AUKUS (Australia, UK, US) Optimal Pathway in March 2023.

Australia's nuclear-powered submarines: A whole of nation endeavour

A conventionally armed, nuclear-powered submarine capability, and the elements of the Optimal Pathway to get there, will be at the heart of Australian deterrence when it enters service. Getting it there, and keeping it there, will take a whole-of-nation effort. **By Gregor Ferguson**

Nuclear-powered submarines lie at the core of Australia's new defence strategy of deterrence through denial. In layman's terms the strategy has changed from "Try it and you'll be sorry" to "Don't even think about it".

Deterrence is all about an adversary's state of mind and ability to plan coherently. Australia's strategic circumstances are deteriorating, so credible deterrents are vital across all five of the Australian Defence Force's operational domains: maritime, land, air, space and cyber. With our circumstances deteriorating so quickly, selecting a conventionally-armed, nuclear-powered submarine and creating the AUKUS [Australia, UK, US] Partnership back in September 2021 was a logical step.

The new submarines will be a key part of Australia's maritime deterrent. They challenge a potential adversary's belief that it could achieve its ambitions by military force at an acceptable cost. "Nuclear-powered submarines' ability to operate undetected for extended periods means a potential adversary must account for their presence over vast geographies in their operational planning," says the Australian Submarine Agency's Head of Nuclear Submarine Capability, Rear Admiral (RADM) Matthew Buckley.

While the existing *Collins*-class diesel-electric submarines can be very quiet, Australia's geography means their ability to meet the country's needs is diminishing. They lack the submerged speed and endurance of a nuclear-powered submarine and will need to raise their 'snorting' masts at periscope depth on a regular basis to recharge their batteries—that risks giving their positions away. "No other platform matches the stealth, endurance, mobility and mix of capabilities a nuclear-powered submarine provides," says RADM Buckley. "They offer virtually unlimited range and increased stealth because they do not need to come to periscope depth to recharge the batteries."

DSTG's role in developing and sustaining this new submarine paradigm is essential. It has decades of expertise in propulsion, materials and acoustics so is already providing technology advice to the Royal Australian Navy (RAN) on construction (it developed the special hull steel and welding regime for the *Collins*-class boats, for example), operation (it developed the *Collins*-class anechoic tiles and adhesive) and sustainment of the new submarines. At Launceston's Australian Maritime College, part of the University of Tasmania, DSTG owns or has access to some of the most sophisticated hydrodynamic and sensor research tools in the southern hemisphere.

The Australian Submarine Agency is working in partnership with DSTG, where technologies relevant to submarine platforms and their operation are rapidly changing or research is needed—excluding naval nuclear propulsion.

The complete, welded power units for the planned UK-Australian SSN-AUKUS submarines will be built by Rolls-Royce in the UK, and Australia will invest £2.4 billion (about $AU4.64 billion) to both expand the company's manufacturing facilities to accommodate the RAN's needs and contribute to the SSN-AUKUS design. "It was never planned for Australia to manufacture power units in Australia, and it makes sense that we would need to contribute to expanding the production line in the UK to accommodate Australia's needs," says RADM Buckley. To get to the planned SSN-AUKUS submarine, the RAN first needs to acquire and operate a sovereign force of three to five Virginia-class nuclear-powered submarines from the early 2030s.

One of the toughest problems for Australia's submarine community, of course, is simply crewing those submarines. Defence is emphatic that Australia's future Virginia-class

RADM Matthew Buckley

IMAGE: CPOIS Nina Fogliani from Defence database

University research steps up to support Defence and national security

The University of Adelaide is committed to supporting the Australian Government's 2024 National Defence Strategy, which calls for a whole-of-nation approach to harness all aspects of Australia's capability to secure national interests. This includes partnering with Australia's defence sector, where such partnerships align with the national interest and are consistent with the University's values and objectives.

The Australian Government has a duty to ensure the safety and security of its citizens. As a research-intensive University, our long history of engagement with the defence and national security sector is critical to improving our nation's sovereign defence capability and fostering conditions for regional security, stability and prosperity.

The defence sector is a major element of the Australian economy, at just over 2% of GDP and with a market size measured at around $51.6 billion in 2023. In South Australia, defence represents almost 4% of our economy and employs around 15,000 people, many in high value jobs.

The defence industry is crucial for national security and regional stability, offering extensive opportunities for innovation and growth. By collaborating closely with this sector, we enhance the employability of our University's students and prepare them with the necessary skills and knowledge to meet future workforce demands. These partnerships support careers in defence and ensure our graduates are well-equipped to contribute and lead in building a robust and forward-thinking workforce.

The University of Adelaide contributes to national security efforts and defence projects through initiatives such as the Defence Trailblazer program and the Defence and Security Institute. We are committed to building and maintaining world-class research, knowledge, infrastructure and commercialisation pathways to support Australia's national interests and promote the economic prosperity of South Australia.

The University will also pursue opportunities from the AUKUS trilateral security partnership, supporting the Australian Government's national security endeavours. Our defence research is focused on key areas: cyber and influence, quantum technologies (materials, timing, sensing), autonomy and artificial intelligence, international security, directed energy and human biotechnologies. Our drive is to build defensive capabilities that help make our nation safe and secure. Complementary to this, much of our defence and national security research finds application in other sectors, which adds resilience and efficiency dividends to the ecosystem.

Collaboration with the defence sector aligns with the University's mission to meet our community's evolving needs and challenges. Our highly skilled graduates will be ready to meet workforce demands now and into the future. ●

IMAGES: Supplied

submarines, then SSN AUKUS, will be a sovereign capability and fully crewed by suitably qualified and experienced RAN personnel. But behind those ship's companies will be a long 'tail'. Delivering the program will require the collective effort of thousands of highly skilled Australian scientists, engineers, project managers, operators, technicians, welders, construction workers, electricians, metal fitters and builders.

Many of them need to be in place from as early as 2027, when Submarine Rotational Force - West comes into being, and UK and US submarines start rotating through Fleet Base West and being sustained there. So, over the next 12 months, more than 100 personnel from ASC in Western Australia will go overseas to learn the skills needed to support visiting UK and US nuclear-powered submarines, and then the Australian submarines.

Defence is working on several fronts to build its nuclear workforce. On the submarine crewing side, six RAN officers have already graduated from the US Nuclear Propulsion School and eight sailors have begun training there. All will serve on US Navy Virginia-class submarines. Similarly, the first three officers have graduated from the UK's equivalent and have been assigned to the Royal Navy's Astute-class boats. And Australian Navy and civilian personnel are currently on US and UK placements in shipyards and education and training facilities.

The Australian Government is also working with Australian universities to expand the training available in relevant science and engineering fields to support the nuclear-powered submarine capability and is working closely with the vocational sector to deliver technical and trade offerings.

Earlier this year, for example, the University of New South Wales launched its Nuclear Innovation Centre to train up to 100 nuclear-qualified undergraduate engineers a year, along with a swag of PhD and Masters students who will form the core of subject matter experts responsible for high-level policy and safety decisions.

As part of the 2023-24 budget, the Australian government allocated $128.5 million over four years to establish a new Nuclear-Powered Submarine Student Pathways Program and to provide an additional 4,001 Commonwealth supported places in science, technology, engineering and mathematics (STEM)-related courses.

The trick is to get a training pipeline operating with consistent numbers entering and graduating. "Ongoing trilateral engagement to develop the nuclear-powered submarine workforce has illuminated a very large amount of shared DNA between the United States Navy (USN) and RAN submarine communities," RADM Buckley says. Australian submarine-qualified sailors and officers moving into the USN training system are already skilled and experienced in many of the proficiency areas necessary to crew Australia's first nuclear-powered submarine. "These submariners are—and will continue to be—key to developing those senior crew positions in the first submarine, which would otherwise take more time to develop from scratch than we have," RADM Buckley says.

STEM subjects matter even more with the Virginia-class submarines and a submariner STEM Upskilling Program has been established to help prepare personnel wishing to be part of the future capability, with the program proving extremely successful.

One of the biggest challenges will likely be Australia's contribution to the design and construction of the SSN-AUKUS submarine. That $4.64 billion Australia is investing in the UK includes a contribution to the boat's design costs.

Already there are Australians working on the design with the UK. The involvement of BAE Systems Australia ensures a close connection with the SSN-AUKUS design led by BAE Systems in the UK, with Australian experts already working alongside their peers in the UK.

Another challenge is qualifying Australian companies. In January this year, the AUKUS partners established the Defence Industry Vendor Qualification Program to streamline and accelerate the qualification of Australian suppliers into US and UK supply chains. Some 50 Australian firms were invited to be part of this program with their sights set on the Virginia-class submarines. A second wave, focused on the anticipated design needs of the SSN-AUKUS, will commence later this year.

The Virginia-class and SSN-AUKUS submarines will share elements of the propulsion and platform systems, with the combat system and conventional weapons being the same in both classes, as they already are in the *Collins*-class and Virginia-class submarines. This commonality will help with the RAN's transition to SSN-AUKUS and enhance interoperability and interchangeability among the AUKUS partners, as well as helping the transition of Australia's workforce.

"Increased embedding of Australian sailors on UK and US nuclear-powered submarines (including the Virginia-class) from 2023 will increase familiarity with these shared systems, enhancing Australia's capability to operate, maintain and regulate our sovereign capabilities from the early 2030s," RADM Buckley says.

The Government has already selected ASC Pty Ltd and BAE Systems Maritime Australia as Australia's sovereign submarine build partners and the SSN-AUKUS boats will be built at an expanded Osborne Naval Shipyard to be known as the Submarine Construction Yard. BAE Systems Australia has already done much advanced ship construction research with Adelaide-based Flinders University.

Engineering firms KBR and an AECOM/Aurecon Joint Venture will design the new yard. The two design teams collectively bring together nuclear infrastructure specialists and experienced personnel from previous shipyard infrastructure projects at Osborne, Henderson and in AUKUS partner nations.

"Workforce is our biggest challenge which includes educating and developing our current and future workforce across the entire Australian sovereign nuclear-powered submarine enterprise in nuclear and other engineering and STEM-related fields," RADM Buckley says. "The AUKUS partnership provides exceptional training opportunities such as our Royal Australian Navy officers and sailors doing nuclear studies in the US and UK. The Australian government is also allocating 4,001 new Commonwealth supported places across 16 universities nationally in areas including nuclear science, naval architecture and mathematics." ●

An underwater operator from the United States Navy prepares to launch an underwater vehicle during Exercise AUKUS at Pittwater, New South Wales.

Navy embraces speed and asymmetry

The former Warfare Innovation Navy Branch within Navy Capability Division has been renamed and has a sharper focus on delivering asymmetric capability quicker. **By Gregor Ferguson**

This year's National Defence Strategy, or NDS, has had a seismic effect on some parts of Defence. It calls explicitly for asymmetric capabilities, for speed to capability and for innovation, and the Royal Australian Navy (RAN) got the message.

At Navy Headquarters in Canberra, Navy Capability Division's, led by Rear Admiral Stephen Hughes, the Maritime Integrated Capabilities Branch (MICB) has only existed since 1 July 2024 and its new Director-General, Commodore (CDRE) Michael Turner, has only been in place since March, shortly before the NDS was published. MICB includes the former Warfare Innovation Navy Branch and is now also responsible for a number of additional integrated capabilities that enable maritime warfare. His workforce consists of up to 100 people, including public servants and some contractors, and their job includes helping develop new technologies and, if they make the right sort of impact, get them into frontline service as quickly as possible.

"The approach Navy's taken now is a little different from the days when Warfare Innovation Navy was established, where it did essentially take seed money through agencies such as the Defence Innovation Hub or Defence co-investment and invest in companies to develop promising technologies just to see what was technically feasible," says CDRE Turner.

With the release of the NDS and its companion, the Integrated Investment Program (IIP), the RAN has moved on from experimentation, some lasting many years, and has identified "a series of technologies that we want to take forward and quickly introduce into service, and that's where the majority of the effort is right now," says CDRE Turner—taking the results of those experiments and working with the companies concerned to get the technology outcomes into the hands of the operators as quickly as possible.

Terms such as asymmetry, minimum viable capability (MVC) and speed to capability are the common language of modern defence capability in Australia. Not surprisingly MICB has a good relationship with Defence's innovation, science and technology (IS&T) agencies, Defence Science and Technology Group (DSTG) and Advanced Strategic Capabilities Accelerator (ASCA). There are DSTG personnel assigned to MICB, says CDRE Turner. "They facilitate access to the various parts of DSTG to support the projects that I manage. DSTG has been heavily involved in the test and evaluation process for these technologies and helped identify those with the most promise, and they continue to be heavily engaged in the process to mature those technologies as quickly as we possibly can."

The RAN is increasing its focus on autonomous systems. "That area is evolving so quickly that keeping up with what's happening and looking for the next opportunity will be so important to how we develop these technologies."

When you are building very large complex systems such as submarines or warships, the technology insertion process needs to be far more measured and structured because some of those platforms might remain in service for decades, so it is worth taking time to get them right. Whereas, says CDRE Turner, "the systems we're talking about, you really do have the ability to rapidly upgrade and improve the capability as we identify opportunities, or technological breakthroughs occur or, in many cases, technology which already exists becomes affordable to suit our approach of producing autonomous systems at the right price."

CDRE Michael Turner

So DSTG works with both MICB and the companies developing the technology. "It's a slightly different model to what was used in the past."

That same overlap exists with ASCA. There is a direct relationship between ASCA's Mission Zero, the Ghost Shark Extra-Large Autonomous Undersea Vehicle and MICB, says CDRE Turner.

"When you look at future ASCA missions, we're already identifying overlaps between what we're doing and what they're doing, and we continue to work those relationships to make sure the projects benefit," he adds. "I expect that process will continue to get better and better as we understand, and they understand, what they're doing and how we can work better together."

IMAGE: ABIS Lucinda Allanson from Defence database

The logic which gave rise to MICB is fairly simple—there are parts of Navy Capability that specialise in long-lived assets such as ships, submarines, communications systems and so on. Most other things lend themselves to rapid integration, says CDRE Turner. Focused IS&T effort can give them a disproportionate impact and so they fall into the new Branch. Hence the name as the new branch embraces robotic and autonomous systems and artificial intelligence (AI).

The Branch also oversees experimentation—MICB 'plans and executes' Exercise AUTONOMOUS WARRIOR; for example, the RAN's regular exploration of experimental and maturing autonomous and robotic systems, which has been running for several years. AUTONOMOUS WARRIOR 2024 forms part of the Maritime Autonomous Experimentation and Exercise Series, which was announced as a key activity under AUKUS Pillar II at the December 2023 AUKUS Defence Ministers' Meeting.

So how does he see the new Branch evolving? "Since we've done the 'lift and shift' phase, the Branch has rapidly expanded its range of functions," he says. "I'd expect it would evolve as we identify synergies between the various areas. So as we see opportunities to better coordinate efforts, create greater efficiencies and, hopefully, it can generate better outcomes more quickly than we otherwise would have.

"Will the Branch look like this in a few years' time? Probably not," he considers. "I think it's too early to tell. I don't think it's a function of the technologies that we're working on. I can see a convergence—areas which were done in different parts of Navy have now all come under the Branch as we seek those efficiencies and synergies. We could see further consolidation."

The Branch might also assume some interesting roles, he suggests. AI and data management are a case in point—they are currently disaggregated across Navy, indeed across Defence as a whole, he believes. "That might be an area where we can do better and work out a more efficient way across Navy to do business."

In an organisation that, at the time of writing was less than a month old, "there's still a bit of a way to go before we settle on what I think is the best and most efficient way forward."

So what are his priorities for the new organisation? "The priorities in this space are well outlined in the National Defence Strategy. So that's what I've orientated the Branch around. The NDS provides clear direction of what's needed and when it's needed," says CDRE Turner.

While the Bluebottle is already in operational service, Ghost Shark and Speartooth are heavily involved in trials involving their manufacturers, Anduril Australia and C2 Robotics, respectively, ASCA and MICB. And Ghost Shark and Speartooth have both been to sea.

The NDS lists two capability priorities in particular that go to what MICB aims to achieve: undersea warfare to project force, hold a potential adversary force at risk and maintain persistent situational awareness; and maritime capabilities for sea denial and localised sea control operations that provide the Australian Defence Force with freedom of action.

CDRE Turner's definition of asymmetry is the same as the NDS definition. It refers to military capabilities that pit strength against weakness in a non-traditional or unconventional manner, and that disrupts a potential adversary's decision calculus. Asymmetric advantage imposes disproportionate costs on a potential adversary and, in some cases, there may be no effective response. Defence's IS&T plans and resources are aligned with this intent, states the NDS.

The NDS and IIP between them list the projects and capabilities being managed within MICB, says CDRE Turner, and many of them have been accelerated to meet NDS demands. "So my constant message to my Branch is, we've been told what we've got to do and we've got to do it as quickly as we possibly can to get these capabilities out to the people that need them."

Speed to capability is more than a theme. It is becoming a reality for the MICB. The three autonomous capability projects it has been progressing for the RAN. The Ghost Shark and Speartooth Uncrewed Underwater Vessels (UUVs) and Bluebottle Uncrewed Surface Vessel (USV) have been brought together under Project SEA1200 - Uncrewed Maritime Warfare, and remain classified, so CDRE Turner is reticent about them. But they are moving fast, he says.

As a measure of how highly classified Ghost Shark is, for example, despite a very public project launch and photocall at Fleet Base East back in April and recent Minister of Defence industry announcements in August, no details have been divulged about its payloads and potential missions and propulsion.

Ghost Shark has become Mission Zero for ASCA, which is a key stakeholder having taken over the funding obligations for Ghost Shark from the former Next Generation Technologies Fund. What has changed with Ghost Shark, now that ASCA is part-funding the $140 million program, is that it now has a clear path to acquisition, so long as it convinces the RAN capability manager that it is working as promised. With that proviso, CDRE Turner believes it is doing well.

In fact, he says, "All three are progressing well. They're still in their developmental stage. The progress so far is encouraging but there's still a fair number of hurdles to clear. Navy needs to get confidence that the systems will do what we want them to do but so far so good. As MINDI has indicated, we are already taking steps to be ready to commence production."

While the Bluebottle is already in operational service, Ghost Shark and Speartooth are heavily involved in trials involving their manufacturers, Anduril Australia and C2 Robotics, respectively, ASCA and MICB. And Ghost Shark and Speartooth have both been to sea.

"All three systems are involved in trials all the time," points out CDRE Turner. He draws the contrast between the traditional and very deliberate approach to building a new ship, and

the rapidly evolving new technology his Branch is working on.

"The approach of these systems is quite different. We're constantly doing tests and evaluations and Navy participates and supports those tests," he says. "I regularly have members from my team involved with all three systems under SEA1200." It is a very iterative and consultative process with very quick feedback loops.

Unlike the old 'big bang' process which saw large, complex ship, submarine and software-driven projects go through successive, lengthy phases of testing before being declared operational (or not), the processes by which projects such as SEA1200 are progressed are much quicker. To use the term coined in the NDS, MICB is building an MVC which can be put into operational service far more quickly, and then evolved to meet changing user needs and circumstances.

"So, we are constantly working with the companies to refine their products through tests and trials, which include testing through things like digital twins and actually putting them in the water," explains CDRE Turner.

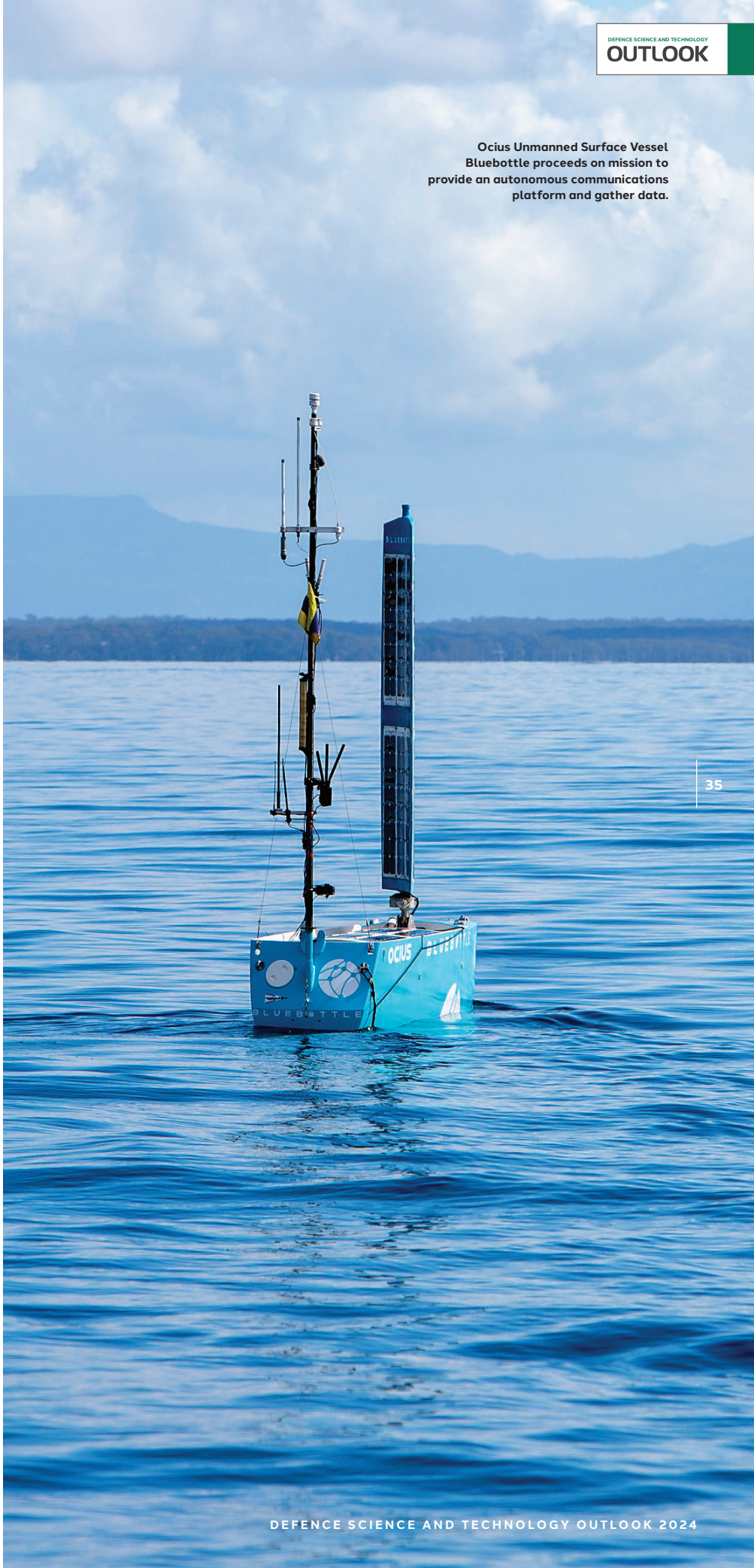
Exact details of the potential roles of Ghost Shark, Speartooth and Bluebottle remain classified, says CDRE Turner. "The Defence Strategic Review specifically says that we'll need to develop uncrewed and autonomous systems to conduct undersea intelligence, surveillance and reconnaissance and strike. So I think that's probably the safest language to use."

All three systems perform discrete functions, but they are all complementary, and they will all inform the development of future autonomous systems, says CDRE Turner. "As we become more familiar with the operation of autonomous systems, that's bound to influence future capabilities."

MICB also works with other parts of Navy Capability, he points out. As his Branch develops both autonomous UUVs and USVs, he works closely with the RAN's surface and undersea warfare specialists integrating these with submarines and warships and their combat systems.

It is clear that the new Branch has a vital role to play in preparing and equipping the RAN for a more uncertain future and that it got the message about speed to capability, MVCs and asymmetry. ●

IMAGE: POIS Justin Brown from Defence database



Ocius Unmanned Surface Vessel Bluebottle proceeds on mission to provide an autonomous communications platform and gather data.

Helping to manufacture rocket motors on Australian soil

The acquisition of a dozen new families of long-range missiles and the establishment of Defence's Guided Weapons and Explosive Ordnance (GWEO) Enterprise have placed added emphasis on Defence Science and Technology Group's (DSTG's) ability to support the growth in Australian rocket motor production. **By Gregor Ferguson**

The National Defence Strategy (NDS) and associated Integrated Investment Program (IIP), published this year, state that Defence "plan investments in new weapons "of $28 – $35 billion over the next decade "to enhance their strike capabilities". During this time it will also invest another $21 billion on its GWEO Enterprise to "complement the targeting and long-range strike investments", build GWEO stocks, "strengthen supply chains and support the establishment of a domestic manufacturing capability."

The National Advanced Surface to Air Missile System fires an AIM-120 Advanced Medium Range Air to Air Missile during its first ever Australian live-fire at Woomera Test Range in South Australia on 14 November 2023.

DSTG is supporting Defence in delivery of these objectives across a broad range of areas—one such area being solid rocket motors (SRMs). DSTG has had an Advanced Rocket Motor Technology Demonstrator, or ARMTD, Program since 2021 as part of its Rapid Prototyping Initiative, says Andrew Hart. The program leverages DSTG's decades of science and technology (S&T) expertise in energetics and propulsion, and its outputs are being transitioned to Australian industry across all areas to help them manufacture advanced, military-relevant SRMs.

Hart sits at the heart of this activity as Group Leader Missile and Space Propulsion in DSTG's Sensors and Effectors Division. He is Program Director of the ARMTD Program.

"Australia's 2024 NDS and IIP explicitly reference the importance of surety of supply and adequate stockpiles of relevant munitions, and how an Australian domestic missile manufacturing capability is critical in enhancing Australia's self-reliance," he says. "Australia's defence industry is a key contributor to the ability to realise this vision."

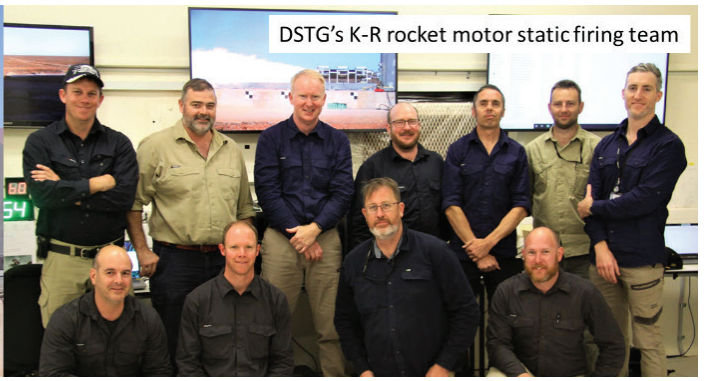
The aim of the ARMTD Program is not to build a specific type of rocket motor but to establish, upskill and demonstrate an exemplar sovereign supply chain that can be leveraged to manufacture whatever advanced, military-relevant SRMs Defence chooses to build in this country. That supply chain must be able to build SRMs to the same standard and specification as those we would normally buy from overseas and be able also to design and manufacture SRMs for future weapons, whether designed overseas or locally.

We will see the first flight test of an Australian-designed SRM delivered through ARMTD in about November this year, he says. The ARMTD Program has already seen live-fire static demonstrations of a series of wholly Australian-designed and manufactured

IMAGE: PTE Nicholas Marquis from Defence database

IMAGES: Supplied


K-R rocket motor loading at the LA5 test site


DSTG's K-R rocket motor static firing team

rocket motors, including the 10-inch (254mm) diameter Koonibba-Rising (K-R) class rocket motor. K-R was demonstrated in September 2023 at Woomera and it represents the largest advanced, military-relevant SRM designed and produced in-country to date.

That test program spawned some incremental improvements in things like design practices, material selection and industrialised manufacturing methods resulting in a version 2 of the K-R Class SRM.

"K-R version 2 is scheduled to be demonstrated through integrated live static firing and then flight tests in October and November of 2024, respectively," Hart tells *DSTG OUTLOOK*.

The next phase of the ARMTD Program will see live firing trials of a significantly larger advanced rocket motor in the second half of 2025. These rocket motors are deliberately focused on advanced propulsion technologies and military relevant design and manufacturing practices. Use of advanced SRM technologies, underpinned by appropriate design expertise, is critical, says Hart. "Maximising the energy-density of the system; minimising the mass of inert components; optimising energy management to maximise mission performance; ensuring that the rocket motor has the necessary structural strength to operate safely and reliably across its intended operating environment are the key enablers for achieving high performance missions such as long-range strike and high-speed weapons, deployed from volume and mass-constrained tactical launch platforms."

Transitioning these technologies into industry and then coupling them with DSTG's mission-specific rocket motor design capabilities—which have been independently assessed by Australia's allies as world-class—in turn pre-positions Australia to design and manufacture complete rocket motors for either 'build-to-specification' or 'wholly domestic' development and construction. It also helps future-proof Australian industry capabilities relating to advanced rocket motors.

Building and testing SRMs of an increasing unit scale and with an expanding range of technologies and functionality as the Program progresses upskills and demonstrates the ongoing maturation of the industry network, that itself also continues to expand in support of the Program. This is critical given that increasing unit scale and rocket motor functionality imposes additional technical, manufacturing and logistics challenges.

"As the ARMTD Program's milestones are met," says Hart, "the proficiency and capabilities of Australia's nascent SRM manufacturing capability are being enhanced. This maturation is being verified and validated through extensive component and integrated system level characterisation, inspection and live fire testing. As a consequence, as the ARMTD Program proceeds, the industry network is demonstrating its ability to contribute to an increasing range of Defence capability options, whether under a 'build to print', 'build to specification' or 'wholly sovereign' construct."

Through its involvement with Australia's allies, DSTG is also confident that the SRM technologies being transferred into Australian industry through ARMTD are the 'right technologies'. In addition, the ARMTD Program is focused on ensuring that these technologies are compatible with industrialised manufacture, as opposed to something that can be produced in the laboratory but is impractical in an industrial setting. "Transferring the 'right materials/technologies' and the 'right methods' into Australian industry through ARMTD helps accelerate and pre-position local companies to be able to contribute into an allied industry base in the area of advanced SRMs," states Hart.

The industry lead for ARMTD is Thales Australia which provides the industrial-scale propellant manufacturing and filling expertise, utilising the Government-owned, contractor-operated explosive ordnance production and non-destructive testing facilities at Mulwala and Benalla. The company also provides and enacts the overarching systems engineering framework and supply chain management for a growing list of Australian small to medium enterprises (SMEs) who manufacture the advanced inert rocket motor components for the Program.

DSTG works closely with Thales Australia and the SMEs, says Hart, to develop and de-risk the underpinning SRM technologies to a level of maturity where they are ready to be industrialised.

"We then assist the industry network through this S&T-to-industrialisation transition process, until they are able to reliably manufacture the rocket motors at the subsystem component and integrated systems level," he adds.

The ARMTD Program was initially a DSTG-funded program but its progress against the initial program milestones, coupled with the increased strategic relevance of its objectives, means the Royal Australian Air Force and, more recently, GWEO Group have subsequently provided considerable additional investment, says Hart.

"This program up-funding has allowed us to invest in critical infrastructure in industry, and also expand the industry network with whom we are engaging, to

allow us to demonstrate rocket motors at a larger scale and with increased functionality than would have otherwise been the case."

Of course, Defence or a prime systems integrator may simply want to leverage the expertise generated through the ARMTD Program to deliver a specific rocket motor component such as rocket motor insulation, a rocket motor casing, or the relevant industrial practices to produce military-grade rocket propellant with the required quality assurances and quality controls.

Its activities with allied partners also sees DSTG maturing advanced propulsion technologies that are at a lower technology readiness level. As these lines of effort are matured, DSTG can then leverage the growing, non-exclusive ARMTD network to transition these advances more rapidly into Australian industry and then into candidate Defence capability options.

There is another challenge too if Australia was to be used as a second-source supplier to either the Pentagon or a foreign contractor for overseas designed SRMs. In these instances, the Australian supply chain must build those missiles to the same specification and standards as the people we might otherwise buy them from. In other words, Australian missiles, or components thereof, must have the same performance and durability and be interchangeable with the foreign ones.

Qualification of an industry supply chain is generally the responsibility of the prime systems integrator who is delivering the missile. However, points out Hart, as Australia embarks on domestic manufacture of complex guided weapon components, "DSTG has a lot of unique capabilities and expertise that can be leveraged to support the assessments of components and/or to work with industry so that they can establish their own characterisation and assessment capabilities in areas where they may have gaps."

Actually, through the ARMTD and its work, DSTG is aiming to satisfy not one but two long-term strategic goals. Defence wants to build a robust and sustainable industry sector that can provide support whenever necessary, and the Government wants a strong industry sector to become a pillar of a much stronger national economy. DSTG, says Hart, is a critical contributor in supporting the achievement of both goals.

DSTG also plays an important role in supporting Defence in making informed decisions regarding acquisition of capabilities, including for guided weapons, through the conduct of technology risk assessments (TRAs). The TRAs help inform Defence as to the technical pros, cons and limitations of the various options in the context of Australia's own operating environment.

Once a specific capability has been down-selected for acquisition, says Hart, DSTG's role shifts to supporting the introduction into service of those capabilities.

"For example, the Australian operating environment, with regards to usage rates and the type and extent of transport and storage requirements, often differs from that of the allied partners from whom we acquire many of these capabilities," he says. "In these instances, DSTG will work with Defence's acquisition community and the relevant ADF [Australian Defence Force] services to determine whether additional characterisation of the system in question may be required, and then support Defence in prosecuting and interpreting the outcomes of these efforts."

Once a system is introduced into service, DSTG is often the first port of call to support Defence if there are any unexpected issues with safety and suitability for service across the weapons lifecycle. For example, if non-destructive testing identifies hidden defects, or if there is a need to either extend the life of a rocket motor or to verify or increase the operational carriage hours of in-service assets.

Hart has his own list of FAQs, including, "*This asset has been [mishandled/exposed to an unintended event or circumstance, etc.] can it safely be returned back into the ADF inventory and, if so, will it still perform as designed?" and "This asset has reached the end of its originally nominated life. Are we able to extend this service life and, if so, by how much?*"

In addition, DSTG also has a long history of helping industry to resolve issues with munitions manufacture where changes in processes, materials or personnel may result in changes in article characteristics. Historically this has included, and in the near future almost certainly will include, the manufacture of Australianised munitions, or munitions that contain Australian-produced materials, Hart says.

To support all of these areas, DSTG has decades-worth of unique, in-country end-to-end design, development, integration and test expertise for rocket motors, warheads and key guided weapon subsystem components.

DSTG work has always been critical to Defence for averting capability gaps and minimising the risk to both crews and platforms from exposure to potentially unsafe ordnance. With the planned increase in the breadth and depth of the ADF's guided weapons inventory, coupled with the planned increase of in-country manufacture of selected guided weapons, the amount of work that will be required across the propulsion and energetics areas will increase substantially, says Hart.

This will represent an ongoing workforce challenge for Australia's entire SRM ecosystem of which DSTG, owing to its support to manufacture with industry, through to support to the ADF across the weapons lifecycle, is a central part.

Range Operations Centre at Woomera Test Range

Hypersonics allows defence at a distance

Hypersonic missiles are expensive to develop and build. They provide operators with a military advantage as well as something you simply cannot buy—time. **By Gregor Ferguson**

You can probably forget about manned hypersonic vehicles, at least for another generation or so. The military applications of hypersonics are currently all uncrewed.

The word 'hypersonic' implies speeds of more than five times that of sound, or Mach 5. That speed alone, combined with the extended range of most hypersonic missiles and their unpredictable flight patterns and trajectories (because they can be steered) makes hypersonic vehicles extremely difficult to defend against. Just to put that in perspective, a 1,000km flight would take less than seven minutes at Mach 7.

The National Defence Strategy specifically names long-range fires as a capability investment priority for the integrated, focused Australian Defence Force (ADF) and names hypersonic missiles (one way of achieving this goal) as an innovation, science and technology priority for the Australian Defence innovation, science and technology ecosystem.

"Hypersonic vehicles are the crown jewel in any arsenal, allowing defence at distance, providing a blanket of protection for our military assets," says Matthew Dragovic. "The cost of developing and manufacturing hypersonic vehicles is significant, so they're likely to be used sparingly."

His colleague, David Hartley, adds, "As technological advancements are made, it is conceivable that hypersonic vehicles could also be developed to undertake other Defence roles where rapid deployment is critical, such as Intelligence-gathering, surveillance and reconnaissance."

Dragovic is Deputy Program Leader of Future Air Weapons in

DSTG's Air and Maritime Division, so he understands the difference that hypersonic vehicles can make, if used properly, and the cost of not using them well.

But can hypersonic missiles actually do all the things that some commentators claim? Dragovic says, "Hypersonic vehicles are here and now but their capabilities are perhaps overstated by some commentators who do not appreciate the complex trade-offs required to realise a desired capability."

Hartley, DSTG's Discipline Leader, Hypersonic Structures Technologies says, "Hypersonic flight is extremely complex and challenging. It is not merely about flying high-technology systems and concepts a bit faster. Hypersonics necessitates new design approaches, technologies and, importantly, complete system integration."

The primary challenges to achieving sustained hypersonic flight include the design of systems capable of withstanding the extreme flight environment. Challenges include friction-induced heating potentially to temperatures above 1,000 °C, propulsion systems, and the integration of critical subsystems such as sensors, warheads, flight control and avionics.

"DSTG is investing in model-based systems engineering as a structured means to develop hypersonic vehicle concept demonstrators," says Dragovic. "We are adopting an approach where we conceive hypersonic vehicle concepts in response to requirements identified through operational analysis. Promising concepts are matured and developed into models of increasing complexity that are validated through subsystem (often hardware in the loop) testing and finally flight trials."

Australia was the first country in the world to successfully launch an air-breathing hypersonic vehicle when the University of Queensland (UQ) sent one aloft from Woomera in 2002 as part of its HyShot program. Australia is still considered to be a world leader in this field with DSTG leading an Australian Hypersonic Research Network.

"UQ is a critical part of Australia's Hypersonic Research Network, which also includes other universities such as the University of Southern Queensland and the University of New South Wales in Canberra," says Hartley. There are also several other universities in Australia working on research and development of hypersonic-relevant technologies, including RMIT, the University of Melbourne and Swinburne University, he adds.

Australia has achieved some significant technological 'firsts'. The late Ray Stalker AO, a former UQ professor, invented the free piston shock tunnel, capable of generating true hypersonic flow conditions for test and evaluation of hypersonic aerodynamics and propulsion systems. He also designed the first supersonic combustion ramjet, or scramjet, to produce more thrust than drag. Why does the scramjet matter? Because, unlike a rocket, an air-breathing hypersonic missile uses atmospheric oxygen but, at Mach 5 or more, it needs a scramjet to compress and slow down high-speed air sufficiently to develop the necessary thrust. This is an incredibly difficult task and designing a scramjet is an extremely complex undertaking.

DSTG's interest in hypersonics goes back some five decades, with serious investment and research over the past two. "DSTG's Applied Hypersonic Branch was originally formed from several staff from the UQ HyShot program," Hartley points out, "and there has been a strong connection throughout several programs including HIFiRE."

Australia's expertise was recognised in 2009 when DSTG teamed with the US Air Force Research Laboratory (AFRL) to establish the HIFiRE, or the Hypersonic International Flight Research Experiment, program. Among the primary signatories in the HIFiRE agreement were UQ and Boeing Research & Technology which already had the hypersonic X-51 Waverider program underway in the US in partnership with AFRL.

"Hypersonics is not a new field of research, but DSTG increased its

IMAGES: Supplied

strategic research funding in this area to support the execution of the HIFIRE flight test program," says Hartley. "This program, and the capabilities developed during this period, formed a foundation for the current iteration of Defence programs which employ hypersonic technologies."

DSTG's HIFiRE program contributed to Australia's scramjet flight test program. The first flight of a UQ scramjet was in 2001 and a total of 14 experimental flights have been conducted aimed at testing and validating a range of scientific theories and technology concepts. The HIFiRE program was rewarded in 2012 with the prestigious von Karman Award from the International Congress of the Aeronautical Sciences.

Australia's most public defence-related hypersonic priority is its commitment to the Southern Cross Integrated Flight Research Experiment (SCIFiRE) partnership with the US.

"Under SCIFiRE we are integrating a prototype hypersonic cruise missile on the F/A-18F," says Dragovic. "In addition, we are developing other hypersonic vehicle concept demonstrators and associated technologies. Those technologies include sensor and guidance systems, rocket motors, warheads, materials and fuels."

One of DSTG's key roles is to establish and maintain unique sovereign infrastructure and capabilities for the demonstration and testing of hypersonic technologies, and to help develop and mature technologies relevant to hypersonic flight. These include core capabilities such as the X3R shock tunnel; a hypersonic structures and materials laboratory; an extreme environment materials characterisation laboratory; and flight test vehicle design, integration and flight qualification capabilities.

Many of these facilities are at Eagle Farm, a Brisbane suburb. The Government's commitment to hypersonics research is evidenced by the establishment of the Australian Hypersonic Research Precinct, which was officially opened by then Minister for Defence Peter Dutton in January 2022.

"The precinct provides unpreceded opportunities to accelerate the technical readiness of sovereign hypersonic flight technologies by bringing together Defence, industry, academia and international partners under the one roof," says Hartley. "This niche area of research attracts national science and technology academics and highly skilled professionals to conduct advanced hypersonic research and development within a secure facility."

So, where is this research actually going?

As already noted, hypersonics is one of the Government's six defence innovation, science and technology priorities, alongside directed energy, trusted autonomy, quantum technology information warfare and long-range fires—or everything else that is in this edition of *DSTG OUTLOOK*.

SCIFiRE has seen multiple collaborations between DSTG and AFRL across a range of hypersonic technology maturation areas, according to Dragovic.

DSTG and AFRL are now exploring opportunities to expand the strong relationship achieved through SCIFiRE to the UK under a new agreement, facilitated through AUKUS Pillar II. AUKUS Pillar II has listed six advanced technology priorities, one of which is hypersonics.

"SCIFiRE has realised a strong bilateral relationship between DSTG, RAAF [Royal Australian Air Force], USAF and AFRL," points out Dragovic. "Noting that hypersonics is a component of AUKUS Pillar II, we are actively pursuing opportunities to expand our relationship to the UK through the Royal Air Force (RAF) and Defence Science and Technology Laboratory."

The Chief of DSTG's Sensors and Effectors Division, Dr Sylvie Perreau, told *DSTG OUTLOOK* last year that hypersonics research is not just about propulsion performance and aerodynamics. A key focus of DSTG's research is scramjets, of course, but the research also addresses every other part of a hypersonic vehicle.

There is an immense amount of research needed into structural materials, both metals and composites. Thermal protection is also

IMAGES: Supplied

important because friction-induced heat can melt conventional materials, and so are thermal management strategies.

Just as important is high-fidelity modelling, simulation and test and evaluation work, simply to understand the hypersonic environment. And that brings in not just the science of aerodynamics but also aerothermal modelling and simulation. None of this is easy.

The ultimate prize for both researchers and industry is flight heritage—an actual flight on a hypersonic vehicle to prove prototype sensors, navigation systems and other payloads.

The US aerospace community wants to test as frequently as once a week to try and accelerate capability and gain flight heritage for its products. That means reducing the cost of a test flight by an order of magnitude to US$15 million and less. An Australian company, co-founded by one of Ray Stalker's former staff members, managed to beat off competition from 63 other rivals to win the Defense Advanced Research Projects Agency HYCAT program. Under this program, Brisbane-based Hypersonix Launch Systems will be able to flight test a range of payloads from early next year, hopefully building to a cadence of about one launch a month.

DSTG has invested significantly, both financially and organisationally, in its hypersonic research. DSTG's Hypersonic Weapons program engages the capabilities of five separate DSTG divisions, all focused on the ADF's challenges and needs. Its Disruptive Hypersonic Technologies Group, led by Dr Todd Silvester, in collaboration with strategic partners, leads the discovery and demonstration of emerging and future integrated hypersonic concepts and disruptive technologies that offer game-changing capabilities for Defence.

And making hypersonic vehicles work properly may have other strategic benefits, believes Dragovic. "While some may see hypersonic vehicles as escalating the likelihood of conflict, there are strong arguments to suggest they will do the opposite. As hypersonic vehicles are difficult to defend against and can be employed at long ranges, they're likely to act as a deterrent for combat. Their ability to impact a target at range in a short amount of time, gives the warfighter more time to assess the intent of a potential adversary, reducing the risk of accidental conflict."

So can we, or anybody, counter hypersonic missiles effectively? "Hypersonic vehicles give us a technology edge over conventional defence systems that are typically designed with a conventional target set in mind," says Dragovic. "However, history tells us that technological advantages are usually transient. Conventional defence systems will evolve and new technologies will be developed, some of which DSTG is exploring, to counter the paradigm shift that hypersonic vehicles have realised.

"For our hypersonic team at DSTG, this means that we must continue to innovate to stay ahead of the curve."

DMTC and DSTG are working with Australian companies ZiP Diagnostics and Axxin to progress development of a prototype point of care testing device to detect leading mosquito-borne diseases.

Working together, from the laboratory to the frontline

The relationship between DMTC and the Defence Science and Technology Group (DSTG) is an enduring and effective one and is helping to keep the nation secure.

In support of the tasks set for DSTG by the Government, DMTC is a natural partner for DSTG. As an independent, not-for-profit organisation, DMTC's expertise is in collaborative program management, with a strong focus on the industrialisation and scalability of Australian research. This integrated perspective enables DMTC to accelerate the development of strategically-important capabilities.

"The relationship is one that works at both strategic and working levels," DMTC CEO Dr Mark Hodge says. "This has been codified in a new contract signed in March 2024, establishing a framework through which DMTC's value to Defence can be maximised, as well as standardising key engagement terms."

The relationship recognises the need for Defence to pursue transformative, mission-based activities such as those under the stewardship of the Advanced Strategic Capabilities Accelerator (ASCA), and the complementary need to maintain focus on the significant challenges around production, sustainment and capability assurance, in which DMTC has consistently demonstrated an adept track record.

Powering undersea capability

One success story is the Advanced Piezoelectric Materials and Applications (APMA) Program, led by DMTC and supported by DSTG and ASCA through its Emerging Disruptive Technologies stream.

Single crystal piezoelectric materials are orders of magnitude more sensitive than their polycrystalline equivalent, which is an important material characteristic for SONAR systems and other undersea warfare applications. The growth of single crystal piezoelectrics is an extremely complex and time-consuming process.

The APMA Program's collaborative approach and structure has allowed it to adjust to the new Defence threat environment as outlined in the 2024 National Defence Strategy. Undersea warfare is a key focus of Australia's strategy of denial, which aims to prevent adversary forces from projecting their own military capabilities.

The Program also aligns with AUKUS Pillar II Advanced Capabilities—a set of trilateral priorities for enhanced defence capability—that includes undersea warfare technologies.

With this strategic imperative, the APMA Program is working with partners to establish an industrial-scale foundry to ensure sovereign manufacturing and security of supply of single crystal piezoelectric materials for defence applications. This industrial outcome is supported by a world-class body of research expertise to enable further development of new SONAR products for above sea and undersea warfare applications.

In addressing the first objective of the APMA Program, industrial partner Thales Australia has successfully grown single crystal piezoelectrics at an industrial scale, ensuring the development of next generation SONAR systems is now a reality.

This achievement has been supported by investment in research and infrastructure to fully understand the structural and electromechanical properties of these crystals, as well as optimising the production process.

The focus of the APMA Program is now shifting to consideration of applications of single crystal piezoelectrics, which have the potential to deliver a series of design and performance improvements associated with space, weight and power limitations of existing SONAR system applications.

These materials provide the opportunity for an asymmetric step change in capability through unlocking potential applications that cannot be realised with conventional piezoelectrics.

Turning up the heat

Elsewhere, DMTC has partnered with DSTG to accelerate the development of high temperature sub-assemblies (HTSA) as a first step towards proving Australian capabilities in the manufacture, at scale, of hypersonic aerostructures.

Australia has a long history in the development of hypersonic vehicles, and recognition of hypersonics as an AUKUS Pillar II advanced capability is expected to take that a step further. The 2023 Defence Strategic Review included hypersonics as an innovation, science and technology priority, and named guided weapons and explosive ordnance as a key enabler of an 'Integrated Force' concept.

DMTC's established and extensive national network of partners is well positioned to support further development of this capability.

The newly established HTSA Program is focused on the development of industrial capability that rapidly moves from proof of scalability to production of component sub-assembly prototypes, and through to test and evaluation.

Foundational projects of the HTSA Program are addressing challenges and already demonstrating positive progress.

Current projects include work with partners from DSTG, Swinburne University of Technology and Amiga Engineering to produce additively manufactured sharp leading edges with advanced thermal barrier coatings; with BAE Systems Australia and Gravitas Technologies to fabricate conformal antennae and/or receiver apertures able to withstand external hypersonic dynamic pressures and temperatures; and with Quickstep Holdings, DSTG and the University of New South Wales to adapt carbon fibre reinforced polymers to high-temperature applications.

Advancing disease detection

Demonstrating the breadth of DMTC's partnership with DSTG, a collaborative project between DMTC, DSTG and Australian companies Axxin and ZiP Diagnostics has progressed a prototype point of care (POC) diagnostic platform to detect mosquito-borne infections, including dengue fever, Zika virus, malaria and encephalitis.

This DMTC-led collaboration, with strong support from DSTG, has successfully progressed a locally manufactured POC diagnostic platform with application in both public health contexts and to enable continued activities of deployed military personnel in remote environments. This is particularly relevant to Australia's focus on development and troop deployments to northern bases, and to providing health and medical leadership across the Indo-Pacific region.

Mosquito-borne infections can be life-threatening and are currently detected through a combination of laboratory-based testing methods—which require equipment and environments not readily available to individuals located in remote and regional areas—and POC diagnostic devices, which provide in-field testing enabling increased detection and better care.

The long-term objective of the project is to develop a low-cost, accurate, disposable cartridge for use in a field-ready POC instrument to detect multiple viruses and malaria parasites from a single clinical sample.

DMTC's strategic investment is enabling the development of a prototype cartridge kit with an interface successfully designed and tested. Ongoing work includes continued testing of various biological materials to detect infection-causing agents.

DSTG has acknowledged that its partnership with DMTC is one of the critical enablers of the national Defence mission, and DMTC is working with its broad partner group to consolidate and deepen support for Defence's objectives.

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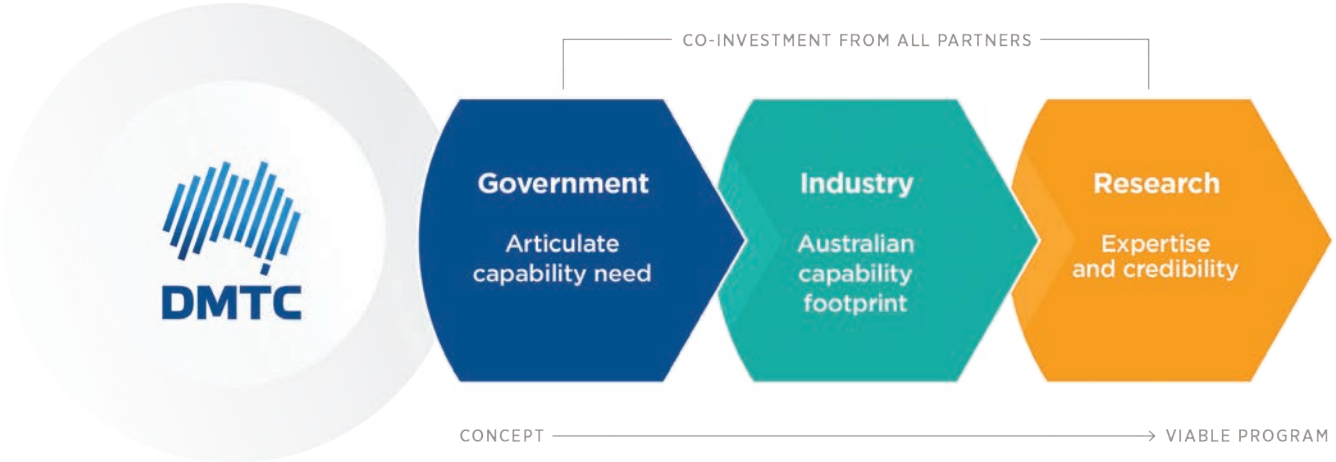


IMAGES: Courtesy of ZiP Diagnostics.

Army demands disruption

The cliché-monger's view of Army is that it is hide-bound, traditional and conservative. The reality is changing quickly: like the Royal Australian Air Force and Navy, and Army has created its own in-house 'disruptor'.

By Gregor Ferguson

Named the Robotic and Autonomous Systems Implementation and Coordination Office, the professional disrupters sit within the Army's Future Land Warfare Branch and the organisation is usually referred to just as RICO. Its job, says Lieutenant Colonel (LTCOL) Adam Hepworth, is to inspire, explore, innovate and lead the investigation of disruptive and emerging technologies to equip the future force.

"We look not necessarily at today's problems as our primary focus, but into

An Australian Army M113AS4 armoured logistics vehicle (right), fitted with optionally crewed combat vehicle technology and a remote weapon station, moves alongside a M113AS4 optionally crewed combat vehicle during a human-machine team exercise at Puckapunyal Military Area.

the future, conceptualising where we could be and what the opportunities are," he says. RICO focuses on concept development, rather than capability development. LTCOL Hepworth adds, "We're trying to help the Land Programs understand the requirements of the future and push those into acquisition."

LTCOL Hepworth is RICO's Technical Director, Artificial Intelligence, having spent most of the past decade as an Operations Research Analyst and an expert in artificial intelligence and autonomy. The Army's Land Capability Division is busy delivering the essential

LTCOL Adam Hepworth

capability that soldiers need today and into the near term. RICO looks beyond the near term for opportunities and unknowns, to find ways to deliver enhanced, meaningful and asymmetric technologies and translating those into capability.

RICO is a trusted adviser to the Chief of Army, through the Director-General Future Land Warfare, on what these emerging technologies may look like into the future and how Army can choose what capabilities it needs to explore. RICO works closely with the Defence Science and Technology Group (DSTG) and the Advanced Strategic Capabilities Accelerator (ASCA).

RICO has a vital role empowering and leading bottom-up innovation within the Army and it does this through its soldier-focused MakerSpace initiative which has seen the establishment of eight facilities around the country.

"The MakerSpace environments offer a range of courses, from systems thinking and design, through to advanced manufacturing," says LTCOL Hepworth. Some 15,000 soldiers have been through the MakerSpaces. He adds, "That helps bring the innovation discussion to the forefront of what we're looking at in Army." It also helps effect the cultural change that Army seeks by ensuring one eye is kept on the future.

Army's Perth-based 13th Brigade is accelerating its adoption of emerging technologies to help achieve missions it could not do any other way. A case in point, is the optionally crewed combat vehicle (OCCV), based on the M113 armoured personnel carrier, developed in collaboration with BAE SA. The experimentation also engaged with other industry partners such as Trusted Autonomous Systems Defence Cooperative Research Centre (TAS DCRC). The TAS DCRC was funded through the DSTG-run Next Generation Technologies Fund which has been subsumed by ASCA.

"A soldier from the 4th Brigade around 19 years of age was driving the OCCV, and didn't hold a driver's licence," LTCOL Hepworth recounts.

"On an activity we conducted in June last year, they learned not only how to operate a 15-tonne OCCV but also use it within a tactical setting within three days, having never driven a vehicle before."

The activity was supported from units across the 2nd Division, including 13th Brigade solders as well. He describes that as a testament to the quality of Army's reserve workforce, to the spirit that is seeking to exploit new and emerging technologies for the Army quickly, and to the processes, procedures and techniques that RICO has put in place to pursue them.

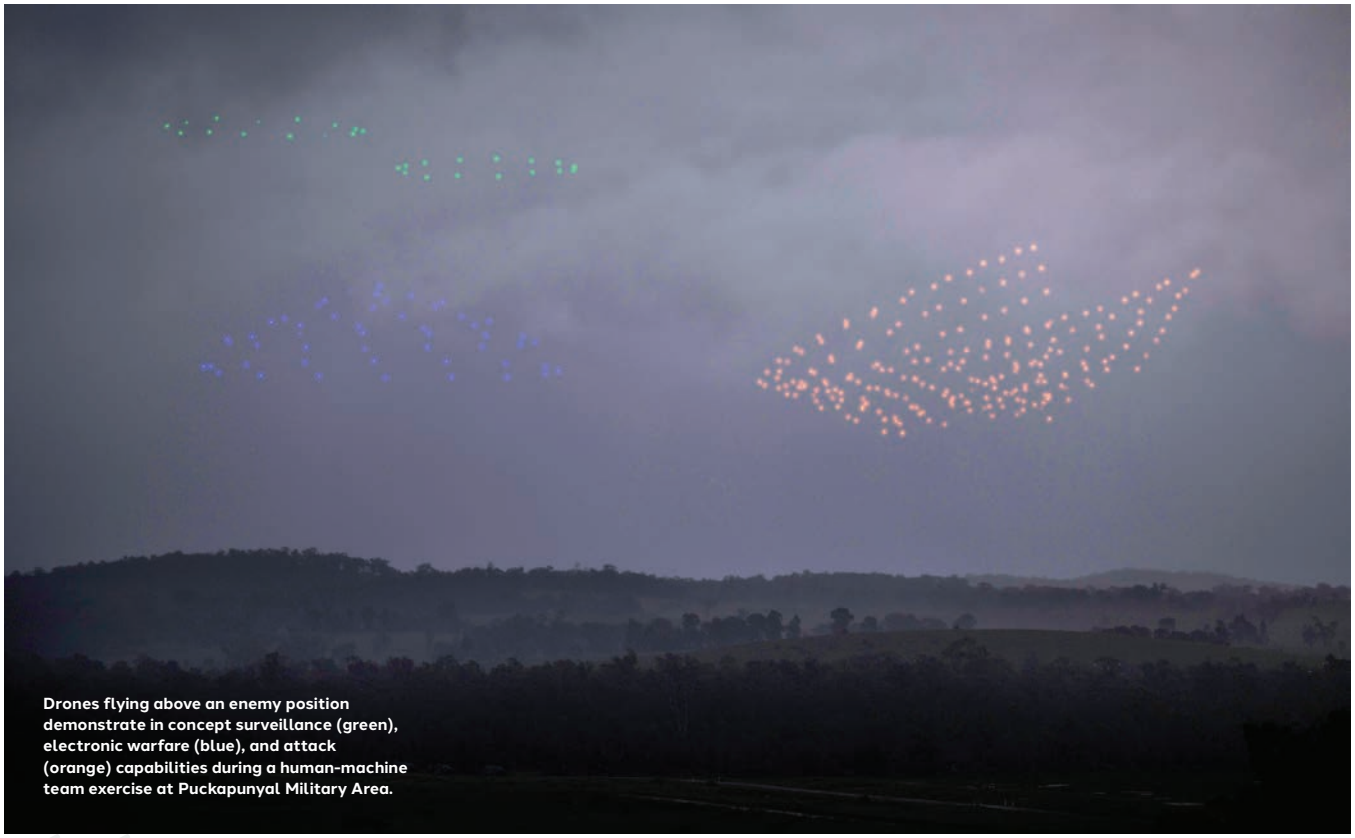
Formed in 2018, RICO's team has expanded with the changing character of modern warfare, Army's requirements becoming clear as Australia's strategic outlook continued to accelerate and change.

The Army released its inaugural Robotics and Autonomous Sçystems strategy in 2018, updating it in 2022. In 2021, it published the Army Quantum Technology Roadmap. Both are harbingers of fundamental change to the way Army does its business and enabling that change is RICO's business.

The challenge now is not just about integrating robotics, autonomous systems, artificial intelligence and quantum technology, but also integrating enablers such as power and energy—batteries, fuel and logistics. RICO is also about priming and growing the innovation pipeline designed to meet Army's needs: not just engaging professional innovators such as academics but, through the MakerSpace initiative, engaging the inherent creativity of individual soldiers at the coalface of what the Australian Defence Force does.

IMAGE: SGT Matthew Bickerton from Defence database

IMAGE: SGT Matthew Bickerton from Defence database



Drones flying above an enemy position demonstrate in concept surveillance (green), electronic warfare (blue), and attack (orange) capabilities during a human-machine team exercise at Puckapunyal Military Area.

Autonomy also removes humans from both harm's way, so reducing casualties and the need for medical evacuation and treatment, and from simple transactional roles. RICO's experimental leader-follower technology for convoys of trucks could mean that instead of needing 20 drivers for a convoy of 10 trucks, Army might need just two.

RICO uses its network of innovators and partners, which includes DSTG and ASCA, to make strategic choices around particular technologies and the consequent workforce profiles and business processes that may be needed in the future, LTCOL Hepworth explains. Some of this work leads to experiments of one kind or another but a key output is a demand signal to its research partners and also to industry: what sort of technology is Army thinking about and so what industry should they be developing as a result?

LTCOL Hepworth cites the examples of the OCCV, RICO's leader-follower technology, and some of RICO's autonomous uncrewed aerial system swarms. "The technology developed may not make it into capability, and that's okay," he says. "The demand signal these projects have set has subsequently informed Army capability development programs that are considering procurement of technologies such as the leader-follower and OCCV to solve today's capability gaps."

Against that background, the Chief of Army has set RICO's priorities for the next 12 – 18 months, says LTCOL Hepworth. The first is exploring the range and lethality of small teams. "How can emerging technologies increase that range and lethality by up to an order of magnitude, so 10 times greater? That's quite a challenge." A cavalry troop might be able to find and strike targets 4km away. How is it possible to find and effect an adversary at 40 or 50km away?

"That's a substantial step change and there's a range of technologies that are new to Army, and new to warfare, that can contribute to this requirement," he says.

The second priority is about increasing the capacity of logistics formations, and this is where novel power and energy solutions can assist. As a simple example, doing away with field generators and their need for fuel and oil and the vehicles to carry them. Can we use solar instead to power our systems and give us greater endurance and reduced demand over time, or use stored electrical energy to support tactical operations in contested environments from small elements to large contingencies?

Autonomy also removes humans from both harm's way, so reducing casualties and the need for medical evacuation and treatment, and from simple transactional roles. RICO's experimental leader-follower technology for convoys of trucks could mean that instead of needing 20 drivers for a convoy of 10 trucks, Army might need just two.

"That's a great capacity uplift, enabling Army to non-linear scale our

workforce and the supply chain," LTCOL Hepworth says.

The third priority is, of course, the counter-UAS, or uncrewed aerial system, challenge that has been so prominent in Europe and the Middle East.

Back in April, Army helped the recently formed ASCA run a trial of 10 small Australian-made intelligence, surveillance and reconnaissance UAS for Defence. Hopefully the outcome of that trial will be known soon.

It has also been working on land systems, which are a particularly difficult challenge. Recently it demonstrated a self-contained, robotic vehicle refuelling system that significantly cuts the personnel involved in the refuelling of crewed and uncrewed vehicles. In 2023, RICO operated an autonomous convoy of four trucks on a public highway—the first time such a thing had been done in Australia—using leader-follower technology. A crewed truck in front with three autonomous trucks following its lead. RICO's partners in this were Deakin University in Geelong and the National Transport Research Organisation.

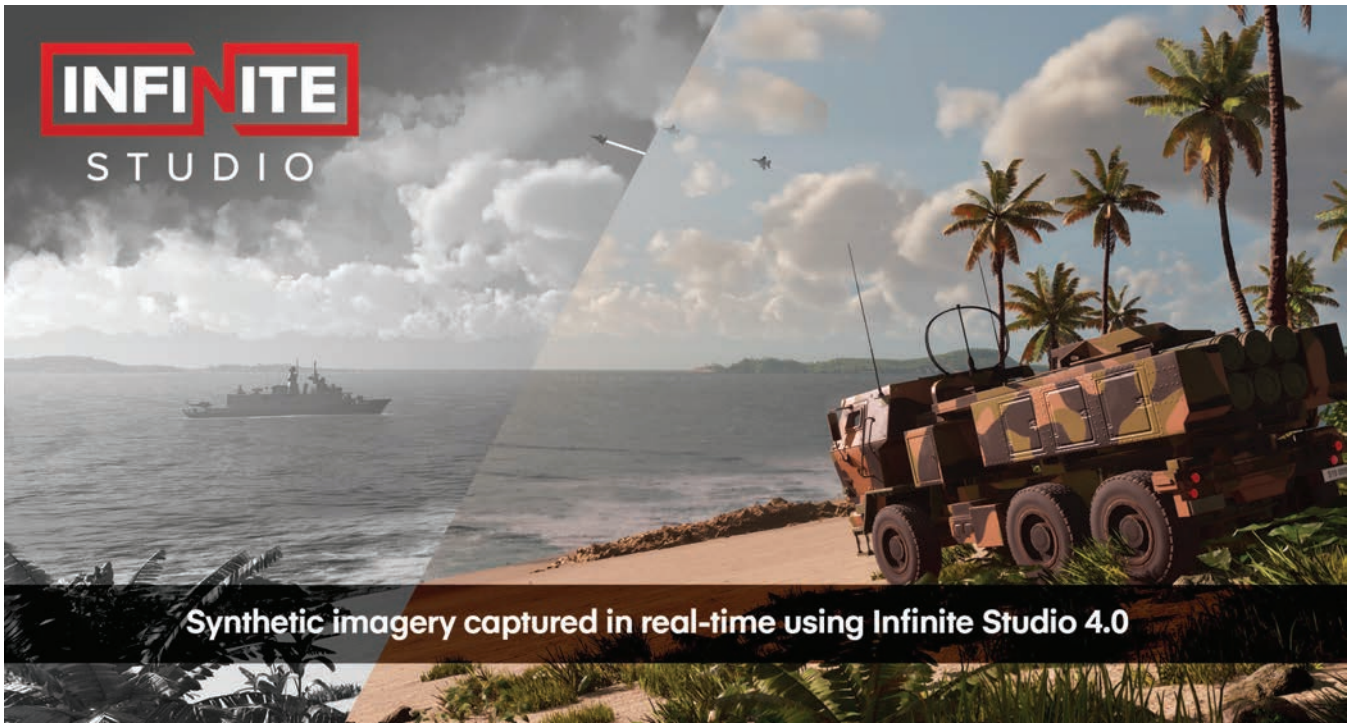
"We have a very close relationship with both academia and industry, and we take a co-development and co-design approach," explains LTCOL Hepworth. "This is really focused on looking at two aspects of the problem space, the technology as one aspect and the operational concept as the other, with both requiring evolution over time.

"The Australian Army has come a long way quickly. Ten years ago RICO did not exist, but we have a clear focus. RICO does not know what new-to-warfare technologies it will be looking at in the future, but it has established processes that enable it to identify and consider them.

"We will be postured to assess and accelerate possible future technologies, adapting as necessary," says LTCOL Hepworth. "The vision and operational view that we offer within RICO is trying to scan the landscape, understand the potential, look for the opportunity and then learn to transition the knowledge into capability programs." ●

Three Australian Army M113AS4 Armoured Personal Carriers enhanced as optionally crewed combat vehicles.

IMAGE: Joyce Holland from Defence database



Advanced simulation drives speed to capability for an integrated force

Aurizn brings the future into focus as the leading capability partner with their synthetic test and evaluation (STE) practice to enable technology acceleration.

The 2024 Integrated Investment Program sets out the Australian Government's investment priorities to accelerate critical capabilities for a new integrated force structure, in line with the National Defence Strategy. This change, born out of the 2023 Defence Strategic Review, is in direct response to the loss of strategic warning time, and the subsequent need for a higher-risk approach to the delivery of capability, to ensure Australia optimises its deterrence and lethality while becoming a formidable partner in its allied national security partnerships.

Greater use of simulation-enabled test and evaluation (T&E) will be required throughout the capability development lifecycle to meet this demand, and to reduce the inherent risk associated with accelerating the path towards asymmetric capability. Aurizn is the leading provider of cutting-edge technology solutions integrating simulation, advanced sensing and artificial intelligence (AI) to the defence, science and technology industry—delivering the knowledge and tools critical to support speed to capability with greater confidence.

Intellectual capital at the centre of the capability development lifecycle

Aurizn's 200-strong workforce combines their longstanding scientific pedigree and engineering know-how to deliver high-precision systems for high-impact outcomes. They focus on the delivery, operation and sustainment of high-fidelity synthetic environments that support the experimentation and analysis of military platforms, assets and operations.

STE provides a continuous multi-domain test environment across the Defence capability spectrum to achieve rapid technology insertion for our warfighters. These flexible and scalable architectures from Aurizn address the capacity, capability and availability challenges posed by traditional T&E methods within strategically relevant and complex environments.

Synthetic environments integrate digital and hardware systems with human

operators to ensure the complexity of any technology or operational system is represented with the right level of fidelity, reliability and impact.

Aurizn's commitment to capability acceleration is demonstrated in how their STE frameworks can map from platform and mission-level through to campaign and force-level operations reliably, and with precision, to provide confidence in the outcomes.

"The rapid evolution and adoption of autonomous systems into our ecosystem is causing a fundamental shift in the way we need to address the experimentation and evaluation of these systems," says Bjorn Wharff, Director of Strategy.

Aurizn explores new techniques and methods where their STE framework can be used for rapid insertion and qualification of autonomous behaviours as part of their broader strategy around trusted and reliable AI. Their knowledge and experience within the engineering, applied research and data science technical streams drives their mission to "push the limits for a more secure future", providing confidence in the development and application of asymmetric technology.

Unique solutions to support multi-domain capability development at pace

Aurizn is advancing the development of multi-domain frameworks by balancing capability across air, land and sea (with space emerging) to deliver virtual and constructive simulation and experimentation capabilities. While the framework is expansive, the genius lies in the heart of the system through the Infinite Studio product.

Their focus on coupling continuous investment in this state-of-the-art electromagnetic spectrum scene generation product, with peripheral simulation technologies (such as machine learning, AI, analytics and experimental design), delivers mixed-fidelity STE and experimentation outcomes.

Infinite Studio is the result of over 20 years of research and development collaboration between Aurizn (in legacy form) and Defence Science and Technology Group (DSTG), resulting in Aurizn being the commercialisation partner for the international product.

Infinite Studio is a high-fidelity simulation framework for visible and infrared (IR) scene generation. Deployed across many domestic and international programs, Infinite Studio enables users to create bespoke simulations of multi-domain operations comprising visible and IR scenes and support STE comprising hardware-in-the-loop, human-in-the-loop, and AI machine learning acceleration and evaluation.

These resulting tools, techniques and procedures are critically valuable to many of the key priority areas for Defence today, including mission planning, platform and mission survivability, sensor performance modelling, complex system assessments, rapid prototyping of new sensors and effectors, as well as integration and adaptation of fielded military technologies.

STE provides the perfect enabler for continuous preview T&E for capability development and acceleration, to achieve a safer and more reliable transition to a minimum viable capability paradigm. By using advanced simulation technology such as Infinite Studio, there is more opportunity to explore edge cases and strategically relevant technologies in both the digital and hardware-enabled domains, while reducing the demand on limited resources such as field-time.

Securing the mission together

Cohesive partnerships are essential to safely deliver the priorities and capability development objectives across the Defence ecosystem; from the new integrated force structure, through to the warfare centres, DSTG and the recently established Advanced Strategic Capabilities Accelerator team.

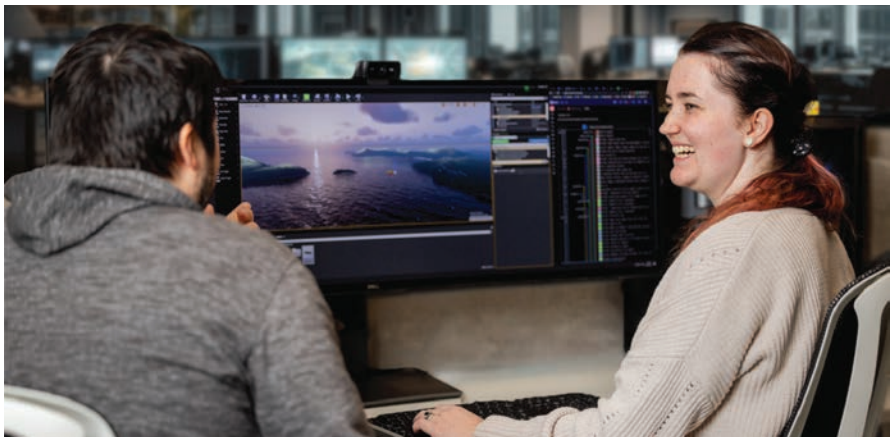
Aurizn is uniquely positioned to provide a continuous and independent technology partnership across the evolving Defence network to ensure a robust support capability, working across the scientific and operational communities, including the tri-lateral regions.

For example, through Aurizn's partnership with Defence they have delivered an advanced behavioural assessment facility for the Joint Survivability Tactics Validation Unit with a long-term experimentation program with DSTG. This leverages the company's know-how with immersive and high-fidelity behavioural technology with the realism of Infinite Studio to accelerate the qualification and development of tactics, techniques and procedures for our warfighters.

With the value proposition of STE now firmly embedded in Defence priorities, Aurizn is investing more than $2m over the next two years into their STE suite—focusing on Infinite Studio—to ensure it maintains its edge in supporting key sovereign capability programs and strategic alliances with our AUKUS partners, where intelligence and data-sharing remain high priorities.

Aurizn is committed to the long-term protection of our national security in the face of a changing geopolitical landscape, providing a partner for technology solutions at pace. With a deep domain knowledge, Aurizn serves to de-risk Defence technology, providing the warfighter with the very best capability.

For further information about Aurizn, please contact Bjorn Wharff (Director of Strategy) **enquiries@aurizn.co**



IMAGES: Supplied

STaR Shot Leader Dr Giuseppina Dall'Armi-Stoks presenting during the More, Together Awards and Summit Awards at the ADSTAR Summit 2022.

Quantum technology for when the sky goes black

How do you navigate when the Global Positioning System (GPS) system has been jammed? You could use quantum technology, which has been named a technology priority in the new National Defence Strategy (NDS). **By Gregor Ferguson**

Most people misunderstand the term 'quantum technology'. It is helpful, says Dr Scott Foster, to think of quantum technology as a collection of tools that allow us to peer into that quantum world and unlock some of its complexity in order to do useful things.

As evidence of how seriously the Defence Science and Technology Group (DSTG) is taking the technology since publication of this year's NDS, they have recently consolidated all quantum activity under a new Quantum Technologies Program, which incorporates the Quantum-Assured Position, Navigation and Timing (PNT) STaR [Science, Technology and Research] Shot, that Dr Foster has previously led since 2022.

Quantum technology has three main applications in defence, he says: quantum computing and information processing; quantum communications; and quantum sensing. Quantum computers are still at quite a low technology readiness level (TRL), he explains, so Defence does not have a specific use case for them at present but wants to make sure that when the quantum revolution comes (as it will), the Australian Defence Force (ADF) is prepared.

> **We have this emerging quantum industry sector which is really exciting but it also provides challenges for us as an enterprise.**

"Defence does not want to be caught off guard," he points out. "We've got to make sure that we're ready to exploit that technology when it's here.

"In the near to medium term, we see opportunities in quantum sensing, and particularly in PNT," he explains. "That's where we're putting the bulk of our effort at the moment because we have a very specific defence challenge that we're trying to address—assuring PNT in contested environments. When the sky goes black, as we say, not only can you not keep your clocks synchronised, but you can't navigate either."

Current PNT systems—navigation and timing, essentially—rely on satellite-based GPS or some other satellite-based system. Defence needs to position itself to continue fighting effectively even where it cannot rely on space-based timing services, and that is a challenge. He says, "We think that quantum technologies could take us partway towards providing solutions to that challenge."

GPS guarantees a permanent timing accuracy of better than 30 nanoseconds—that is 30 billionths of a second—and is synchronised to UTC or Coordinated Universal Time. The best atomic clocks are not portable, and those portable clocks that are currently available, can only maintain GPS-level timing for a few hours at most.

That is the opportunity for quantum technology, says Dr Foster: maintaining GPS-levels of accuracy in PNT on the battlefield or on ships, aircraft and missiles so they can navigate accurately and coordinate efficiently. Quantum technologies enable space-independent navigation.

If it all sounds theoretical, it is not. In 2022, the Five-Eyes nations who make up The Technology Cooperation Program held an Alternative PNT Challenge as part of that year's RIM OF THE PACIFIC Exercise in Hawaii. Australia brought two different atomic clocks and a cavity optomechanical accelerometer, mounted on a Royal New Zealand Navy frigate.

"It was quite a prominent demonstration," says Dr Foster. "In some respects, that was the activity that really kicked us off and got people interested in what we were doing in this quantum PNT space."

In global terms, Australia is probably abreast of the best in the world, reckons Dr Foster, but he cautions that this is not a level playing field. "Quantum research and commercialisation is really expensive. Countries that can invest significant sums will take that risk, because it is a risk." He adds, "There are no guarantees. There's a lot of claims around that have not necessarily yet been tested.

"In global terms, I think we have an opportunity, is the way that I would say it."

While DSTG has academic research and industry partners, Dr Foster sees the quantum ecosystem in Australia as very much a national enterprise: Government, DSTG, the CSIRO, universities and the private sector. But the leading edge seems to be populated by small to medium enterprises—companies like Silicon Quantum Computing, Diraq, Q-CTRL, QuantX Labs, Nomad Atomics, Quantum Brilliance, Infleqtion, and others—a number of which are already partnering with Defence.

"We have this emerging quantum industry sector which is really exciting but it also provides challenges for us as an enterprise," says Dr Foster, citing a skilled workforce as a particular challenge. "Ultimately, we're still relying on our university sector in order to take the risks and to come up with the really creative ideas.

"Our role is to help to nurture and shape that enterprise and that ecosystem. Technology never really comes to life until it leaves the lab."

And that is DSTG's other challenge in an era where our strategic circumstances are deteriorating. He points out, "The imperative is to accelerate the development and the transition of capability. And, in the quantum space, that's really challenging because often you're starting with technology that's very, very low TRL."

To justify investing in this technology through traditional procurement pathways, Defence would typically need something that is already demonstrated at TRL 5 or 6, at a minimum. "That's why ASCA [Advanced Strategic Capabilities Accelerator with its 'speed to capability' mandate] is so important."

The Defence Trailblazer, combining the University of New South Wales and the University of Adelaide with significant involvement by DSTG, has a quantum theme that could also work well for Defence, he says.

"Defence would provide support to an industry partner who would be able to leverage Trailblazer in order to be able to deliver to Defence at a lower cost than would otherwise be possible. What [Trailblazer] facilitates is the moving of IP [intellectual property] across that boundary. It's more than just the documentation. It's that knowhow, it's the people.

"We're very focused on trying to work with Defence projects that actually have a demand for the technology, rather than just developing a latent capability that can sit there until Defence needs it. We're working with our ADF customers in order to drive technology in the direction that actually meets their requirements." ●

IMAGE: Navin Chandra from Defence database

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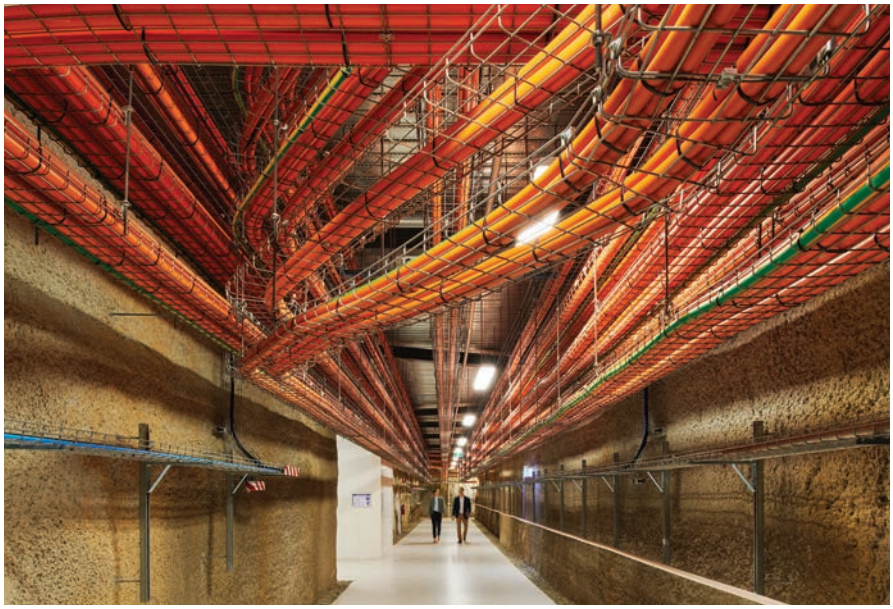

CDC Data Centres: The sovereign environment for defence AI and supercomputing

CDC is the largest developer, owner and operator of sovereign, highly secure and connected large-scale data centres across Australia and New Zealand (ANZ). We provide the critical digital and data infrastructure that underpins national security, social and economic wellbeing. CDC's unwavering focus on security, resilience and availability—coupled with its long-term outlook aligned with the national interest—means CDC is at the forefront of artificial intelligence (AI), quantum, and supercomputing as these technologies become intrinsic to national security agencies.

"We help protect the nation's goals—progress and security," says CDC founder and CEO Greg Boorer.

Cloud, AI, supercomputing and quantum-ready data centres

CDC enables advanced computing across ANZ and has delivered both liquid-to-air and liquid-to-liquid cooling solutions for high-density information and communications technology equipment since 2007.

For defence operations, continuous uptime is non-negotiable, as any downtime can have catastrophic implications for national security.

CDC designs its facilities with a purpose-built architecture that integrates cutting-edge technologies such as immersion and liquid-to-chip cooling, modular design, vibration isolation, on slab rack deployments, and ultra-high rack power densities to support the requirements of advanced technology platforms, including many of the nation's most important supercomputers to government-grade cloud platforms and generative AI workloads.

CDC's state of the art certified direct liquid cooling infrastructure is particularly effective in dissipating heat generated by high-performance computing equipment, allowing supercomputers to operate at optimal temperatures and ensuring the reliability and longevity of the hardware.

Data sovereignty and security for defence

CDC's highly secure, sovereign data centres are an ideal choice enabling decision superiority for defence operations. Backed by three of ANZ's largest institutional investors, CDC's sovereignty is further strengthened by legally binding change-of-control protections and undertakings with government.

"Our unique ability to deliver trusted services that support the preparedness of government and critical infrastructure organisations to keep society functioning is vital, especially given the world's evolving geopolitical environment," says Boorer.

As a Defence Industry Security Program accredited member, our robust security measures are crucial for defence agencies protecting sensitive and classified information.

Scalable high-speed connectivity for mission-critical operations

The ability to enable our customers to scale and grow at both short notice and as the technology evolves is a significant advantage of CDC. Defence environments often require rapid expansion of computational resources to reduce the time to capability in meeting evolving operational demands. CDC's dedicated high-speed connectivity solutions for defence and government customers allows for rapid data uploads, onramps and offramps, ensuring data is always accessible and secure. CDC's network infrastructure provides tailored, uncontended, low latency network services to enable real-time data processing and analysis, which is invaluable for AI enabled, mission critical decision-making during defence operations.

Commitment to sustainability and national security

CDC is the industry leader in water efficiency, seeking to establish new world-class data centre water usage benchmarks that will help set sector standards. This commitment to sustainability aligns with broader national security goals, ensuring that critical infrastructure remains resilient and environmentally responsible. ●

Jericho Disruptive Innovation helps transform Air Force

Jericho Disruptive Innovation (JDI) reports direct to the Chief of Air Force and the organisation is part of Defence's innovation ecosystem, charged with delivering advanced capability as quickly as possible. **By Gregor Ferguson**

The Royal Australian Air Force (RAAF) was the first of the three services to embrace innovation formally. The Chief of Air Force stood up Plan Jericho in 2015, reporting to him directly, with a mission to help transform the RAAF into one of the world's first fifth generation air forces.

The RAAF's performance in a succession of overseas deployments, to the Middle East and Europe on live operations and also to US-led exercises such as Red Flag, show it has succeeded in that aim. However, as the meaning of the term 'fifth generation' continues to evolve as technologies grow and develop, Plan Jericho has itself evolved, into JDI. And it has spawned an innovation-focused spin-off, Edgy Air Force.

It "has matured into a comprehensive and sustainable champion of defence innovation melded with air domain expertise," says its Director, Group Captain (GPCAPT) Jesse Laroche.

The three themes originally articulated by Plan Jericho remain relevant. In fact, they have been adopted by Defence more widely. These themes were to harness the combat potential of an integrated force; to develop an innovative and empowered workforce; and to challenge the way we acquire and sustain capability.

That first theme, harnessing the combat potential of an integrated force, is a task without a finish line, says GPCAPT Laroche. The DSR defines the integrated force as one that harnesses effects across all five of the Australian Defence Force's (ADF's) operational domains—land, sea, air, space and cyber—and it lists 10 critical capabilities for such a force. Almost all of these require advanced, innovative capabilities from the RAAF, including surveillance, reconnaissance and strike, targeting, air operations, air and missile defence, and logistics. Therefore, they require focused, ongoing effort from JDI and its partners as well.

While the NDS reinforces the absolute criticality of an integrated and focused force and is driving significant change for the ADF as a whole, the RAAF pioneered this approach on a single-service basis nearly a decade ago.

When the RAAF deployed a mixed force of fighter-bombers, Airborne Early Warning and Control aircraft and tankers to the Middle East in 2014, sustained by an air bridge back to Australia, it was immediately recognised as one of the few air forces in the world able to deploy and sustain a complete combat capability in theatre. Most other air forces could deploy one, or perhaps two, of the three—strike, surveillance and logistics—but very few could do it all.

That deployment, in its way, informed the DSR and NDS and, just as important, these documents showed that they exist to define and deliver operational capability.

The second theme, developing an innovative and empowered workforce, sustains the Edgy Air Force initiative which was launched by JDI and then adopted by Air Command. The RAAF bears its own share of the ADF's recruitment and retention burden but it has a particular need for technically skilled and trained personnel, so science, technology, engineering and mathematics students and graduates are vital.

Also, as Australia's strategic circumstances continue to deteriorate, it needs people who can innovate and deliver quickly, says GPCAPT Laroche. "Ground-up innovation is quite literally business as usual for Edgy Air Force," he says. Its purpose is to "creatively design and rapidly prototype next generation and disruptive solutions to today's problems."

This approach is supported by commanders at all levels, he adds, and Edgy Air Force Laboratories offer an integrated system of physical 'maker-spaces' across the RAAF, similar to those that exist in the Army and Navy innovation ecosystems, for people to meet, develop ideas and innovate in a supportive environment. These rank-free spaces connect with local industry and across the ADF, creating a multi-layered innovation ecosystem.

The third theme aims to challenge the traditional method of developing and delivering capability. In 2015, the RAAF recognised it needed to field advanced capability much more quickly than traditional methods allowed. As a technology driven service it anticipated "that we would need to take advantage

of rapid development and look to refresh or replace our systems more frequently in order to keep pace with the march of technology," says GPCAPT Laroche. "This assumption proved correct, and today JDI continues to help research, develop, prototype and fast-track strategy led and threat-informed capability for the Air Force and the integrated force."

Although a single-service organisation, JDI illustrates that the importance of innovation is being understood Defence-wide. The Defence innovation ecosystem talks about innovation, asymmetry, speed to capability and Minimum Viable Capability (MVC) and these are all themes that JDI was among the first to explore systematically. The Defence innovation ecosystem now has many elements, he points out, a reflection of the recognised organisational benefits of combining critical and creative thinking.

But there is another feature of defence innovation that must never be forgotten, adds GPCAPT Laroche.

"On reflection one of the most useful lessons JDI has confirmed over the past decade of harnessing innovation is the importance of partnership and collaboration," he says. "One of the most important relationships has been with the Defence Science and Technology Group [DSTG], which has from the outset been an essential supporter of Air Force's innovation activity, as well as a beneficiary of the domain expertise provided through JDI engagement."

For example, at last year's Avalon Air Show, Air Force and DSTG demonstrated they had taken a paper design for an Uncrewed Air System (UAS) and built and flight tested it within two months. The idea of developing a low-cost, expendable UAS emerged in about August of 2022. By September of that year Air Force and DSTG had jointly developed a paper design for a runway independent UAS with a 4m wingspan, a 2kg payload, a range of as much as 1,400km, a ceiling of 1,500m and a bearable cost for a high-end attritable UAS of about $50,000. Dubbed the Wanderer, it can be launched from the roof of a moving vehicle and uses commercial off-the-shelf components so there are no export restrictions.

The first flight test of the Wanderer was in November 2022. Some of the payload elements were delivered by industry in March 2023, after the Avalon Air Show, but the UAS itself was designed entirely in-house. "The process would have taken longer if the groups had asked a vendor to do the work," said Wing Commander (WGCDR) Paul Hay, JDI Deputy Director Advanced Sensing and Uncrewed Aerial Systems. "These are the kind of timelines we want to get to," he added at the Australian Association for Uncrewed Systems Conference, held to coincide with Avalon.

Current acquisition models in Australia "just don't work for us. We need to move much, much faster," WGDCR Hay said. "We want to have a more agile process where we are developing things more often and working with them on a regular basis and not having to wait for major programs."

> **Looking to the future, JDI must continue to adapt to the needs of the strategic environment and the technological landscape.**

Illustrating how rapid innovation and development can deliver an MVC, the Wanderer is a combat ready prototype, meaning that it has most of the capabilities needed to be used on live operations. Robotic and Autonomous Systems are very much on the ADF's radar, across DSTG and all three services, but illustrating also how highly classified this space can be, nothing has been heard about the Wanderer UAS since, even though the ADF has recently announced purchases of loitering munitions and lightweight, short-range intelligence, surveillance and reconnaissance drones. JDI did indicate that Air Force and DSTG have continued their work on Wanderer through trials and operations and is planned to participate in an AUKUS focused Robotic and Autonomous Systems activity in October this year.

Unsurprisingly, says GPCAPT Laroche, the JDI of 2024 also finds itself a natural partner for Defence's Advanced

GPCAPT Jesse Laroche

Strategic Capabilities Accelerator (ASCA), and has collaborated and assisted in mission delivery since the organisation's launch in 2023.

"ASCA's goal to accelerate the delivery of capability and uplift Australian industry and universities perfectly complements JDI's long-standing objectives," says GPCAPT Laroche. "JDI is thrilled to be able to harness the expertise of air force innovation to support this initiative."

Looking to the future, JDI must continue to adapt to the needs of the strategic environment and the technological landscape, he says. Presently the focus is on UAS, advanced sensors, artificial intelligence/machine learning, data science and other disruptive effects, but the ability to pivot and exploit new and disruptive technologies as they emerge will be critical, as will the partnerships JDI has forged and strengthened across Defence, industry and academia over the past decade.

Asymmetry is an important theme of JDI's work as well. The DSR defines asymmetry as something that pits strength against weakness, at times in a non-traditional and unconventional manner, against which an adversary may have no effective response and which may cause the adversary to suffer a disproportional cost.

The ability to innovate and to get new and asymmetric capability into service quickly is what may give the ADF a vital combat edge. This is very much JDI's business, and with DSTG it has helped introduce the concepts and language and, more important, the reality of innovation across Defence as a whole.

The AIM Defence Counter-UAS Directed Energy Weapons System at Puckapunyal Military Area, Victoria.

Directed Energy weapons capabilities

Directed Energy (DE) sounds like a bureaucrat's way of describing a death ray. It is actually a bit more complex than that. DE covers a couple of very different technologies and protecting against an adversary's use of DE is also a vital piece of Defence Science and Technology Group's (DSTG's) research. **By Gregor Ferguson**

"We're looking at both directed energy weapons capabilities and also at protective capabilities," says Dr Alex Hemming, DSTG's Deputy Program Leader Directed Energy. "We want to understand the technology to develop capabilities for the ADF [Australian Defence Force] to use and adopt. We also want to understand the technology to enable the protection of Australian personnel and platforms from adversarial use of directed energy as well."

There are basically two types of DE systems relevant to Defence, he explains: high energy lasers (HELs) and high-power radio-frequency (HPRF) or high-power microwave (HPM) systems. The HEL is scaleable: it can go from just dazzling or disrupting the sensors of an incoming missile to destruction of a target through thermal effects. Similarly, HPRF and HPM are also scaleable. At their simplest, a microwave jammer will shut down many 'drones' (and also probably nearby mobile telephones) but a directed HPRF system could disrupt or destroy electronic circuitry leading to catastrophic failure.

"There is a sovereign capability in this area," Dr Hemming says. "There are local industry players developing systems relevant to the ADF in HPRF, HPM and HEL, and there's quite an established sovereign research network across Australia." Several Australian companies are investing in HEL technology and are engaging with DSTG, including EOS Defence, QinetiQ Australia, AIM Defence and BAE Systems Australia.

DSTG's support takes the form of technology transfer, running joint trials with industry partners, supporting networking, trials and demonstrations to the ADF, and coordinating targeted innovation activities. "We are focused on ensuring that the ADF has the best capability and that there is a solid foundation of Australian industry partners to build these capabilities and deliver value for Defence."

DSTG's commercialisation strategy is to develop and demonstrate capabilities and products that will be sold to Defence. "Whether those technologies are a sovereign solution, or an Australian contribution to a foreign system," says Dr Hemming, "increasing the Australian content or the Australian industrial capability around these technologies is critical for our future industry workforce and manufacturing base."

A key thrust of the Defence Strategic Review was doing things smarter and addressing asymmetric threats. "HEL, HPM and HPRF definitely give you the ability to deliver an asymmetric effect." That asymmetry could be financial: the conflict in the Red Sea shows how the economics of attacking and defending a warship have changed drastically. To take out an uncrewed aircraft system (UAS) that may only cost $1,500 could require use of a missile costing more than $1 million. Even forcing a ship to leave the battlespace to replenish its missile stocks is a victory in that calculus.

> **How do you make these systems more efficient and smaller to integrate them onto a broader range of Defence platforms?**

"That's why you're seeing some of the UK [DE] programs in particular being accelerated," says Dr Hemming. But, he emphasises, a DE capability needs to be part of a layered defensive suite. "DE definitely enables those kinetic effectors to be saved for harder threats and DE will be used to defeat the smaller, softer targets," he says. "And so your [total] defensive suite of weapons and systems would be able to address a broader range of threats with the inclusion of directed energy systems."

DSTG is uniquely positioned to understand Defence's requirements and to direct and foster the research in the broader national ecosystem. Many advances in laser development have come from dual use applications, he points out. Fibre laser technology, for example, which has had billions of dollars of industry investment in cutting and materials processing, has then been taken to the next level as a specific military capability underpinning HEL for DE.

One of the major DE system issues at the moment is size, weight and power. How do you make these systems more efficient and smaller to integrate them onto a broader range of Defence platforms?

And the technology is not confined solely to the DE weapon itself, Dr Hemming points out. Directed infrared countermeasures have quite a large beam that is directed onto an incoming threat, whereas a HEL application puts a spot the size of a 50 cent piece on a moving target a few kilometres away and holds it there for several seconds. So, there is expertise needed in building the laser and also the optics and control systems to achieve that effect.

It is the same with HPRF. Industry has experience building RF systems for radar but to then take those technologies and apply them to HPRF systems is quite different in terms of antenna and power supply design, for example.

DSTG has been cooperating with industry partners in the space for decades and issued a call in 2020, under the former Next Generation Technologies Fund, for partners interacting in the DE field. DSTG scientists also work closely with AUKUS governmental partners such as the Defence Science and Technology Laboratory in the UK and the US Air Force Research Laboratory.

"In certain areas, in terms of laser technology, in terms of high-power RF devices, we're world-leading in some aspects," he considers. "In areas like adaptive optics, around Australia there's really strong world-leading capabilities and so there's definitely areas where we punch above our weight.

"I think the scale of the industrial base determines what systems are likely to be built wholly in Australia or what systems we could contribute to overseas. At the moment the industry base in Australia is behind places like the US or the UK and so we need to develop and understand these capabilities, then focus on what we have an advantage in—where we have expertise and demonstrated excellence." ●

IMAGE: CPL Jacob Joseph from Defence database

Your partner for Defence in the north and beyond

Charles Darwin University (CDU) is a unique contributor to Australia's defence environment. The University has a diverse history of support to Defence, worldleading research capabilities, and a suite of Higher Education and Vocational Education and Training (HE and VET) courses that are relevant to government and the defence industry. With a principal campus in Darwin, and campuses and centres located throughout the Northern Territory (NT) and across Australia, CDU is your partner for defence in the north and beyond.

A distinguished history of support to defence

CDU has for years worked with the Australian Defence Force (ADF) and Defence more broadly. The University's diverse support has included:

- Training ADF units to directly produce spare parts using a world-leading metal 3D printer developed by Darwin company SPEE3D, reducing Defence's logistics burden.
- Providing regional languages training to soldiers at Darwin's Robertson Barracks.
- Working on the effects of heat stress on ADF personnel in Australia's tropical areas.
- Providing environmental and ecological assessments, and feral pest and fire management strategies for Defence training grounds in the NT.

Advanced and unique Defence research capabilities

Drawing on the advantages of its location in the tropics, CDU offers unique benefits in its combination of people, systems, and place to address some of the most challenging research topics facing Defence. Capabilities spread across the University's three academic faculties and 14 research institutes and centres include:

- Over 30 research staff ranked in the top 2% of their disciplines globally within fields as diverse as artificial intelligence, chemical physics and microbiology, with researchers focusing on issues such as cybersecurity, fire and explosive safety, and infectious diseases.
- Deep experience in the identification and treatment of post-traumatic stress disorder (PTSD) and complex PTSD, conditions prevalent in military forces.
- Drone research through the North Australian Centre for Autonomous Systems, with excellent access to one of Australia's only commercial drone ranges—the Katherine Test and Operations facility in the NT.
- World-leading expertise in tropical biosecurity, infectious disease control, and tropical impacts on equipment operation and maintenance, through bodies such as the Research Institute for Environment and Livelihoods and the Menzies School of Health Research.

Diverse training programs for Defence and defence industry

As one of only six dual-sector (HE and VET) institutions in Australia, CDU offers a comprehensive capability to meet the spectrum of Defence and industry's training needs—for personnel commencing their careers, conducting ongoing professional development or preparing for transition. The University's HE and VET offerings are diverse. The University also has an extensive track record in providing VET training to local Defence and industry personnel in the NT.

How will you work with CDU?

Regardless of your research or training requirements, CDU is ready to partner with you and apply its unique expertise to assure success. ●

To learn more about working with us, contact:

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IMAGE: Supplied

Developing Australian Defence capabilities

As Australia's only university headquartered in the Northern Territory, including key campuses in Darwin, Katherine, and Alice Springs, Charles Darwin University is strategically placed to support the ADF and defence industry with on-the-ground training, higher education, and research capabilities.

Advanced Manufacturing Alliance

We undertake research in several fields including cold spray metal manufacturing, mobile manufacturing, metallurgy, corrosion science and obsolescence management. We also train Defence personnel in the use of the SPEED metal 3D printer for in-field operations.

TAFE Training to Defence

We are one of several TAFE partners delivering training to Defence across Australia. Through multiple partnerships, we deliver targeted training in areas including building and civil construction, engineering, electrical systems, and electronics and communications.

Cyber Security

Our researchers are leaders in utilising Artificial Intelligence and Machine Learning as essential tools for cybersecurity. R&D capabilities also include big data analytics, the internet of things (IoT), remote sensing and algorithms and software development.

Drone Systems and Industry 4.0 Test Lab

The North Australia Centre for Autonomous Systems is developing remote-area drone operation techniques and technologies that can support Defence.

Health and Human Resilience

We are conducting important research into the prevalence and management of Complex Post Traumatic Stress Disorder (C-PTSD) and have expertise in studying the effect of tropical conditions on soldier performance and resilience.

Environmental Chemistry, Microbiology, Ecological Assessment

We are experts in providing environmental and ecological assessments, biosecurity, pest, disease and fire management strategies for facilities, including bases and training ranges, in the tropics.

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MQ-28A Ghost Bat aircraft in a hangar.

IMAGE: Supplied Boeing from Defence database

Trusted autonomy and assurance

By Gregor Ferguson

Thirty years ago, underwater robotics was already cool. Underwater vehicles used for mine hunting were deployed from small ships, such as minehunters, and would be tethered allowing for power to the vehicles and for remote control. While remotely operated underwater vehicles are still used extensively by commercial and Defence organisations, says Brendon Anderson, the Defence Science and Technology Group (DSTG) is working with a new generation of untethered underwater platforms where operators could be located hundreds or thousands of kilometres away from their underwater autonomous platforms.

Anderson is Research Leader of DSTG's Mission Autonomy Branch with a team of researchers working on land, air and space and, especially, maritime autonomy technologies. He began his career at DSTG 34 years ago working on the ECA PAP104 and the SAAB Double Eagle, both of them tethered robotic mine hunting systems that were state of the art at the time. Now he is thinking about autonomous vessels that can go very long distances, remain at sea for long periods of time, work pretty much by themselves without breaking down or bumping into anything. That is the difference a generation in technology makes, he says.

For the past five years, Defence has been contributing to the development of autonomous systems on land and in the air. Famously, DSTG is part of the MQ-28A Ghost Bat 'Loyal Wingman' program with Boeing Defence Australia and is part of the autonomous M113 optionally crewed armoured personnel carrier program with BAE Systems Australia.

In the maritime domain, several autonomous systems will be delivered

under the Royal Australian Navy Project SEA1200, including the Ghost Shark Extra-Large Autonomous Underwater Vehicle (XL-AUV) program with Anduril Australia being accelerated under the Advanced Strategic Capabilities Accelerator's Mission Zero, the Speartooth Large Uncrewed Underwater Vehicle with C2 Robotics and the in-service Bluebottle Uncrewed Surface Vessel (USV) program with Ocius Technology. In each case, DSTG is working closely with Navy—as well as with the industry and other research partners.

"Our deep scientific and technical knowledge base has allowed DSTG to play a unique role in accelerating autonomous maritime platforms into service for Navy." Scientists working on the Ghost Shark program, for example, have applied their long and broad experience to provide design support, offering potential solutions to technical risks.

There is the operational side to consider alongside the technical. "We're supporting Navy to understand what it means to have a Ghost Shark in the fleet, and how to best use it. So we're supporting the assurance role working closely with Navy, and at the same time we're working closely with the industry partners to support the technology development."

And it has paid off, says Anderson. In April this year, Defence unveiled the first Ghost Shark XL-AUV prototype an astonishing 18 months after work began on the project. Normally this kind of thing would take much, much longer.

Everything to do with an autonomous system and machine learning is grist to DSTG's mill: batteries; for example, safety cases for different types of battery in different applications; goals-based planning; communications—even paint and approaches to prevent bio-fouling build-up on uncrewed underwater vehicles or USVs.

The Autonomy Branch is part of DSTG's Platforms Division, headed by Dr Greg Bain. The Division still invests in deep knowledge but it is also developing a short-term, asymmetric advantage for the Australian Defence Force. This means having mastery of the technology (which is where, very often, the deep knowledge plays a vital role), working closely with the end users who own the operational problem and working also with industry who will build the equipment they operate. Which means, in turn, being master of commercialisation and, with such short timescales, being more tolerant of risks.

You can only be risk-tolerant if you know what you are doing, which brings us back to DSTG's long-term research and knowledge base.

How does Anderson define the words trusted and assurance?

"For me, trust is understanding the risk and being confident in its acceptance," he explains. Break a mission down into its key elements and then identify the technology risks. "It's the measure of success versus risk. When you understand the context of the mission and the technology maturity and the risks involved, then the commander is in a better position to make a decision around the application of the technology."

Assurance, he says, comes from Objective Quality Evidence (OQE) that the technology is at the required maturity level. That OQE might come from a high-fidelity simulation or a field trial. The key for researchers is to define what to measure, measure it and come to conclusions on technology risk. Assessing a technology's maturity, conducting a technology risk assessment, is DSTG's formal and traditional mechanism for working with Defence projects: using deep knowledge and experience to assess the maturity of the technology involved, identify and develop any mitigation needed, and then work closely with the end user.

But now, he says, "we're actually working with industry earlier in the technology development cycle, working alongside as partners to mature key elements of their technologies." This partnership model helps to identify and mitigate the risk more rapidly, but also helps DSTG transition its knowledge, says Anderson. "If industry is working in Australia, we can work with them to bring what we know."

The research group from RMIT's CADSME in front of the Seahawk helicopter used for testing in the lab.

RMIT's Transformative collaboration for national defence excellence

By Pier Marzocca and Jo Zimpel

RMIT University's strong partnerships with the Australian Defence Force has driven significant innovations in research, development and workforce training. The Sir Lawrence Wackett Defence and Aerospace Centre embodies this legacy by combining academic expertise with national defence needs, reinforcing the university's commitment to enhancing Australia's sovereign defence capability.

Embedded within the Defence Science and Technology Group (DSTG), RMIT's Centre for Advanced Defence Structures and Materials Experimentation (CADSME) exemplifies a long-term partnership that enhances capabilities in structures and materials experimentation. A second Joint Chair with DSTG in Supersonic Propulsion and Flight Technologies reinforces its role in advancing Australia's national interests. These, alongside RMIT's Centre for Additive Manufacturing, showcases RMIT's innovative approach through advancements in additive manufacturing, such as laser metal deposition for aerospace and the creation of high-strength titanium lattice structures. These efforts drive technological advancements in lightweight materials, crucial for Defence, thereby boosting both manufacturing technology and Defence capabilities.

Jointly with APV Corporation, Memko and CADSME, we launched the FutureEdge Alliance, offering multi-domain testing and evaluation capabilities. This collaboration supports Defence through advisory services, research and gap analysis.

RMIT developed a portable low-signature power supply using reversible hydrogen fuel cells for land, sea and air defence in the DSTG Capability Technology Demonstrator Program. The supply recharges from solar, wind or other sources. Partnering with QinetiQ Australia, MTM Automotive, CSIRO Manufacturing and UNSW Materials Science, RMIT progressed the project with the Defence Innovation Hub and the Advanced Strategic Capabilities Accelerator, evolving from concept to prototype. This innovation supports net-zero emission goals and underscores RMIT's commitment to sustainable energy.

RMIT's involvement in the DSTG Multi-Function Aperture Program underscores its role in developing next-generation prototypes and subsystems, especially in phased array antennas. The program leverages extensive expertise in radar, microwave systems, metamaterials and RF energy harvesting, demonstrating RMIT's commitment to transforming research into scalable technologies.

RMIT's quantum physicists and engineers have developed Hybrid Quantum Sensing Materials to enhance performance and detect failures. Their laser-based diamond sensor measures magnetic fields with unprecedented precision, aiding in brain abnormality detection. In collaboration with UNSW, RMIT applies physics-guided neural networks for quantum device control, advancing quantum research.

The Industry 4.0 TestLab in Darwin, launched with Charles Darwin University, showcases RMIT's leadership in autonomous systems. It focuses on drone technology, advanced air mobility, and additive manufacturing for aerospace and defence.

The 2023 Australian Strategic Policy Institute Report ranked RMIT number 1 in Australia for advanced composite materials, additive manufacturing, coating, hypersonics detection and tracking, artificial intelligence algorithms and hardware acceleration. RMIT's aerospace engineering and aviation training are recognised both nationally and internationally.

RMIT's transformative collaboration with DSTG and its continued dedication to defence innovation exemplify a commitment to national security, workforce development and technological advancement. RMIT not only drives progress but also ensures that Australia remains at the forefront of global defence excellence. As we face evolving global challenges, RMIT's role as a catalyst for innovation and collaboration remains indispensable in safeguarding our nation's future.

For more information or to contact our experts, email: **defence&aerospace@rmit.edu.au**.

IMAGE: Supplied

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- Photonics & Quantum PNT Sensor Technologies
- Propulsion Systems
- DSTG Joint Chair Supersonic Propulsion & Flight Technologies

Trusted Autonomy & Digital Engineering

- Autonomous Systems & AI
- Digital Twins (Aerostructure Design and Simulation)
- Rapid Prototyping & Testing
- DSTG Collaborative Program in Fluid-Structures-Interactions and Aerovibroacoustics

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Information Warfare: Prevailing in contested information environments

The definition of Information Warfare (IW) has evolved remarkably quickly—and is now in the public domain, especially as it relates to disinformation. Defence Science and Technology Group (DSTG) and collaborators are working on techniques to counter it. **By Gregor Ferguson**

"When I took up the job as a STaR [Science, Technology and Research] Shot leader a couple of years ago, we had a description of IW that was more of an integrating concept for all non-kinetic effects," says Dr David Matthews. "It included things like electronic warfare, cyber and influence operations."

So DSTG's IW STaR Shot incorporated all of those things, and more. Now, following a reorganisation within the Department of Defence, IW has gone from being an integrating concept to a significantly more tailored activity, with its centre of gravity within the Cognitive & Information Warfare (CIW) Directorate of the newly established Cyber Command.

So what actually is CIW? CIW is focused on informing, persuading, influencing, coordinating, protecting and, at times, deceiving in order to gain an information advantage, he explains.

"To achieve Defence's CIW goals," says Dr Matthews, "there's a few things that you need to be able to do."

Persuading and influencing people begins with knowledge of your audience, so you know what will actually be persuasive or influential. "Most of the time our audiences are not in the room with us, they are perhaps in other countries and we don't always have direct access to them," he explains. You need to know what narratives will work for them and what vector or modality of influence is best—are they social media people, for example, or do they listen to the radio or get their information from traditional leaders or the government? Are they influenced by family, or religious leaders, or specific key leaders or 'influencers'?

It is also important to understand that influence can be directed at both partners, in order to provide assurance, as well as adversaries, in order to deter—because deterrence is essentially an influence effect. It all comes down to what happens inside somebody's head.

"So there's a range of audiences you might want to reach and because so much is happening online these days, most of our methods for understanding our audience and reaching people are online as well," says Dr Matthews.

One component of DSTG's IW effort is countering malign actors. "We've had an explosion of disinformation in the last five years or so. A big turning point was 2016 and Russia's interference in both the Brexit referendum and the US elections, but since then there's also been disinformation around COVID and various conflicts, such as the situation in Ukraine.

"So information is weaponised by our adversaries to either achieve military outcomes—for example, in Ukraine at the moment—or to achieve more strategic, long-term outcomes—such as eroding democracy or trust in institutions."

Of course, a lot of public discourse, even polarising and vitriolic arguments laden with misinformation is just normal democratic activity playing out online. There is a difference between disinformation and misinformation, says Dr Matthews. "Misinformation is spread without malign intent. Disinformation is deliberate malign intent, often by a state actor or its proxies, to deliver a strategic outcome. Governments have an interest in correcting misinformation for the public good, especially if that misinformation is around critical services

> **To counter disinformation, DSTG has also done some fundamental psycho-sociological research and learned that people do not unlearn things easily.**

such as health. However, Defence, is particularly interested in disinformation because it constitutes a deliberate intervention, typically by a foreign power, for a specific strategic purpose.

"Understanding these actor's intent, their strategies and getting better at detecting, countering and measuring their impact is vital," says Dr Matthews.

So what, without breaking any confidences in a very highly classified area, is DSTG actually doing?

It has developed algorithms to detect disinformation across different platforms and languages. DSTG and its university and industry partners can now identify when there is a coordinated campaign, even if it is happening across seemingly disparate accounts, platforms, languages and even countries.

To counter disinformation, DSTG has also done some fundamental psycho-sociological research and learned that people do not unlearn things easily. If they have already absorbed some disinformation, presenting them with facts after the event will usually not help much—disinformation is 'sticky'.

So DSTG is helping Defence to understand which communities are being targeted for disinformation, what the narratives might be and, in a sense, inoculating them in advance: put out a positive message first to counter what the adversaries are going to say, and make the positive message the sticky one.

There are other things to consider, too: mobilising identity, for example. People believe things that reinforce their existing identity-markers, including narratives around belonging ("and our adversaries have been using that against us, actually," he says in an aside).

In addition, DSTG's research has led directly to changes in how Defence organises for IW, he says, and its cognitive and IW specialists have participated in major Australian Defence Force exercises to help the Headquarters incorporate this little-understood dimension of warfare within its traditional military planning processes.

He does not talk much about grey zone operations, for obvious reasons, except to say, "five years ago, around the time of the 2020 Defence Strategic Update, grey zone operations were the main effort for IW. However, since the Defence Strategic Review and National Defence Strategy it is clear that the main effort has shifted to deterrence and denial." Defence structures its forces for conflict and then uses what it has for other types of contingencies such as grey zone competition—that is an important distinction.

Shortly after this interview, Dr Matthews was appointed DSTG's Program Lead for Asymmetry. Jennifer Stephenson has taken up the Program Leader Information Warfare role. In his new job, Dr Matthews is looking more widely at asymmetry and deterrence. "There's a huge psychological aspect to deterrence so CIW remains relevant. However, it's only one of a number of potentially asymmetric capabilities," he says. "First, we need to develop a campaign approach to asymmetric effects planning, second we need to develop asymmetric options that address current or future risks, including by pitting our strengths against a potential adversary's weaknesses and, third, we need to support investment decision-making within the Department around asymmetric opportunities." CIW will be part of these considerations, no doubt.

Defence has partners in this effort—the Five Eyes and AUKUS communities, NATO, regional partners, the Departments of Home Affairs and Foreign Affairs and Trade, and the Australian Communications and Media Authority.

All these understand something important about CIW. To quote Napoleon Bonaparte, who lived in a very kinetic age, "In war, the moral is to the physical as three is to one." CIW has an undeniable moral element which speaks directly to a country's legitimacy in the battle for influence and, if the worst happens, the decision to fight and the resilience to win.

IMAGE: CPL Lisa Sherman from Defence database

We need a coordinated research approach to counter disinformation

Information warfare, including disinformation and malign influence, are major threats to Australia, as well as other democratic nations and institutions around the world. The University of Melbourne is developing a coordinated research program, including training and education, to tackle the problem.

Misinformation and disinformation represent the most severe global risk over the next two years, according to the World Economic Forum 2024 Global Risks Report. While distrust in traditional media and government information grows, information warfare gains more power to divide our society.

"Over the past decade, many countries have experienced state-sponsored and pressure group disinformation campaigns that undermine trust, subvert elections and encourage violence," says University of Melbourne disinformation expert Dr Morgan Saletta.

As close to three billion people vote in democratic elections over the next two years, information warfare could undermine newly elected governments. Misinformation and disinformation could deepen political divides and lead to violent protests, hate crimes, civil confrontation and terrorism.

How do misinformation and disinformation affect Australia?

Australians are not immune to misinformation and disinformation. Many of us do not trust our media sources, institutions or institutional leaders. And one in two Australians feel the country is more divided today

> **Combating disinformation needs more than fact checking. Research has shown that even when a person accepts a fact correction, their overall belief may not be altered.**

than in the past, according to the 2023 Edelman Trust Barometer Report.

The polarisation of our society can undermine social justice efforts and public health campaigns. Were public responses to the government's COVID-19 lockdown and immunisation policies influenced by disinformation campaigns?

"This polarisation directly affects how Australians interact with each other," says University of Melbourne Associate Professor (A/Professor) Piers Howe, who is an expert in cognitive science.

Only one in four Australians surveyed for the 2023 Edelman Trust Barometer Report said they would help someone who strongly disagrees with them on an issue they feel strongly about.

Fact checking cannot counter information warfare

Effective strategies to counter information warfare are essential for Australian national security. But countering information campaigns is complex.

"Combating disinformation needs more than fact checking. Research has shown that even when a person accepts a fact correction, their overall belief may not be altered," A/ Professor Howe says.

True information may convince some people. Others find false information that fits into their belief system more convincing—even if individual facts might be obviously incorrect.

Disinformation spreaders often include as much true information as they can. The response must separate fact from falsity and address each point individually. Counter messages may be tedious and lose the target's attention.

To effectively counter disinformation, we need to understand the people who accept it. What belief structures hold up their worldview? What kinds of claims and reasoning will they pay attention to?

"Effective countering campaigns are appeals to emotions—to change the mind you may need to tug at the heart," says A/Professor Howe.

How can universities help combat disinformation?

The Australian Department of Defence has asked universities for help to battle fake news.

The University of Melbourne's Professor Eduard Hovy has developed a framework to identify and measure information campaigns. He says Australians have long been unknowingly subjected to political misinformation and disinformation campaigns.

"But nobody has ever yet developed metrics that measure the strength, intensity, duration, and direction of such campaigns. That means we cannot easily say, when we see a campaign, how 'directed' it is—if at all—when and where it started, and how it evolves," says Professor Hovy.

"As soon as we can measure the presence of a campaign, we know what kinds of signals we are looking for. Then we can make much more solid statements about what is happening to us. Don't we have the right to clean info, like we have a right to clean water and clean air?"

The framework gives partners the tools to evaluate targeted information campaigns and to decide how to respond.

International experts contribute to disinformation training

The Department of Foreign Affairs Cyber and Critical Tech Cooperation Program has granted funding to the University of Melbourne to help build resilience to disinformation, misinformation and malign influence. The project's research team includes A/Professor Howe and Professor Atif Ahmed and is led by Dr Saletta.

"We recruited 66 international experts from 20 different countries. The goal was to try to understand current challenges, opportunities and best practices in the space," says Dr Saletta.

As part of this work, Dr Saletta has travelled to the Philippines to deliver three training workshops to government and civil society organisations.

Dr Saletta says the work will culminate in the development of an advanced micro-credential focused on combating and building resilience to misinformation, disinformation and malign influence.

"The micro-credential will be informed by the expert opinions we've collected, our training in the Philippines, as well as by a series of case study interviews I've been doing with civil society organisations in the Philippines who are working in this space."

The micro-credential will be offered online by the University of Melbourne.

A coordinated research effort is essential

"A coordinated Australian research effort is essential for strengthening national security, maintaining democratic integrity, advancing technology and developing effective policies," says A/Professor Howe.

A University of Melbourne information and influence research hub is fostering collaboration between Australian researchers. It is jointly chaired by A/Professor Howe and Professor Andrew Perfors.

The hub's collaborators include researchers from the Defence Science and Technology Group. They also include people from universities around Australia, such as the University of Western Australia, Monash University, Australian National University and the University of Technology Sydney.

"By facilitating collaboration between academia, industry and government, the hub drives innovation," says A/Professor Howe.

"This partnership will also strengthen Australia's international standing in digital safety and influence management, promoting economic stability and informed public discourse." ●

IMAGE: Supplied

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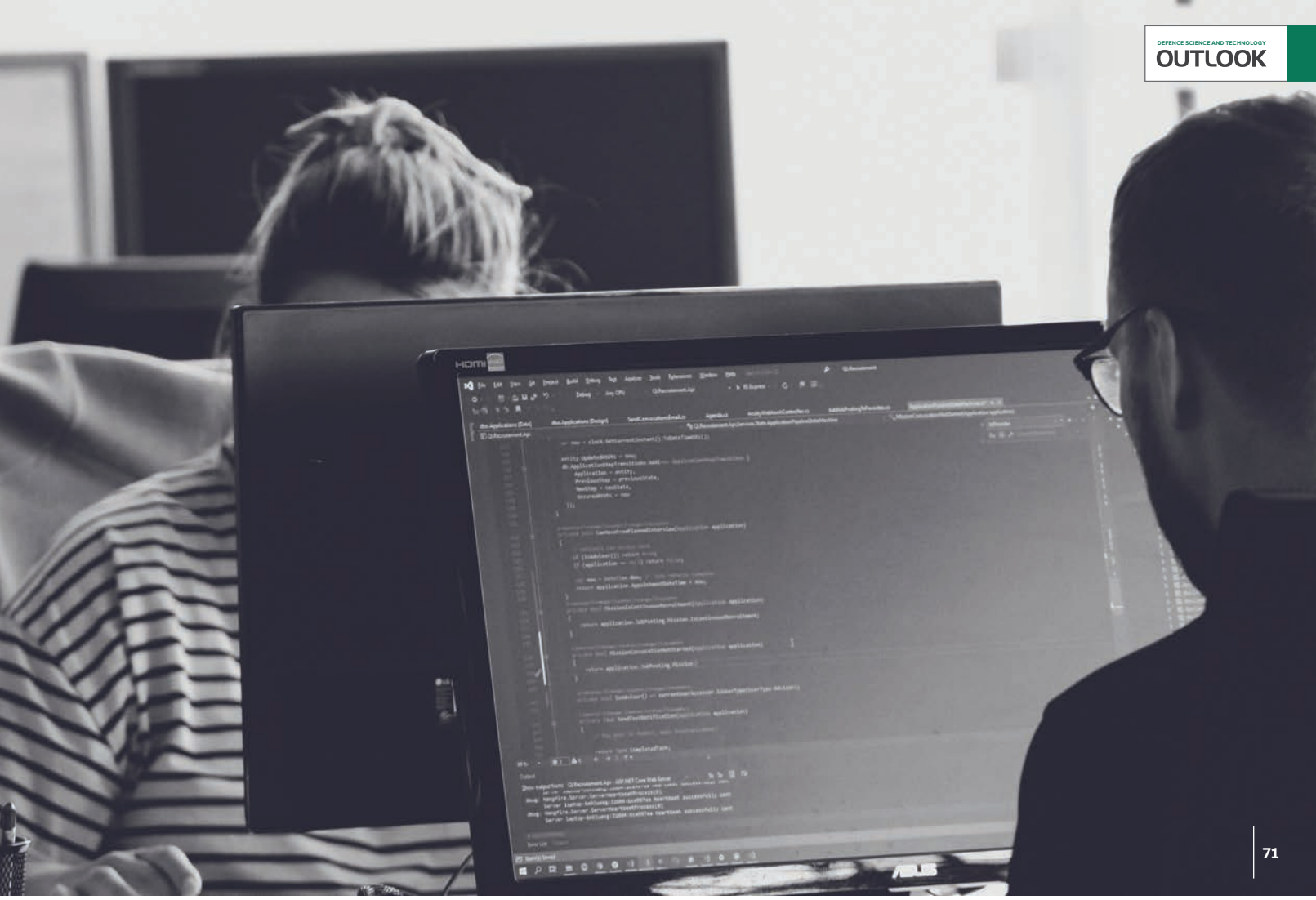


The looming biggest cyber-threat in history: Quantum computing

By Simon Galbally

The rise of state-sponsored cybergangs, geo-political conflict and increasingly well-resourced and skilled cybercriminals have put all defence, critical infrastructure, government and commercial organisations' high-value data at risk. There is no hiding from cyber-attacks. But the worst is yet to come!

Not to sound overly dramatic, the fact is that in the next few years the biggest cyber-threat in history will arrive—quantum computing. While the quantum computer will provide enormous benefits to science, healthcare, technology innovation and broad commercial applications; it will also be weaponised by cybercriminals.

This is such a significant cybersecurity issue now that governments are legislating cybersecurity requirements for 'quantum readiness'. The US government was the first to do so under its *Quantum Computing Cybersecurity Preparedness Act* (2021-2022). Moreover, the US standards organisation, National Institute of Standards and Technology (NIST), has just announced the quantum resistant algorithm standard. The threat of quantum computing is so important that even suppliers to US federal government agencies will soon be required to meet quantum-readiness encryption standards before sharing technologies and even doing business with US federal agencies.

IMAGE: Supplied

Why so significant today? It is about being prepared. Most sensitive data (e.g. business and government secrets, intellectual property and citizen identities) has a very long life—from 10 to 50 years. What is encrypted today using conventional algorithms will easily be hacked in a post-quantum world. Today's stolen encrypted data will easily be decrypted in the future.

Consider that in 2023, Australia experienced a 23% increase in state-sponsored and organised cybergang cyberattacks, with nearly 94,000 incidents reported. They primarily targeted government agencies, Defence and critical infrastructure. These attackers focused on espionage, extortion and disruption, particularly in sectors like technology, defence, communications, energy and healthcare which are vital to national security.

The real costs of successful cyber-attacks are not just financial. Loss of reputation can be the highest cost. Supply chain, technology partnerships and customer impacts cause loss of trust among all stakeholders—even shareholders.

It is a fact of good business practice that all long life and sensitive data be encrypted—at rest when stored and in motion across data networks. Moreover, as a future world of quantum computing rapidly approaches, the critical business issue of protecting high-value long-life data is even more critical now.

Secure defence technologies

As Australia's leading federal government agency charged with responsibility for applying science and technology to protect Australia's national interests, the Defence Science and Technology Group (DSTG) collaborates with the Australian Defence Science and Technology industry (DST industry). It plays a critical role in Australia's economy bolstering defence capabilities and ensuring national security. Encompassing activities from advanced research and development to the deployment of cutting-edge technologies across the Australian Defence Force (ADF), DSTG is driven by innovation and collaboration between government agencies, academic institutions and private sector companies. All work together to develop technologies providing Australia with a strategic advantage. By definition, DSTG and the wider industry are high-value targets for all cybercriminals. All participant organisations should be completing their plans for quantum resilience now as a core part of their cybersecurity strategies.

Because key areas of focus within the DST industry include autonomous systems, cyber defences, advanced materials and space technology, DTSG will increasingly look to the industry for the integration of state-of-the-art cyber defences in their products/technologies. And sooner rather than later this will include quantum resilience. Today, autonomous defence assets and asset control systems' operational technologies (OT) require encryption protected communications. These areas are vital for enhancing the operational capabilities of the ADF, protecting autonomous defence assets and ensuring the resilience of critical infrastructure. For example, developments in autonomous systems are transforming how military operations are conducted, making advancements in cyber defences crucial for protection of these assets from increasingly sophisticated cyber-threats.

Through their collaboration, DTSG and the industry form a dynamic and essential sector that underpins national security, supports economic growth, and positions Australia as a leader in various global defence technologies. Hence, the risks of intellectual property theft and disruptive harm are very high. There is a great deal of long-life and high-value data cybercriminals want.

Defence science and technology as critical infrastructure

The DST industry is not just another sector; it is a vital component of our critical national infrastructure. This industry is rapidly growing, driven by advancements in technology, increasing investment, strategic international partnerships and Australia's geographic advantages. The industry has far-reaching impacts across various industries, including defence, telecommunications and manufacturing.

The industry's broader impact includes driving technological advancements, creating high-skilled jobs and supporting economic growth in related fields. Overall, DSTG and the DST industry are estimated to contribute approximately $12 billion to the national gross domestic product. Given its pivotal role, the industry demands state-of-the-art cybersecurity to protect its data assets and ensure national security.

When we consider that the industry's contributions are critical to areas such as advanced materials, cyber defence, autonomous systems and space technology, it is easy to see why all players are prime targets for cyber-attacks. Further, in the hands of state-sponsored cybercriminals, weaponised quantum computing could have catastrophic impact, including loss of reputation.

The industry's capabilities are essential for national security, emergency response and maintaining Australia's strategic advantage and must be kept fit for purpose. The government's decision to replace the Defence Innovation Hub and the Next Generation Technologies Fund reflects that. The newly launched Advanced Strategic Capabilities Accelerator program seeks to implement new, innovative technologies into priority defence capabilities, through a streamlined process designed to accelerate the acquisition process. This highlights Australia's ongoing commitment to fostering innovation in defence science and technology. Similarly, the cybersecurity posture must be fit for purpose demanding quantum resilience. There is a lot at stake—cybercriminals are seeking to steal technologies, compromise data or disrupt critical operations. Australia will not be immune.

Cybersecurity challenges in defence science and technology

The DST industry, with its complex mix of interconnected systems, data networks and cutting-edge technologies, is highly vulnerable to cyber-threats.

Given the rapid pace of technological development and the strategic nature of defence missions, the industry faces persistent cyber-threats from a wide range of adversaries. It is a high-value target with vulnerabilities that must be addressed to prevent catastrophic harm to defence assets, critical infrastructure

and national security. The primary vulnerabilities include:

1. **Inadequate risk management-based cybersecurity strategies:** Both the likelihood and severity of cyber-attacks are high, requiring state-of-the-art cybersecurity to ensure preparedness and resilience.
2. **Complex interconnected systems:** Reliance on complex data networks and interconnected systems, communication networks and data centres, increases its vulnerability to cyber-attacks. This requires the use of state-of-the-art network encryption across their information technology and OT asset control systems.
3. **Legacy systems:** Dependence on outdated cybersecurity systems not designed to counter today's threats exposes the industry to increased risks.
4. **Supply chain vulnerabilities:** The industry's reliance on global supply chains for components, technologies and services introduces cybersecurity risks through compromised products or services.
5. **Human factors:** Employees, contractors, suppliers and partners with access to sensitive systems and data may inadvertently or maliciously compromise cybersecurity.

Addressing these challenges requires an holistic approach to risk management, including investments in advanced cyber defences, comprehensive training programs and fostering a cybersecurity-first culture. Cybersecurity must be viewed as fundamental to the DST industry's business operations to safeguard critical assets, protect sensitive data and ensure the integrity of defence missions. Ultimately, these are essential to maintaining reputational integrity.

Cyber threat landscape

As the DST industry continues to advance, it faces an increasingly complex and sophisticated cyber-threat landscape. Cyber-attacks on defence-related industries in the US and EU

IMAGE: Supplied

demonstrate the growing attractiveness of this sector to cybercriminals, including state-sponsored groups.

To counter these threats, a comprehensive cybersecurity strategy must be in place, beginning with security-first principles. This includes an approach encompassing policy development, risk assessments, resource allocation, and investments in cutting-edge threat identification and prevention technologies. It is no longer sufficient to rely on outdated security measures or simply 'tick boxes'.

Encryption is crucial in protecting long-life sensitive data. As highlighted by ASIO's director-general, Mike Burgess, encryption is vital for safeguarding our economy, including the protection of intellectual property, defence secrets and national security information. Given the high value of the data generated by the DST industry, state-of-the-art encryption protocols are essential to protecting against cyber-attacks and ensuring the confidentiality, integrity and availability of critical information.

Weaponised quantum computing

The emergence of quantum computing presents both opportunities and challenges for the DST industry. While quantum computing holds the potential to revolutionise defence technology through advanced data analytics, simulations and optimisation, it also poses significant cybersecurity risks.

In the hands of adversaries, quantum computing could break conventional encryption methods, potentially compromising sensitive defence data and threatening the security of critical operations. To mitigate these risks, the industry must adopt quantum-safe encryption solutions, including NIST's quantum-resistant algorithm standard, quantum key distribution and quantum random number generation.

Strengthening cybersecurity in defence science and technology

DSTG and the DST industry form a cornerstone of Australia's national security and economic prosperity. It is imperative that cybersecurity remains a top priority, with proactive strategies—including quantum readiness—and significant investments in cutting-edge technologies, threat prevention and data protection.

In an era where cybercriminals are constantly seeking to exploit vulnerabilities, the DST industry must adopt a zero-trust approach to cybersecurity. By implementing 'military-grade' encryption, quantum readiness and fostering a culture of cybersecurity awareness, the industry can safeguard its assets and operations against the ever-evolving cyber-threat landscape.

As quantum computing looms, the industry must face today's and future cybersecurity threats. By staying informed and ahead of these challenges, the industry can avoid the greatest cybersecurity threat in history—quantum computing.

Stronger Commonwealth partnerships for chemical detection and beyond

How do you know if an enclosed space, your protective equipment or an entire area, is safe or not? That is where the MIST sensor comes in. It can help detect and identify toxic vapours for both military and civilian operators in real time and may be the start of an important Commonwealth partnership. **By Gregor Ferguson**

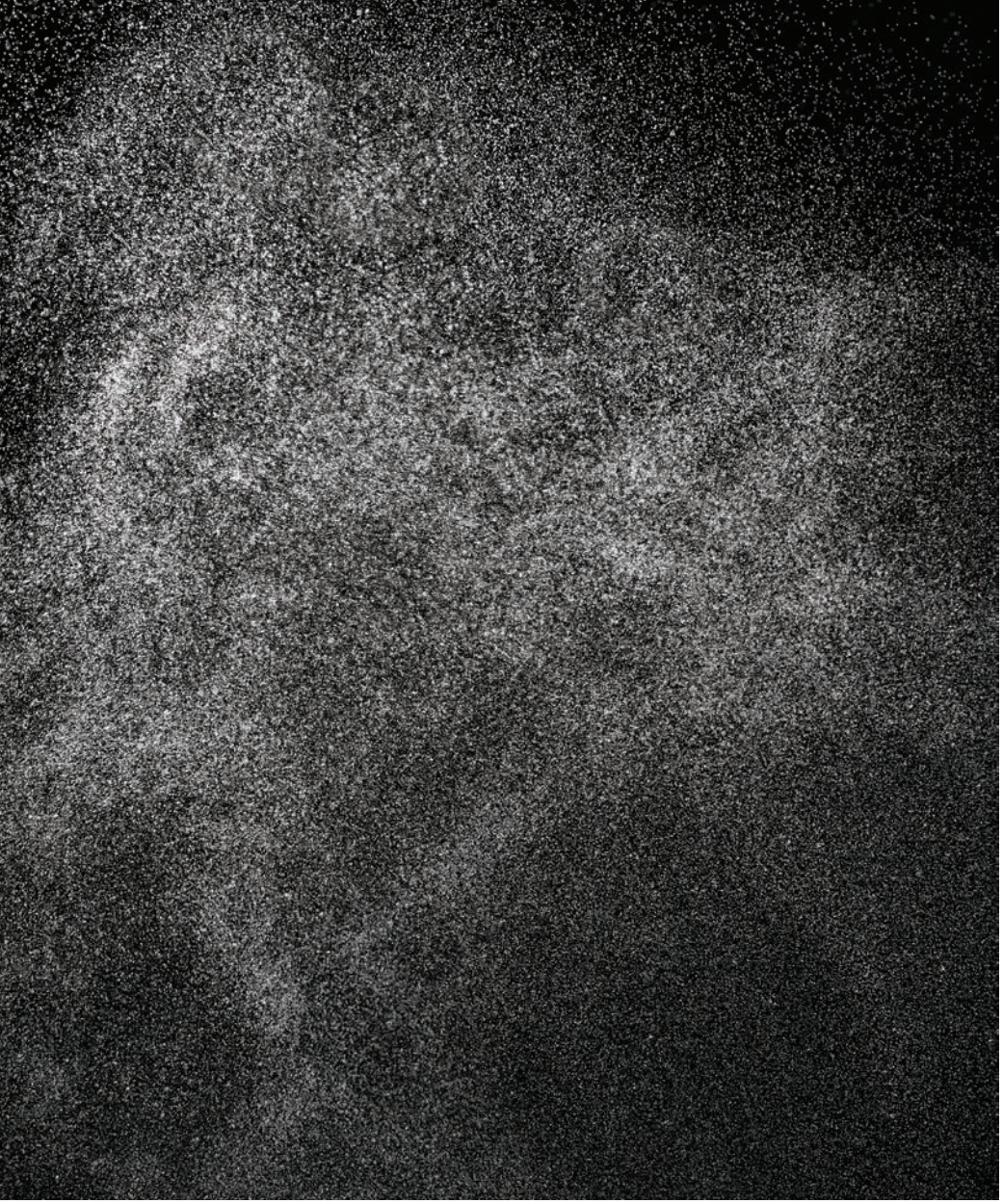
The 'MIST' is a miniaturised chemical vapour sensor that was designed to address a key weakness in current test methodologies that emergency services and Defence use to assess chemical protective suit ensemble systems. The sensor is low-cost, powered by a button battery and only slightly larger than a USB drive. These attractive features paired with an adaptability to a range of different vapour types has led to the exploration of MIST's potential as a widely deployable early warning sensor technology in the field.

Thanks to a Memorandum of Understanding (MOU) signed in April 2024 between the Defence Science and Technology Group (DSTG) and the Department of Agriculture, Fisheries and Forestry (DAFF), the MIST is also the subject of an important dual-use technology development program to keep biosecurity officers safe while working in potentially hazardous environments.

Dr Nicholas FitzGerald works for DSTG's Operating in a Chemical, Biological, Radiological and Nuclear (CBRN) Environment (OCE) STaR [Science, Technology and Research] Shot and co-invented the MIST when he was a member of the Chemical Detection Team from DSTG's CBRN Defence area.

"The genesis of the MIST sensor was the need to track, in real time, the leakage of chemical vapour into and beneath chemical protective ensembles," explains Dr FitzGerald. "In a test, we dress people or manikins in a protective ensemble and have them complete controlled exercises in a chamber filled with a simulant vapour challenge. This allows us to assess how different items of protective clothing

IMAGE: Paperkites from iStock



work together as a holistic system." Traditional analyses of the test are offline providing only a single data point from passive adsorbent dosimeters.

The MIST is a colorimetric reader technology. Air is drawn into the device via a tiny piezoelectric pump and past a substrate doped with tailored reactive chemistry. If a target vapour is in the air, even in concentrations of low parts per million (and in some cases parts per billion), the reactive chemistry changes colour and the patented optical system detects the colour change at sensitivity far exceeding that of the human eye.

The technology's adaptability to detect other chemical vapours is why DAFF became interested and implemented an MOU to take advantage of this exciting technology. DAFF conducts thousands of biosecurity inspections every year at ports and inspection facilities, and biosecurity officers may encounter harmful vapours left over from fumigation during an inspection.

DAFF's Director of Research and Innovation, Jessica May, explains that "the continued use of methyl bromide, phosphine and the increasing use of sulfuryl fluoride as fumigants for goods entering the country, means biosecurity officers are required to check for the presence of potentially dangerous gas while undertaking inspection duties. It is important we continue to support innovation such as this to find better ways of working and keeping our staff safe."

For Defence, vapours relevant for deployed scenarios could include chemical weapons, their precursors and toxic industrial chemicals and is why the MIST detection head was designed from the start with flexibility in mind.

"It has been exciting to work with Defence and better understand why CBRN threats are so important in a conflict environment," she says. "And also understand how the technology used to meet these threats can be applied to our work within or around hazardous environments."

Initial trials, co-designed and co-executed by DAFF and DSTG, in the context of fumigant exposure during biosecurity inspections, have been successful and DAFF have worked closely with DSTG to fund enhancements in the manufacturability of MIST.

Dr FitzGerald states, "This MOU is an important first step relating specifically to the development of the MIST, but we expect it to be the beginning of a more strategic inter-department relationship with DAFF and serve as an exemplar for other inter-department partnerships." The OCE STaR Shot recently stood up the Centre for Advanced Defence Research and Enterprise OCE at the University of Melbourne and Dr FitzGerald believes that "as this relationship develops, DAFF can participate in such initiatives and we can utilise their networks in an important step towards the future of multi-departmental research centres."

DSTG's long-term industry research partner for MIST development has been Melbourne-based Ideation Product Solutions and its university research partners have included RMIT, Swinburne and Deakin Universities. DSTG is now engaging commercial licencing and mass manufacturing partners. An advantage of dual-use technology is being able to be open to additional markets such as DAFF and the future Australian Defence Force technology refreshment programs to progress the technology to commercialisation quicker and deliver a minimum viable product earlier.

The MIST technology is effective, shows commercialisation potential and is suitable for different missions across varied users and is an exciting example of inter-departmental partnerships. A potential dual-use technology is a prize worth chasing, with benefits across the science, technology and innovation ecosystem and beyond.

A credit card-sized gas sensor for chemical hazard monitoring

Scientists from the University of Melbourne and Monash University have developed a credit card-sized gas sensor for better situational awareness of chemical hazards. The research was funded by the Defence Science Institute and the Defence Science and Technology Group (DSTG) Operating in Chemical, Biological, Radiological and Nuclear (CBRN) Environments Science, Technology and Research (STaR) Shot.

Toxic gases can threaten the safety of our defence personnel, industries and the Australian public.

Such gases can occur naturally, but they are also emitted in common industrial processes. In industrial accidents, natural disasters and deliberate attacks, we need sensors capable of monitoring large areas for very low concentrations to reduce human exposure to chemical agents.

Researchers from the University of Melbourne and Monash University have developed a low-cost, lightweight, battery-powered gas detector for field use. The research team has built and

tested a fully functional prototype device.

Low-cost gas sensing cards could monitor chemical contamination in a large area

The new gas sensing methods are capable of accurate and specific detection of various gases.

Commercially available devices are mostly based on chemiresistive sensors. They are bulky and sensitive to a broad range of gases and have high dependency on temperature and humidity. Some require powered heaters to operate.

"The existing devices suffer from non-specificity and sensitivity for detecting multiple gases—you may need multiple sensors for an accurate detection of a chemical. Furthermore, miniaturisation is a challenge when specificity and sensitivity are not compromised," Associate Professor (A/Professor) Ranjith Unnithan says. A/Professor Unnithan is an expert in sensor engineering at the University of Melbourne.

The device A/Professor Unnithan developed with his colleagues can detect multiple gases at low concentrations. The device is a chip-sized electronic nose that also retains specificity. The team has developed techniques to compensate for noise from the surroundings.

"The credit card-sized device has sensors to detect different gases at very low concentrations. It also has a signal processing and a GPS tracker unit, together with a wireless communication antenna to transmit data," he says.

To monitor or test large areas for contamination, several of the low-cost sensing cards could be deployed in unmanned aerial vehicles. The devices would transmit data to the unmanned aerial vehicle, which would return data for analysis at a centralised communications hub.

"Small low-cost sensitive and selective sensors are an area of key focus for our project," says Dr Nick FitzGerald, DSTG Science Technology and Innovation Lead for Defence's Operating in CBRN Environments STaR Shot.

"The prototypes from this project have a number of promising features that warrant further evaluation while also having scope for further improvement via ongoing R&D. More broadly, this is a great example where the STaR Shot partnered with Victoria's Defence Science Institute to fund a challenge called the 'Hazard Agent Challenge' and drive rapid prototyping developments that draw together talented transdisciplinary and cross-institutional research teams."

The sensor continuously samples its surroundings with a fan that directs air to the sensor's microfluidic channels. The microcircuitry in the sensor monitors for a change in currents, which corresponds to the concentration of hazards in the air.

"The sensor material has chemicals that bind to a specific gas in the air like a key in a lock. When a chemical is detected, there is a change in current, which is amplified and referenced to a reference sensor to subtract other disturbances," says Areej Shahid, a graduate researcher at the University of Melbourne.

"We can modify the device to sense different chemicals."

The research team built their fully operational prototype device at the Melbourne Centre for Nanofabrication. It is a world-class nanofabrication centre that combines cutting-edge technologies with the knowledge and skills of expert process engineers. The centre is a joint venture between the University of Melbourne, six other Victorian universities and the CSIRO. It is openly accessible to any researchers in academia, CSIRO or industry.

Collaboration makes better gas-sensing capabilities possible

A/Professor Unnithan and his team developed the device in collaboration with materials scientist and engineer A/Professor Sudha Mokkapati at Monash University.

The University of Melbourne researchers developed the electronic nose, sensing layers, electronic processing and wireless platforms. The Monash University team developed 2D materials for sensing and has been responsible for testing the prototype device.

"A game-changer in our gas sensing is the use of 2D materials to increase the sensitivity of the sensors," says A/Professor Mokkapati.

This collaboration has allowed the team to achieve better capabilities for the sensor.

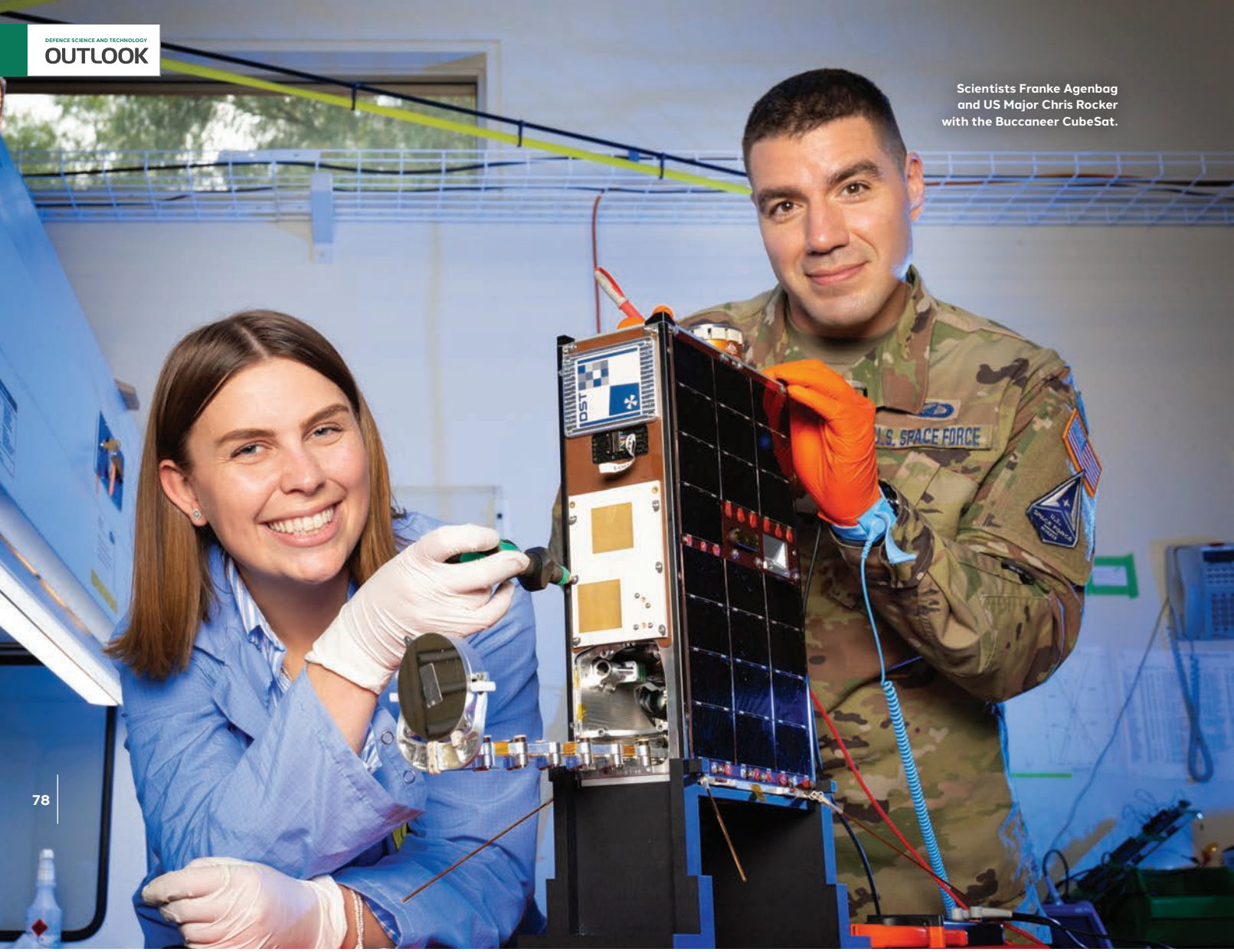
"We've made an electronic nose with high sensitivity, selectivity and the ability to detect multiple gases on a credit card-sized device, which is very challenging," says A/Professor Unnithan.

The team has continued to develop the electronic nose for industry applications like detecting the quality of wine and beer.

"We also continue our discussions with the Defence Science and Technology Group to meet defence requirements," says A/Professor Unnithan.

"The new device that we are working on will incorporate some of the challenges mentioned by DSTG, such as the influence of operating environments like high humidity and other contaminants." ●

IMAGE: Supplied



Scientists Franke Agenbag and US Major Chris Rocker with the Buccaneer CubeSat.

Buccaneer: Seeing from the ultimate high ground

Learning by doing is a time-honoured way of absorbing knowledge and Defence Science and Technology Group's (DSTG's) Buccaneer Main Mission has that as an objective for Defence personnel, alongside its main mission: learning how to better calibrate the Jindalee Operational Radar Network (JORN) radar sensor. **By Gregor Ferguson**

IMAGE: Megan Popelier from Defence database

Late this year, or very early next year, Defence will put a second Buccaneer satellite into orbit. Designed by DSTG in partnership with the Royal Australian Air Force (RAAF) and Joint Capability Group's Australian Space Command, the Buccaneer Main Mission (BMM) will see the second of two Buccaneer CubeSats launched from an as-yet unconfirmed location in the US.

The main purpose of the BMM, says Dr David Lingard, is to help calibrate the JORN, which is operated by the RAAF. Its primary payload is a digital high frequency (HF) receiver and antenna because JORN operates in the HF band.

It also has a secondary purpose, to demonstrate high data-rate space-to-ground laser communications, so it also features a DSTG-developed optical communications terminal. And it carries a self-inspection camera to check the deployment of the HF antenna and an Iridium transceiver which enables real-time, constant monitoring of the satellite's state of health using the Iridium commercial satellite constellation.

The BMM ground station and operations centre are currently under development at a secure site at DSTG Edinburgh in South Australia.

There is a third, and arguably more persistent, aim to the BMM. "A key aim of the Buccaneer program is to advance the space capabilities of DSTG and to train a cadre of Australian space professionals," Dr Lingard says. Dr Lingard is one of a small, but growing number of these in Australia as Group Leader for Space Autonomy in the Space Autonomy Science and Technology Capability within DSTG's Platforms Division.

The on-orbit outcomes from the BMM will inform future space-based capability for Defence, he says, and the technology and knowledge gained will be available for Australian industry for use in developing future capabilities for Defence.

The BMM is actually the second of two CubeSat missions. The first was the Buccaneer Risk Mitigation Mission (BRMM), which was developed in partnership with the University of NSW in Canberra and launched in 2017. It was operational for just over 12 months.

The BRMM fulfilled all of its more limited primary mission objectives. These included testing the design and deployment of a novel HF antenna that will be flown on the BMM.

The second mission objective was to give university and Defence personnel genuine experience in spacecraft design, development and operation, including solving problems such as how to put the HF antenna into space in a tiny CubeSat.

The BMM incorporates lessons learned from BRMM and the satellite has a planned service life of 12 months, though, as Dr Lingard points out, "DSTG will continue to operate the spacecraft for as long as it is functional."

The space environment is harsh and CubeSats are not designed with as much redundancy and protection against environmental factors like radiation and repeated hot-cold cycles as larger spacecraft. The satellite's orbit will naturally decay and the satellite will completely burn-up on re-entry to the Earth's atmosphere.

The satellite platform itself—the 9kg 6U satellite bus has been designed, manufactured and tested by an Adelaide-based space specialist subject matter expert, Inovor Technologies. The bus includes the electrical power system, main flight computer, radios, satellite pointing control and structure. This will be integrated with the primary and secondary payloads developed by DSTG to form the complete satellite.

The US Space Force is providing a rideshare for BMM to be launched into low Earth orbit. The exact launcher site and type have not been confirmed as yet. The US Space Force has also provided a laser communications module for the secondary payload's optical communications terminal. There have been contributions from academia such as the University of South Australia developing optical modem technology for the optical communications terminal.

To help build and validate an in-country space industry, DSTG has also made use of national test facilities throughout Buccaneer's development. The BMM CubeSat is being tested at the Australian National University (ANU) National Space Test


Dr David Lingard

Facility in Canberra. This testing is to demonstrate that the satellite will survive launch and the harsh space environment for at least 12 months.

Components of the BMM CubeSat have also undergone radiation exposure testing at the Australian Nuclear Science and Technology Organisation in Sydney, and at the ANU's Heavy Ion Accelerator Facility in Canberra.

Why does the BMM matter? A couple of reasons, explains Dr Lingard. Firstly, it is focused on the JORN over-the-horizon radar network, which is operated by the RAAF and looks up to 3,000km offshore, helping build a picture of what exactly is out there, both on the surface and in the air. It achieves those range figures by bouncing HF radar waves off the ionosphere, between 70 and 350km above the Earth.

JORN was built in the 1990s and is now undergoing a mid-life upgrade. As part of this, the BMM's primary payload will receive JORN transmissions, allowing measurement and analysis of its far-field radiation pattern and research into its transmit system calibration. From an altitude of 500km, the satellite will look down on the ionosphere and fly through JORN's pencil transmit beam to ensure it is the correct shape when it hits the ionosphere. If it is not, the satellite will tell DSTG.

"The Buccaneer program is an example of DSTG's innovative R&D contributing meaningful outcomes for Defence," says Dr Lingard.

It contributes to the development of a skilled, experienced and confident space workforce in Space Command, the RAAF and DSTG. Australia is having to learn a lot, and quickly, about designing, building, launching and operating space craft. The two Buccaneer missions are designed to help.

STEM pipeline

The Defence Science and Technology Group (DSTG) is Defence's lead in developing Australia's STEM population and is looking hard for people who have studied STEM subjects—science, technology, engineering and mathematics—at secondary and tertiary levels. The pipeline actually begins at primary school believes DSTG. **By Gregor Ferguson**

STEM subjects matter, let us be clear about that. STEM is especially important for DSTG but is becoming more important also for uniformed and civilian engineers and technologists within Defence and the Australian Defence Force.

It is not just the knowledge that studying these subjects imparts, says Dr Kathryn Parsons, it is about knowing how to think.

"Given the changing world around us when it comes to things like automation, globalisation, and lots of advances in technology, there's a clear need to prioritise our focus on STEM skills," she says. "There are jobs in the future that we know are going to require STEM skills but exactly what those will look like is a bit undetermined in some cases."

Dr Parsons is currently acting in the Executive Director role for Workforce Capability and Talent within DSTG. She is an organisational psychologist by profession and her work involves applying psychological principles to human factors and organisational problems. Her research background involved the human aspects of cybersecurity and online social influence, which makes her a perfect fit with some of the new technologies and business models that DSTG is exploring.

Maintaining a focus on STEM, both today and in the future, needs a Department-wide approach, she says. "We want to have schools and universities and government and industry all involved. So this is why DSTG leads STEM outreach and engagement activities across different parts of that pipeline."

But STEM is not just about developing technology skills and knowledge. "STEM skills aren't just technical in nature. There are also non-technical skills that come with STEM that are really critical. So, DSTG is seeking professionals that can communicate really complex information to a wide range of people, can effectively lead teams, can understand group dynamics and how people function—and those are really critical STEM skills as well.

"In the future we're going to need people who are amazing at solving really complex problems, dealing with difficult sorts of data, asking really smart questions and looking at things in different ways and so the less technical aspects of STEM can do that really well," Dr Parsons adds.

One of the things that DSTG is trying to do is change its culture, as quickly as continuity allows. To some extent it is still a male-dominated environment with a small workforce turnover and does not really reflect the growing diversity and gifts of much of Australia's fast-growing population. It has deep knowledge but has not, until quite recently, been structured for diversity of either approach or viewpoint. At the same time, the nature of Australia's defence technology challenges is changing fast, along with the demographics of the external community of scientists. Hence, DSTG's NAVIGATE recruitment program.

NAVIGATE was designed to attract mid-career researchers, many of them women, who could provide a different viewpoint and new leadership in tackling fast-evolving technology and science challenges. It has been a resounding success.

"So NAVIGATE 1.0 in 2022 offered 80 positions," says Dr Parsons. DSTG was also actively seeking a very different gender mix: 40% male, 40% female and 20% from either gender. "From that first version of NAVIGATE we had 69 participants commence the program," says Dr Parsons. "In the end we had 40% females, so we met that target."

For NAVIGATE 2.0 in 2023, DSTG sought 40 entrants, with a gender target of 50% female appointees. "In that case we ended up with 36 participants for NAVIGATE 2.0 and 61% of those are female. Those participants commenced in the program in 2024."

The NAVIGATE Program was unlike anything DSTG had done before, says Dr Parsons, but it successfully increased the percentage of females at more senior levels within the organisation. DSTG also made the NAVIGATE program open to many of its employees. She points out, "It was a real broadening experience for existing DSTG employees and a great way to provide its STEM professionals with a mobility opportunity, either externally as secondees or in other parts of Defence."

The experience of the NAVIGATE program has resulted in some important changes to DSTG's human resources

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processes and the career management of its staff, says Dr Parsons. "I think that NAVIGATE has made us think differently about mobility and the importance of having, not just a career in a single group all the way through, but also having that broadening opportunity."

One of DSTG's goals is to increase the proportion of women in its ranks and there is an important reason for that, says Dr Parsons. "We want to make sure that we're representing the society that we live in and if we're not then we can't be sure that we're getting the best ideas to solve the problems that we have to solve."

DSTG is embracing both diversity and different, less stovepiped ways of working, points out Dr Parsons. "DSTG has some amazing examples of multidisciplinary groups that are really able to solve problems in better and different ways because they're bringing together those different disciplines, those different mindsets, those diverse ways of thinking."

But traditionally, in the science and technology areas, women accounted for only about 20% of DSTG's workforce no matter what it did to try and change this. "If we only have 20% female, and most of society has 50%, then we're probably not recruiting from the whole talent pipeline. We're probably not getting the most innovative ideas to solve our problems," says Dr Parsons.

Hence, NAVIGATE and also DSTG's relationship with ATSE, the Australian Academy of Technological Sciences and Engineering, and especially ATSE's Elevate program, says Dr Parsons.

"The primary goal of ATSE is to boost women in STEM by addressing the inequities that are at play," she explains. Elevate is open to both women and non-binary people at undergraduate and post-graduate levels, and it is distinct from other scholarship programs because it takes into account not just success but success relative to opportunity.

"So, as part of the application process they take into account an individual's success within university but also those broader aspects of a person's journey," she explains. "Life challenges and so on form a part of that selection process. So then those scholars are supported financially through their studies and that's also complemented with other things like mentoring, events, networking, and other meaningful opportunities for them to develop professionally and propel their career as well."

The Chief Defence Scientist, Professor Tanya Monro, is a Fellow of ATSE and the relationship between the two bodies has blossomed. DSTG is currently halfway through a pilot one-year program with ATSE where DSTG is sponsoring some Elevate program undergraduate scholarships.

The pilot program is already proving so successful that it will be extended a further four years, she says. "Basically, we're extending that partnership to really allow that significant impact, breaking down some of those barriers for women and non-binary people in STEM education.

"Those scholars are also going to be welcomed into DSTG events and programs and given different opportunities to upskill and maximise their achievements," she says.

They will also be part of Science Alive, the nation's largest schools science festival which was held in August in Adelaide. Up to 40,000 people attended, the majority primary school students, an acknowledgement, says Dr Parsons, that the STEM pipeline begins with attracting primary age students to STEM subjects.

But Science Alive is not Defence's only form of outreach, she points out. Defence is also a supporter of the


Dr Kathryn Parsons

Engineering is Elementary program managed by Questacon. This upskills STEM teachers at both primary and secondary levels and helps them to better engage and create inspiration in the classroom.

DSTG has also partnered with CSIRO in a program called STEM Professionals in Schools. "Essentially, the program brings real-world STEM applications into the classroom, allows for students to be exposed to real STEM professionals and understand what it might be like to work in a STEM field within Defence."

Defence's own figures state it employs around 83,000 people full time, has a turnover that can be as high as 10% in some jobs and as low as 1 or 2% in others, and a permanent and growing need for STEM professionals. "It's clear that they are going to play a really critical role in solving some of our nation's greatest challenges," says Dr Parsons. In 2025, DSTG and Defence will be looking predominantly for graduates in computing technology, aerospace and mechanical engineering and physics.

"The part that I find most fascinating myself is that broader, non-technical aspect of STEM that I think sometimes gets overlooked," she says. Australia, and especially Defence, will need people with both technical and 'soft' skills, because those are the skills that provide an asymmetric combat advantage quickly, and also because they are the skills that can deliver the sort of longer-term cultural change that DSTG is embracing.