AUSTRALIAN SPACE OUTLOOK

2022 EDITION

SPECIAL FEATURE

NASA & ELA

Australia's first commercial launch

OPENING INTERVIEW

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Astrophysics and Space Sciences

USQ's Mount Kent Observatory is at the forefront of new planet discoveries and is the only facility in the Southern Hemisphere dedicated to providing ground-based observations to support NASA's Transiting Exoplanet Survey Satellite (TESS) mission.

Aerospace Materials Technologies

USQ is working with Boeing and Defence Science and Technology Group to develop a radical approach to composite repairs that uses advanced manufacturing technologies to reduce cost and speed up repairs to aerospace structures and machinery.

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UniSQ's Mount Kent Astronomical Observatory features state-of-the art telescopes including the MINERVA-Australis array and spectrograph providing ground-based support to NASA's Transiting Exoplanet Survey Satellite (TESS).

University research expertise is leading Australia's space and defence industry growth

The Australian space manufacturing sector has grown significantly in recent years, fostered by government policy to develop the Australian space industry, and emerging opportunities for research institutions and industry to work together. A critical step towards establishing a sovereign space capability is the Australian launch manufacturing sector, comprising the development of civil rocket technology capability, test capability and launch facilities.

The University of Southern Queensland (UniSQ) was recently named one of Australia's trailblazer universities working in partnership with the Australian National University (ANU) and the University of South Australia to lead the Innovative Launch, Automation, Novel Materials, Communications and Hypersonics (iLAuNCH) program.

iLAuNCH aims to deliver the industrial and R&D ecosystem that is essential to ensuring that emerging technology manufacturers can capitalise on commercial opportunities without competing with, or being dependent on, international space economies or launch facilities.

Industry partnerships are building the critical pathway to sovereign capability by providing opportunities to improve Australia's skills in the space sector, creating new jobs and boosting the success of this market. iLAuNCH will support the commercialisation of research and the development of a complementary supply chain for the rocket launch manufacturing sector as the logical next step for a thriving sovereign space industry.

UniSQ is the only Australian university with true end-to-end rocket manufacturing capability—from design to fuel development and structural manufacture, all the way through to testing and launch capabilities. As a leading regional research institution, UniSQ is actively delivering expertise to support local defence industries and the associated emerging manufacturing sectors. UniSQ's Institute for Advanced Engineering and Space Sciences leads this work through the delivery of space and defence related research, with strengths in developing hypersonic propulsion systems, advanced materials and astrophysics.

The Institute is home to world-class infrastructure and equipment, including the longest duration hypersonic wind tunnel in Australia. This enables researchers to design and test hypersonic vehicles under dynamic conditions, with a focus on aerodynamics, free-flight, proximal body separation, heat transfer control, and fluid-structure interaction experiments that cannot be performed anywhere else.

UniSQ's Mount Kent Astronomical Observatory is Queensland's only professional research and teaching observatory for astronomical space sciences. The observatory is the only facility in the Southern Hemisphere providing a key support role for NASA's Transiting Exoplanet Survey Satellite mission, using transit photometry to detect Earth-like exoplanets near our solar system.

In addition to providing the research expertise required to expand sovereign capability, UniSQ is well placed to address the skills shortage through the co-design of a series of micro-credentialling courses with industry partners, undergraduate and postgraduate course offerings and training programs tailored to the space manufacturing sector, with downstream benefits to the aerospace industry.

Together with our partners, iLAuNCH will improve Australia's skills in the space and defence sectors, and provide new and exciting career paths for upcoming space scientists to ensure that the growth of Australia's sovereign space capability expands into the future.

IMAGE: Supplied

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Enrico Palermo

HEAD OF THE AUSTRALIAN SPACE AGENCY

A ‘spaceman’ since an early age, Enrico Palermo made his own giant leap in 2005 when he and his wife quit jobs in Western Australia’s resources sector (he worked as a mechanical engineer for Woodside Energy) and moved to London to get closer to the space sector. By the end of 2006, he was one of the first 10 employees at what was then a space startup—Virgin Galactic. Two years after that Palermo was in Mojave, California, establishing Virgin Galactic’s subsidiary, The Spaceship Company, and he did it all from the ground up as employee number one: the team, facilities, IT infrastructure, and supply chain and business processes needed to build and assemble spacecraft.

Palermo rose eventually to become Chief Operating Officer of Virgin Galactic and President of The Spaceship Company. He was recruited by the Australian Government in 2021 to become Head of the four year-old Australian Space Agency. He has built on the foundations laid by his predecessor, Dr Megan Clark, AC. He spoke to **Gregor Ferguson.**

IMAGE: Supplied


Arnhem Space Centre

The Australian Space Agency has been going now for four years. It was founded on 1 July 2018. How would you characterise this period in the Agency's history?

Obviously it was a big moment for the nation to get a space agency. We were one of the last OECD countries to have a space agency.

The world has changed dramatically, and it was important to form a national space agency to bring together a lot of disparate efforts across government, to drive increased societal benefits from space activities and also give the world an international front door to Australia.

What used to be the preserve of the world's major superpowers is now in the hands of commercial entities and everyday citizens. Australia has an incredible opportunity to be part of this commercial shift. We've got all the conditions to do some important and inspirational things in space and so how do we bring those opportunities together and capitalise?

That's why I came back to Australia to do this role.

Our Civil Space Strategy is a good starting point. The first four years focused on setting the conditions for growth, establishing the Agency, and getting a beachhead of programs and activities. But now it's 'How do we implement the strategy?' There's been a proliferation of new enterprises across a diverse set of areas. And we've not just seen more companies, we've seen the diversity of the sector blossom.

I'd characterise the period by a sector that is energetic, ambitious and in its early stages of developing, that is starting to mature rapidly. It's time to see some of these new space enterprises scale, grow revenues and pull the sector forward.

What are the most important things the Agency can do, in your view?

The most important thing for us to achieve is to demonstrate how critical space technology is to supporting our lives on Earth.

Not everyone understands space and the extraordinary benefits it provides our world, but space has so much crossover with other industries such as manufacturing, health, mining, resources, transport and defence.

There's probably not one industry that space doesn't impact in a positive way, and that's why investing in space will secure Australia's future by creating more jobs, unite and strengthen industry, and help uphold our way of life.

Now if we look to the issues we are facing on our planet right now, such as climate change and natural disasters like bushfires and floods, space technology is critical. It provides us with a unique perspective of Earth and gives us data and insights that we don't get on the ground to mitigate and better respond to these issues.

Through our mission to emphasise the criticality of space, we can ensure investments into the industry supports Australia's economic, social and environmental future.

The Agency also has an important role to set the vision for Australia's space industry. We are guided by seven space priority areas, where Australia has advantages and real opportunity to grow. Areas include Earth Observation, Communications, Robotics and Automation, and Leapfrog R&D: Applied Space Medicine and Life Sciences.

These priority areas are supported by the space roadmaps we are delivering. These roadmaps will help set the direction for industry, so we can build our capability and increase our contribution to the global space industry. This will help open more doors for Australia internationally and get more Australian products and technologies into global supply chains and into space.

And finally, being a responsible space nation is incredibly important. As the regulator for Australian space activities, it is fundamental we lead by example and ensure we fulfil our international obligations under the United Nations Committee on the Peaceful Uses of Outer Space.

What other milestones and achievements on the Agency's journey really stand out?

The Agency's four pillars, International, National Capability, Responsible and Inspire are a good way for me to characterise milestones and achievements so far. On International, our collaboration with the Japan Aerospace Exploration Agency or JAXA on their Hayabusa2 asteroid sample-return mission was a tremendous success. The Agency led a whole-of-government effort to support the samples return from an asteroid, Ryugu,

that are billions of years old and the science that's going to come out of this is just amazing. We showed the world we can work on complex missions, we can be a destination for sample return, and we're talking to JAXA about potentially their future MMX, Martian Moons eXploration mission, for example. That was a real watershed moment, showing the power of an agency to coordinate across government.

We've established many key agreements with overseas space agencies and it's clear the world wants to work with Australia. It's not just about our geography. We've been a trusted partner in space for a long time and we've also got some niche technologies.

In terms of National Capability, I'd add the deal we signed with NASA to take a rover to the moon. Australia will design, build and operate a semi-autonomous lunar rover that we'll send to the moon around 2026 in a program called Trailblazer. That's a big step for Australia as a nation. That deal also shows the leverage possible with international collaboration. We're making an investment of $50 million and we're getting the flight to the moon to demonstrate to the world our capability in remote operations. It's going to make us develop robotics for a harsh environment and teach us about operations in GPS-denied environments. Trailblazer is a big effort, our boldest adventure you can say.

On Responsible, we have fully activated the *Space (Launches and Return) Act* 2018 and have seen Australia returning to a launching nation with the recent NASA sounding rocket campaign at Equatorial Launch Australia's site in East Arnhem Land. As the regulator for Australian Space Activities, it's important we ensure Australia remains a responsible operator in space. And this is not just across

> **"... we have fully activated the *Space (Launches and Return) Act* 2018 and have seen Australia returning to a launching nation with the recent NASA sounding rocket campaign at Equatorial Launch Australia's site in East Arnhem Land.**

Arnhem Space Centre

IMAGES: Supplied by ELA & NASA

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launch, but across all space activities Australia undertakes in the future.

And then on Inspire we launched the Australian Space Discovery Centre here in Adelaide, which has been a phenomenal success so far, and will lead into larger national inspire activities.

What milestones can the Agency look forward to over the next 2 – 3 years and out to 2030? The past 12 – 18 months has included some exciting announcements—when will they become reality?

Obviously the Rover program. We are in the process of down-selecting the two consortia that will take the Rover to preliminary design review and then we will down-select again to the final consortium. We'll look to get that Rover on the moon by 2026, which isn't that far away, so it's quite an aggressive program.

Our National Space Program for Earth Observation. This is a critical step for a couple of reasons. One, it's starting to invest in space with a long-term view. Our early pilot programs are great, but they only run two to three years. What we're seeing is a seismic shift to build a sector with a long-term view and increased funding. That's going to allow us to compete for work in the long term and allow us to do more sophisticated things in space. And secondly, it's a procurement program, not a grant program. That's what will stimulate and really accelerate the growth of the sector.

> That 'Team Australia' perspective is something the sector has called for.

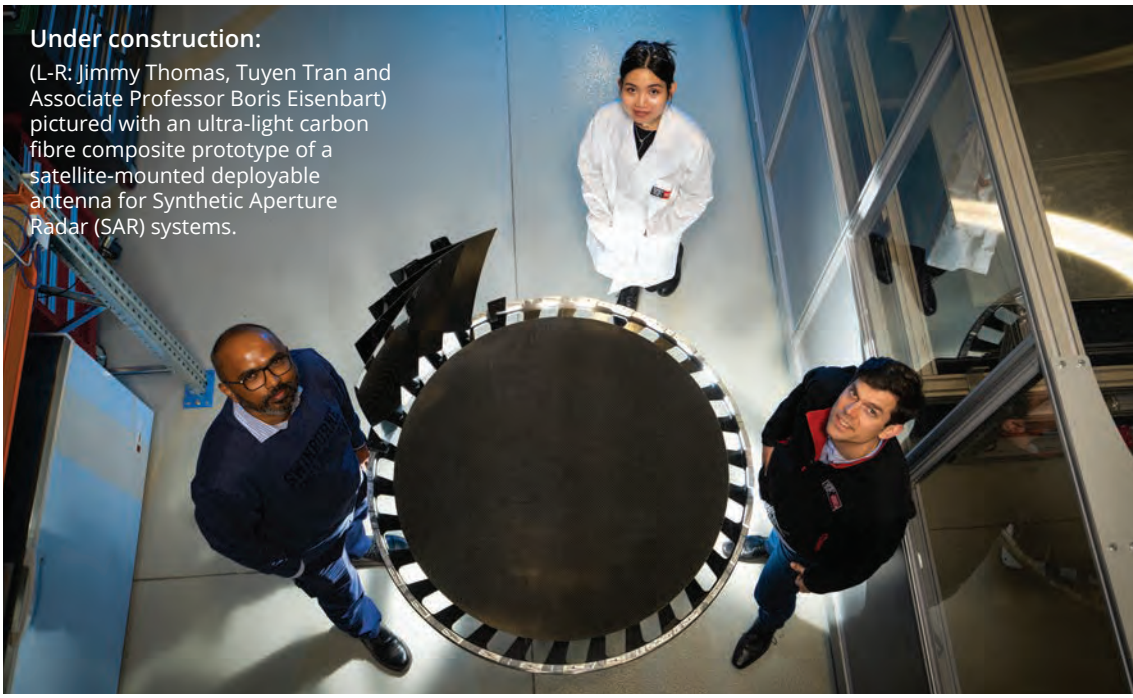
In the next few years, we'll complete our roadmaps. That will dovetail with working out how we have a more cohesive space sector here in Australia. There's a tremendous amount of energy and momentum in the sector. We've got federal government programs and state and territory governments that are co-investing now significantly. But how do we make sure the sum of all that activity is more than the individual parts? That 'Team Australia' perspective is something the sector has called for.

Australia has launched sub-orbital rockets this year for NASA from the Arnhem Space Centre, and we have seen launches from Whaler's Way and Koonibba as well, but there are more commercial launches planned. What can we look forward to, purely as a launch site?

Access to space, which includes launch, is one of our seven priority areas. You know, inspiration captures imagination; we saw that with the NASA sounding campaign in June and July [which saw three rockets launched from the Arnhem Space Centre in northern Australia].

Launch is the one thing that opens up the full value chain of activities around space. Once you've got launch, you've got flow-down to that supply chain, you

IMAGE: Supplied



Under construction:
(L-R: Jimmy Thomas, Tuyen Tran and Associate Professor Boris Eisenbart) pictured with an ultra-light carbon fibre composite prototype of a satellite-mounted deployable antenna for Synthetic Aperture Radar (SAR) systems.

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have access to missions that you might not have had access to. You just need to look at Rocket Lab operating from New Zealand and what that's done to its space sector, driving revenue into the supply chains and major companies, and also the international missions they now get involved with.

In terms of what we have to offer, clearly, we offer geographical advantages. We've got sites close to the Equator, so you need less energy for geosynchronous orbit; and then we can target pretty much any other inclination, depending on where you launch in Australia.

I'd say we also offer trusted partnerships. Space launch technology is sensitive. It has dual uses and so we can offer our partner nations, like the United States, those trusted alliances to protect sensitive technologies. And that's why we're negotiating the Technology Safeguards Agreement right now with the United States.

How important to Australia's space sector is its future workforce?

I visit industry a lot and engage through space industry associations, and the common refrain is that workforce is quickly becoming one of the top inhibitors to growth of these companies, and we shouldn't be surprised by that. As a nation we haven't built depth in spacecraft systems engineers, program managers and space scientists. All the companies that are starting to scale up need those resources.

We've got to look at where is the talent these companies need now. And where's the talent of the 2030s and '40s coming from?

What I would say is we've attracted some great talent to Australia. We've definitely allowed a brain regain. In the past a lot of people left Australia to work in the space industry and we'll keep them here if we have missions of national significance, like the Rover, like the National Space Program. I think we'll also see skilled migration come through that.

What is your vision for space beyond the civil space strategy which sets the direction for Australia's civil space sector to 2030?

This is really how we evolve the Civil Space Strategy to its next iteration and fill in that big, open canvas about implementation.

Defence published its Defence Space Strategy this year and if you put the two side by side, they're not divergent. There's a lot of commonality in priority areas, in workforce development, in the need for missions.

So how do we bring that together? We both need the same workforce, we both want to see an industry capability built in Australia, we both value international partnerships.

So really, the Agency has a vision to tie it all together and give options to government. It's up to government how this sector is funded, but there are a lot of options for government to have more national missions that are squarely about solving some of our greatest challenges and opportunities and looking to the future, whether it's NASA's Artemis Program or how space can support disaster resilience by helping mitigate bushfires and floods.

The Australian Space Agency built up significant momentum very quickly when it was established. How are you going to keep this up? Do you need to focus all the enthusiasm and effort more productively?

We absolutely need to focus and nurture this. We're not yet in a self-sustaining state. We need to responsibly bring down the barriers to entrepreneurialism. We need to help the sector move. As an agency, we're moving from a start-up to scale-up phase ourselves.

We're in an implementation phase. There's a need to make our efforts across the nation more cohesive, and that means that the precious dollars that are invested get a better return on investment and impact on society, and so that's what I'm committed to doing as Head of the Agency. ●

IMAGE: Triff from Shutterstock

Australia's future as a space middle power

Just a few years after establishing a space agency and a few months after establishing space command, Australia is in a great position to become a reliable, stabilising space middle power.

Australia's strong history of providing space-based technologies, including satellite communications, remote mining and farming technologies, ground-based sensing for space situational awareness and supporting international space exploration programs, creates the potential for Australia to extend its leadership globally and regionally.

Space is a strategic domain

Space geopolitics mirrors Earth's geopolitics: it always has. While space has always been an enabler of military operations and security, our global dependence on space-based technologies means space is now a strategic domain too.

National security has always been critical to research at the Australian National University (ANU). The ANU was established after World War II to address enormous societal, technological and international change. As Australia's national university, we strive to advance Australia through excellence in research and education.

Today, the ANU Institute for Space (InSpace) operates at another time of great national renewal. Our current director, Professor Anna Moore, sat on the Expert Reference Group that decided Australia needed a national space agency. Her work linked dozens of multidisciplinary ANU researchers to help advance Australia's growing national space effort. Their research was so compelling that we created Australia's first multidisciplinary space institute, the ANU's InSpace.

Good governance through diversity of opinion

The depth and breadth of space research at the ANU includes space communication, exploration, building sovereign capability and translating space innovation back to Earth to benefit all Australians. At InSpace, we combine those disciplines with space law, economics, medicine, policy and strategic studies to create holistic outcomes for our country.

InSpace aims to foster space innovation with an eye on good space governance to address the challenges of space as a strategic, commercial and civil domain. We aim to strengthen our national response to climate change,

regional stability, economic stability and the challenge to diversify our future workforce to strengthen Australia's future. We also hope to bolster sovereign capability and create more robust space tools for a stronger nation.

InSpace supports the important work of the Australian Space Agency as it integrates native technology into the global space industry. Our researchers are helping to shape the national space effort through Australian Space Agency technical advisory groups and international space leadership groups like the World Economic Forum, the United Nations and NASA science teams.

Australian Centre for Space Governance

To integrate even stronger governance protocols and help Australia achieve an ethical, responsible and safe space future, InSpace hosts the Australian Centre for Space Governance (ACSG). The Centre has participation from Australia's leading experts in space law, policy, security, strategy and governance from across the ANU and six other universities. Its mission is to advocate for Australia's interests in space and set the agenda for responsible space governance.

The international responsibility to do the right thing in space is increasingly important. There is a global imperative to face the challenges of space debris and space traffic management. Australia has an opportunity to model practices of long-term sustainability as we develop our regulations and cultivate a culture of sustainability in our growing space sector.

Similarly, the need to defend our and our allies' and partners' space systems from counterspace threats with our own counterspace capabilities is critical. To prevent a space arms race, we need to help to shape norms of responsible behaviour in space and integrate those norms into our strategies, policies and strategic commitments.

Australia is an active voice in the UN Open-ended working group on reducing space threats through norms, rules and principles. We have an opportunity to be more impactful and build on our reputation as norms entrepreneurs. We can work with other key space middle powers, such as Germany, Japan, the Republic of Korea, New Zealand, and the UK, to build international consensus on responsible behaviours. We can thereby influence the bigger players—the task of middle powers. The ACSG can help guide national thinking on how to do this effectively and in our shared interests.

Earlier this year, the Artemis mission began the first human spaceflight program to return to the Moon since 1972. While it was not a crewed launch, it was a test flight for Artemis II in 2024, which will put the first woman and first person of colour on the Moon. But just like the Cold War space race was driven by geopolitics, so is this return to the Moon.

India, China, Russia and the UAE have competing lunar programs. Commercial entities are driving necessary technologies. These programs are all focused on lunar resources: water and gases, which could support long-term human habitation on and near the Moon in space stations. Eventually, what we learn will take us to Mars.

In the next five years, we will likely see enormous tensions from this new race to the Moon. It will be both a mirror and a root cause of political and economic tension on Earth. The lunar economy and lunar politics will affect the Australian space sector and our economy. It will implicate Australian scientists in developing technologies for Artemis missions. We must ensure we are at the decision-making table as these missions mature.

Australia as a strong space middle power

As these tensions rise, the ACSG and its experts will be an increasingly important resource for Australia as a space middle power. The ACSG aims to support the building of a strong, well-thought out and fully informed foundation for Australia's national plan. The experts of the ACSG are well-placed to help Australia become a savvy player in the geopolitics of space and space diplomacy.

As Australia emerges as a space middle power, InSpace and the ACSG at the ANU are your trusted partners for a more secure future in space for all Australians and our region.

IMAGES: Supplied

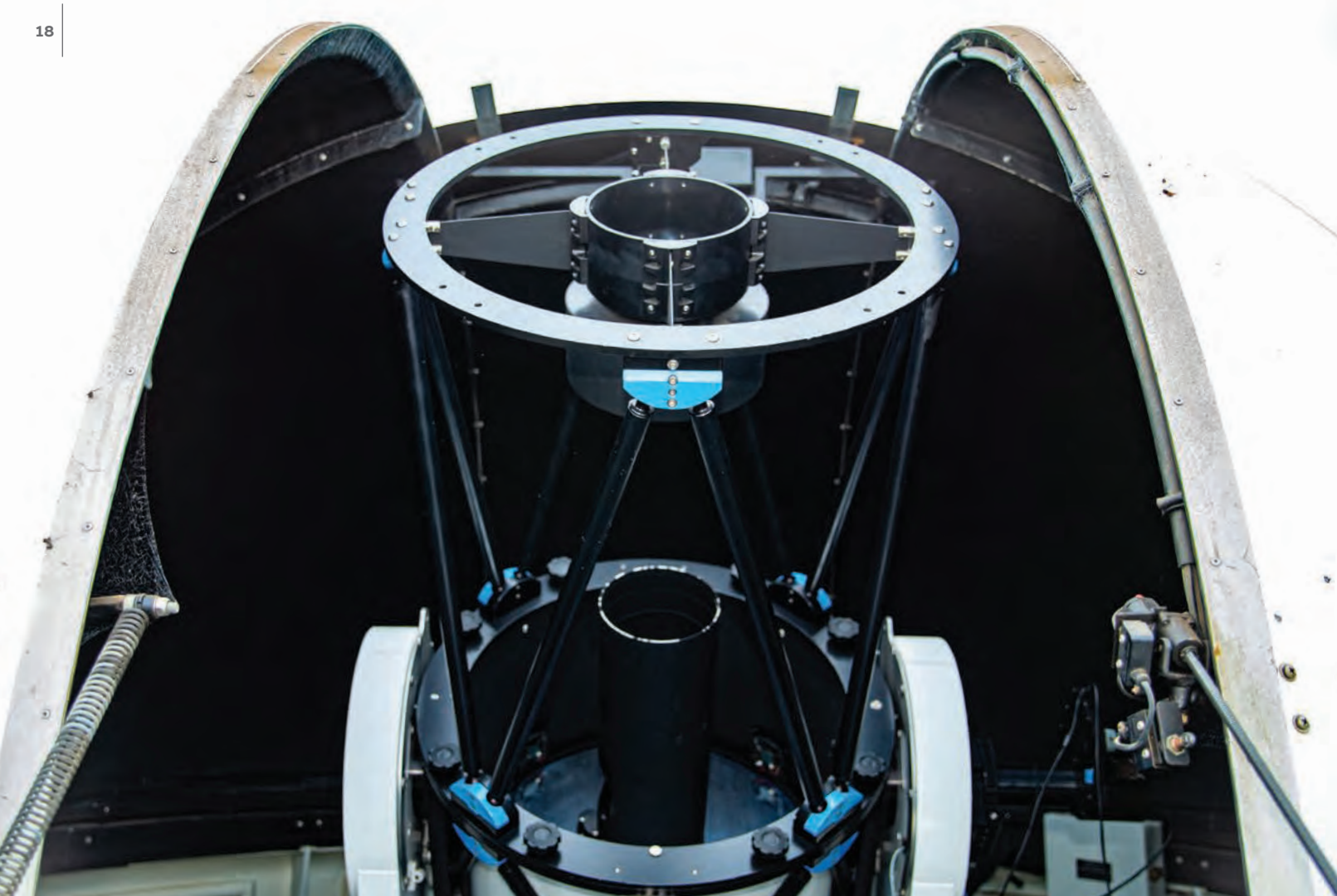
International Space Centre at University of Western Australia

Can you name the only Australian public R&D program to be a NASA-accredited outreach partner of the James Webb Space Telescope program? It is the International Space Centre at the University of Western Australia. In July this year the Centre was one of the first in the world to share and celebrate the astonishing images produced by the JWST, says **Gregor Ferguson.**

Simon Driver, a Professor at the University of Western Australia (UWA) node of the International Centre of Radio Astronomy Research (ICRAR), led the presentation of the JWST imagery along with ICRAR astronomers Dr Elisabete Da Cunha and Dr Sabine Bellstedt. Their presentation was an enormous achievement considering the International Space Centre (ISC) had been established just one year before, in 2021.

The establishment of the ISC, with an initial cadre of 100 UWA staff and students under Associate Professor (A/Prof) Danail Obreschkow, was a recognition by the university that space is a strategic priority for Australia.

"At the University of Western Australia we realised that in the last 5 to 10 years the research activity around space has been booming," he tells *Australian Space OUTLOOK*, adding that space is about more than just astronomy, rockets and satellites, "It's also the legal



questions around space, the psychology of astronauts and medical questions, biology in space.

"Essentially the whole range of activity that happens at a major university is somehow reflected in the space sector as well."

The ISC acts as an umbrella organisation bringing together all the university's different research groups and gives them a common brand, a common strategy, and a common voice to talk to the outside world.

"Essentially the objectives of the Centre focus around strengthening our space research, building up a strong education in the space domain and engaging with the public, with government and with industry."

ISC staff focus on research and education across an array of disciplines, from Laser Communications and Space Situation Awareness (SSA) to Plants in Space, Extraterrestrial Civil and Resource Engineering, as well as Microgravity experimentation.

The ISC is designed to lead UWA in Western Australia's growing space sector and to build new bridges for ongoing investments, such as the new Square Kilometre Array telescope at Murchison Springs. The ISC will do this by leading both basic research, focused on building new knowledge, and applied research to solve specific industry problems.

The ISC is focused primarily on civilian space activities, A/Prof Obreschkow says, but relationships with bodies such as DSTG and Defence Space Command exist at a technical level because, "Of course the technology and the science that gets you to space and allows you to operate in space is exactly the same in the civilian world as in the defence world."

The Centre works to WA's strengths. The State is home to some of the world's leading mining and offshore oil and gas companies. This sector has become world-renowned for its mastery and application of robotics, automation and remote operations technology.

"And that's why WA is extremely keen on building that bridge between the mining sector and the oil industry, offshore drilling and so on, and space technology," says A/Prof Obreschkow. The challenges are very similar—remote operations, extreme conditions, often without a conventional GPS, high pressures and sometimes extreme temperatures. "Very similar sets of conditions that you find in space, and the ability to operate in a robust and autonomous way in these conditions is something that WA has developed over the last century."

IMAGEs Supplied

Indeed, the AROSE not-for-profit consortium taps into this expertise. AROSE stands for Australian Remote Operations in Space and on Earth. UWA and a team of aerospace and resources industry professionals, including Nova Aerospace and petroleum company Woodside, were founding members of the consortium which launched WA's first satellite, the Curtin University BINAR-1 CubeSat, in August 2021.

Why do you go there in the first place? Space Materials and Resources: this is the realm of off-Earth mining and mineral processing, a technology where, here on Earth, WA is a world-leader. Closely related to this is Space Civil Engineering: how exactly do you build accommodation for human beings as well as extraction and processing plants for the minerals that justify your investment and presence? Think about this. You need mortarless joints to build habitable and airtight structures; you also need mining technologies optimised for local materials and harsh conditions. And these might be encountered on big asteroids as well as on planets.

You need to be able to generate and store energy, distribute it and manage its use. The space energy node of the ISC is part of a national consortium that was awarded a $2.4 million grant to develop ultra-long-lasting batteries for space and defence applications.

And whether you are in orbit but minimally manned or overseeing off-Earth exploration or mining operations from a control room back on Earth, you need to be able to get there (or get your equipment there) and then control that equipment and use it safely. This is where WA's strengths in autonomous systems and robotics come in. The State's mining sector has developed world-leading skills in artificial intelligence and autonomous systems and aims to build in WA a testing ground for planetary rovers that is akin to the 'Martian Field' at NASA's Jet Propulsion laboratory in Pasadena, California.

The UWA is also a supporting partner in the Adelaide-based SmartSat Cooperative Research Centre which last year awarded ISC's Laser Communications and Timing team a $1 million grant to help pay for a three-year research project to advance optical communications between Earth and Space. Optical lasers can

ASA visit (from left to right) Pru Steinerts, Industry Engagement, ISC; Christopher Hewett, General Manager Strategy and Industry Growth at ASA; Professor Peter Quinn, Executive Director of Research Initiatives: Astronomy, Space and Data; Dr Elyse Allender, Seniro Project Manager, ASA; Mike Bayliss, Senior Policy Officer, ASA; Larissa Wiese, Centre Manager, ISC; Dr Shane Walsh, Laser Communications and Timing, ISC; Alisa Abbott, Senior Executive Assistant, ASA; Enrico Palermo, Head, ASA and Associate Professor Danail Obreschkow, ISC

transmit signal throughputs thousands of times greater than can be achieved at present by radio links, and they can be very narrowly focused as well, for both security (they are harder to detect and, therefore, to jam or intercept) and efficiency (you can place multiple signal streams very close to each other).

The trouble is atmospheric turbulence can badly affect optical signals so the ISC research team, led by A/Prof Sascha Schediwy, will investigate how to mitigate these effects using a combination of adaptive optics and coherent phase stabilisation. The aim is to develop and demonstrate successfully high-speed, free-space optical communications using laser links between a ground station and airborne vehicles.

Related to this is ISC's Satellite Remote Sensing team whose research will focus on two streams. Firstly, remote sensing data, including detailed studies of things like sea surface temperatures, bathymetry (to measure ocean depths), and maritime safety through satellite surveillance of ships and prediction of tropical cyclones in WA.

The second stream will focus on the hardware of remote sensing: electro-optic and infrared sensors, imagers and other electronic sensors as well as on the modelling of atmospheric effects on optical propagation. And they are bringing quantum sensing technologies into the mix through a partnership with UWA's Quantum Technologies and Dark Matter Research Laboratory.

Space Situational Awareness, or space domain awareness as it is known in defence circles, is a preoccupation of space users for a very good reason. The low Earth orbit (LEO) band, in particular, is becoming increasingly congested with constellations of satellites and an alarming amount of 'space junk'. The ISC team, led by Associate Professor David Coward, uses UWA's Zadko Telescope, built at Gingin just north of Perth in 2008, to track space debris, operational satellites and potentially hazardous bodies on behalf of the European Space Agency, the French Space Agency, CNES, and the Polish Space Agency. The ISC's Zadko Telescope team is also leading construction of the Australian section of a global array of LEO sat radio receivers.

The Radio Astronomy Node, led by ICRAR's Drs Richard Dodson and Maria Rioja, also use the Zadko Telescope. As part of their work, they are collaborating with the American National Radio Astronomy Observatory's Very Large Array in New Mexico on detection and tracking of both Earth-bound debris such as asteroids and deep-space missions.

The roadmap for space exploration inevitably includes manned settlements on the moon as well as in orbiting space stations. The cost and complexity of crewed space missions means that astronauts need to be carefully selected and trained—and supported by autonomous and robotic systems, because there simply will not be enough humans to do everything a space colony might need.

Expand that thought bubble into a task description, and it becomes clear that the challenges of manned space exploration are not just technical—they are also ethical, legal and philosophical. Human interaction and the creation of resilient teams is vital; mental and physical health need to be monitored and maintained; and the optimum balance between using automation to help humans, and keeping them busy, needs to be considered as well. How do you feed men and women in space for extended periods? And how do you monitor their health and minister to them when they fall ill?

> **People are always inspired by black holes and alien life and galaxies, and so on, we can use this inspiration to drive clever or inspired young minds to go to university, become engineers, become scientists.**

The ISC examines all of these issues, says A/Prof Obreschkow. For example, it has research teams working on living and working in space, space medicine and plants in space. "Bringing plants along from the Earth to Mars is not feasible. You have to be able to grow your plants in the spaceship and on whichever body you land, and you can imagine that this involves a lot of research. How do you deal with plants exposed to radiation? How do you grow plants vertically? How do you deal with varying gravity? How can you not use too much water?"

And how do you deal with corrosion caused by the water you do use? "Exactly! Now if you solve these questions for space, then you can say, okay, now let's do vertical growing in the city, or put tomatoes on a rooftop—that's got to be easy if you can grow tomatoes on Mars."

The ISC is also examining space propulsion: not the design of rockets, but the design of propellants and their storage systems. Did you know that the heat generated by air flow friction during launch can boil away an important proportion of stored liquid fuel? How do you develop high-pressure tanks to contain the vapour? ISC is researching these problems. And how do you design for and then use materials that you can pick up at your planetary landing site? In-situ resource utilisation is the answer—exploration and mining once again.

One of the most important investments UWA is making through the ISC, however, is in STEM education. STEM, or Science, Technology, Engineering and Maths, is a major preoccupation of every high-technology sector in the Australian economy. Not enough students are tackling STEM subjects at school and then university, so the potential postgraduate workforce is growing only slowly, at best.

But what recruiters have found is that young people are enthused by the magic of space flight and rocketry. However, they often lack a vision of how to become involved; this, and the perception that 'STEM is hard', steers many away from the sciences and engineering. UWA Aerospace, a node of the ISC, aims to tackle this. It is essentially a student-led technical team that, as well as developing high-altitude research rockets, promotes space science and STEM in the wider Australian community.

The ISC's Space Boot Camp teaches teamwork and creative problem-solving skills by putting school and university students into small teams with the Aerospace node to design, test and build what amounts to 'bottle rockets' which are launched across the James Oval at UWA at the end of the workshop.

"People are always inspired by black holes and alien life and galaxies, and so on," says A/Prof Obreschkow. "We can use this inspiration to drive clever or inspired young minds to go to university, become engineers, become scientists. Whether then they work in the space sector or not, is not even so relevant.

"I think Bill Gates was 14 years old when Neil Armstrong did the first steps on the moon and Steve Jobs was 13, and they had learned that they lived in a country where if you pull the right forces together, you can land on the moon. That inspiration value is very hard to measure but it's got to be huge; much, much larger than all the spin-offs that you can list, and they also are huge." ●

Plants in Space lab with Dion Wright (Space Command), Leanne Cunnold (AROSE) and Professor Harvey Millar (ISC)

IMAGEs Supplied

Saab brings sovereign capability to space

Maintaining real-time observational intelligence, protection, and communication between Earth and space-based assets is a critical function of defence and security activity that keeps people and society safe.

For over 30 years, Saab Australia (Saab) has established itself as one of Australia's most respected defence and security system integrators, specialising in command and control (C2) solutions. Using this C2 specialisation, Saab has adopted an open architecture paradigm aligned with Space 2.0 in actively developing and integrating products that combine inputs from all domains operating in this multi-faceted environment. Its work on a sovereign C2 mission system stands to deliver invaluable intellectual property that will further enhance Australia's security and future.

In recent years, Saab has grown to over 700 employees, headquartered in Mawson Lakes, South Australia, with offices in most states and territories of Australia. The organisation projects further growth as it continues excelling in developing and enhancing long-term sovereign capabilities for defence and civil sectors, across underwater, maritime, land, air, and now the space environment.

Advancing Australian expertise and industry

Sovereign capability is a key concern for Australia in order to ensure our national security, economic and future growth for the benefit and safety of the community. The national space strategy, defined by the Commonwealth Government for realisation by 2030, defines key objectives in ensuring Australia's successful participation in the space domain. Saab's experience in Defence and the development of complex system solutions has laid down the foundation for the space aligned C2 system, which is predicated on developed and 'in operation' capability.

This emphasis on advancing Australian expertise is reflected in Saab's commitment to increasing industry capability, which is supported by Saab's long-established practice of engaging and establishing sustainable

relationships with Australian companies. As well as national defence and security, the intelligence harnessed from assets in space can be used for sectors including climatic analysis and monitoring, disaster management and recovery, resource management, health and financial services, and entertainment.

Saab has a strong history of defence interoperability and proven success in its networked C2 functions. This success positioned Saab well in its transition of established C2 solutions to address the challenges that arise through the accelerating growth of the space domain. Using its pedigree stemming from mission system augmentation, and adopting next generation technology and deployment platforms, Saab is executing an agile development program that has the opportunity to assist Defence in answering the current and future capability needs for the Australian Defence Force.

Translation of skills across domains is key to Saab's recently awarded contracts with various cooperative research centres, academia and Defence agencies. Pivotal developmental outcomes associated with mission planning, visualisation, and the intelligence gains from the 'Information Advantage' associated with the exploitation of low and medium Earth orbital planes underpins essential capability functions being provisioned for Saab's space program.

Open architecture enables agile development

Saab's strategic approach to using open architecture enables agile development with the integration of products from SMEs while simultaneously increasing the involvement of Australian suppliers in this exciting sector. This in turn results in more discoveries and developments that further enhance sovereign capabilities. The ability to collaborate with SMEs and integrate third party technology stands Saab in good stead to assist in positioning Australia as a nimble leader in the utilisation of low to middle Earth orbit space technologies. In fact, a key differentiator for Saab is its ability to pursue innovation through collaboration across diverse yet symbiotic teams and partnerships. It is smart partnering at its best.

Greater need to protect information and assets

As space becomes a greater source of information for defence and security, and more heavily populated with physical infrastructure, the calls for protection of assets become similarly weighted. A strong sovereign-controlled ecosystem that encompasses from under water through to space domains, is essential to meet the needs of our citizens. For space, frontline protection will come in the form of the space domain awareness effort, being surveillance that monitors capabilities in space as well as adverse and optimal actions and behaviours of others. This surveillance through ground-based and spaced-based assets, data aggregation through communications nodes, and launch facilities all need to be supported and developed to ensure operational assurance and security.

This requires highly skilled personnel at the helm of modern manufacturing along with specialised componentry to support "Australia's need for undeniable access to space".

Space presents untold opportunities for discovery. Saab is igniting the industry and opportunities around space, to translate solutions, build the skills of Australia's workforce, and contribute to healthier economies and ecosystems. In every way, Saab's continued support of the Commonwealth's strategy, and its commitment to further engaging in the space domain will result in greater Australian-designed and controlled mission system solutions. These solutions will yield vast benefits to the sovereign capability and economic opportunities of this country, and the current and future needs of the mission operators.

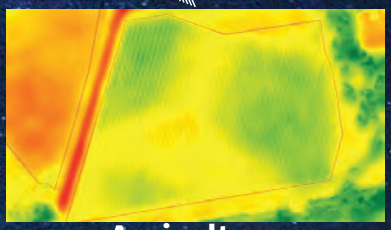
IMAGES: Supplied

Earth Observation

The Possibilities & Benefits Are ***Unlimited***

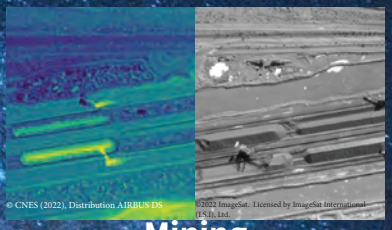
Disaster Management

Intelligence



Agriculture

Maritime Monitoring



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Earth Observation from Space Roadmap

If you want to know tomorrow's weather, or the likelihood of a devastating bushfire, or want to check on the movements of merchant ships, or how much water your paddock needs, you almost certainly use some aspect of Earth Observation, or EO, technology. EO is now a US$2.7 trillion market, and Australia is about to become a massive contributor to this vital field of technology as well as being a committed user, **says Gregor Ferguson.**

IHEADSHOT: Supplied •MAGE: Gorodenkoff from iStock

The Australian Space Agency published its 10-year Earth Observation from Space Roadmap late in 2021, just over a year after some of the most devastating bushfires in the country's history. As Agency Head, Enrico Palermo stated in the Roadmap, "Natural disaster response and climate science also look to EO to model and mitigate the impacts of catastrophic weather events like bushfires and drought, which have significant economic and social effects on the community.

"Of note, the economic benefits to Australia attributable to EO data were estimated to be up to $2.5 billion in 2020," he added. But the potential future benefits are even greater, especially as Australia becomes an active player. Globally, the value of EO is estimated to be some US$2.7 trillion, and rising.

"Earth observation data is no longer just a research activity," says Dr Alex Held, Director of CSIRO's Centre for Earth Observation. "It informs policy, helps manage natural environments, assists recovery from major catastrophes, and

Aude Vignelles, Chief Technology Officer, Australian Space Agency

generates agricultural and industrial development opportunities."

"I think the next revolution is going to be around Earth observation," predicts the Agency's Chief Technology Officer, Aude Vignelles. Australia has traditionally been a consumer and consummate user of EO data, but not a contributor, because it does not actually own any EO space assets—though this is about to change, she says.

The Agency's response to the opportunity represented by EO has been to publish the Roadmap and to embark on the National Space Program for Earth Observation. The program will see the design and construction of Australian-owned and operated satellites, boosting Australia's sovereign capability and enabling EO to be conducted for Australia in ways that are also relevant for other international users. The National Space Program is being led by the Australian Space Agency in partnership with Geoscience Australia, CSIRO, the Bureau of Meteorology and Defence.

"We are too reliant on overseas capability," says Vignelles. "I think COVID has also taught us a few things about supply chains. For us to have a sovereign capability is going to make us a better contributor to the international scene and, as you know, space is all about international cooperation."

EO is the Agency's third (of seven) technical roadmaps covering:

1. Earth Observation
2. Robotics and Automation (released last year)
3. Communications technologies and services (released in 2020)
4. Leapfrog R&D
5. Space Situational Awareness and debris monitoring
6. Position, Navigation and Timing
7. Access to Space.

Each of these roadmaps represents an area where Australia either has a competitive advantage in technology terms or where its unique location gives it an important role, says Vignelles. What they each have in common is that they are all enabled by six 'cross-cutting' technologies—advanced manufacturing, artificial intelligence, cyber security, interoperability, digitised and data-driven systems engineering, and platform-based architectures.

Downstream, EO is expected to deliver some very significant national benefits. These range from national socio-economic game changers such as maximising land use, to increased security and resilience from the monitoring of ships at sea, measuring marine pollution, and watching and warning about bushfire risks and bushfires themselves.

To achieve all this, the Roadmap identifies five focus segments where Australia's space sector can deliver resilient capabilities and services to both civil and defence end-users:

1. Australian EO missions and payloads
2. Data quality assurance and integrity monitoring
3. Enhanced data management
4. International EO partnership and leadership
5. Access to international data and missions.

Each of these focus segments is discussed in the Roadmap under three main headings: Opportunity, Objective and Outcome. And the Roadmap also crucially identified the manufacturing opportunities as well, everything from building satellites and their subsystems to manufacturing ground segment equipment and testing and calibrating sensors and infrastructure.

All of these segments and technical domains are essential for every part of Australia's space capability, so the emerging opportunities for the future workforce are immense and broad. If you have expertise in any of these areas, you can almost certainly make a contribution to Australian industry's space capability.

Defence will be a major supporter in the National Space Program for Earth Observation because it is a key Australian player in the space sector. "We're working very closely with Defence and I see the relationship like a push/pull," says Vignelles. "The Agency is pushing the sovereign capability of Australia and Defence is pulling it."

At the point Defence issues requests for tender for major space-based capabilities, she says, one of the Agency's priorities is to ensure that there will be Australian primes and an Australian supply chain able to respond.

One such emergent company is Sydney-based startup Spiral Blue, whose CEO, Taofiq Huq, told *Australian Space OUTLOOK* that one of the challenges for both EO providers and consumers is that EO can be very bandwidth-intensive. Downloading massive amounts of raw, unprocessed data can place a huge burden on a communications system. Which is why the company is manufacturing Edge computers to go aboard satellites and process imagery data in-situ.

In Project Rainbow Python, Spiral Blue will launch two missions in 2022 in partnership with fellow Sydney firms Esper Satellite Imagery and Dandelions, which builds space-based Internet of Things networks.

In this project, funded to the tune of $578,000 by the Australian government's Advanced Manufacturing Growth Centre (AMGC), Esper's

hyperspectral imagers OTR-1 and OTR-2 will be launched in two separate missions to capture EO imagery. Spiral Blue's Space Edge 1 Hyperspectral computer will be part of OTR-1 and -2 and process images onboard the satellites. This processed data will then be downlinked to Earth faster and at a much lower cost than traditional data links. Over the next five years the company forecasts revenues of some $36 million from Project Rainbow Python.

Multi-band hyperspectral sensors generate vital data for a range of users and can see through multiple layers of foliage, including camouflage, which makes the capability very relevant for defence users. Furthermore, Edge computing makes it possible to download processed data direct to users, whether it be a pollution control ship at sea, an agri-business or a soldier on the front line.

Spiral Blue was only formed in 2018 and last year received a Moon to Mars Supply Chain Improvement Grant from the Australian Space Agency. This grant program is designed to help build industry capacity to deliver products and services that could support Moon to Mars missions and is part-funding the development of Spiral Blue's Space Edge Services computing platform.

The company put its first Edge computer into orbit in 2021 and now has three systems in space. The Rainbow Python missions will launch later in 2022, and the company will put one more Edge computing payload into orbit this year with established American EO company, Satellogic. It is too early to say whether or not Spiral Blue's Edge computers will equip the National Space Program satellites, but that is one future opportunity on the company's radar.

The unique selling points of Spiral Blue's Edge processor, says Huq, are its affordability and the fact that its Linux-based operating system and NVIDIA Jetson hardware enables customers to write their own software which Spiral Blue can then host in orbit. This makes satellite services in general more accessible to new markets. For example, he tells *Australian Space OUTLOOK*, small farms may be too small for any meaningful detail to emerge on an EO satellite with a 20-30m resolution but using the right type of image processing and compression means that resolutions of as little as 15cm are achievable on an image whose original size was 50km^2. For small farmers, that enables very detailed land use strategies.

"Sovereign manufacturing of space hardware is key to Australia achieving the ambitious goals set by our Space Agency," says Huq. The AMGC grant, "accelerates our roadmap for bringing Rainbow Python and associated technologies to maturity, helping ensure we are able to do our part for the Australian space industry and other Australian sectors which benefit from accessible hyperspectral data on space services, such as agriculture, mining, financial services, utilities and environmental monitoring." "

MAGE: vchal from iStock

The new Western Australian Optical Ground Station (WAOGS) at the University of Western Australia Campus

Research sector providing the thrust behind Australia's success in space

Australia's leading space research centre is accelerating the nation's space technology R&D through its unparalleled industry and research networks, delivering game-changing technologies to address key national and international challenges.

Since its inception, three years ago, the SmartSat Cooperative Research Centre (CRC) has made significant contributions to the sector, delivering technological innovation critical to building a strong sovereign capability by encouraging collaborative partnerships between research, industry, and government to create a hive-mind featuring some of the brightest minds in space.

Supporting the Australian Space Agency's national priorities

SmartSat takes seriously its role in growing and supporting the Australian space industry, evidenced by a broad portfolio of research projects across advanced telecommunications and the Internet of Things (IoT) connectivity, intelligent satellite systems and Earth observation (EO) next generation data services. Many of these projects directly align to the objectives of the Australian Space Agency (ASA), providing a strong, evidence-based foundation on which the agency can build.

Having assisted with the development of the ASA's Communications Technology and Services Roadmap, SmartSat is well-placed to ensure its projects are aligned with the government's priorities for space—low

Earth orbit satellite services; optical ground stations; hybrid RF-optical communications; reconfigurable networks, radios, modems and waveform; satellite communication network management tools; and quantum-enabled communications.

Most notably, a research project into coherent free-space optical communications being conducted in partnership with the University of Western Australia and Defence Science and Technology Group (DSTG) links to the goals set in the Communications Technology and Services Roadmap. The project demonstrates a system that will enable optical fibre-like data transfer rates for atmospheric free-space communication links, over distances of 10km+ through ground-to-ground and space-to-ground links. DSTG is also partnered in a project on modem development for optical and hybrid RF-optical communications with the University of South Australia and engineering consultancy Solinnov. DSTG is also collaborating with SmartSat partners on an on-board processing project to improve advanced tactical communications.

With links across the country through its New South Wales Node, Victorian Node and Queensland Earth Observation Hub, and through partnerships with some of the nation's leading universities, SmartSat is funding research that addresses key sector priorities encompassing agriculture and natural resource monitoring, defence and national security, climate change and natural disaster management, and connectivity and advanced communications. The establishment of the EO Hub, in particular, in collaboration with the University of Queensland and Queensland Government, is bolstering Australia's EO capability by providing EO data, product development and commercialisation services to the broader space community.

SmartSat's commitment to delivering solutions to real-world challenges is evidenced through the ground-breaking South Australian Space Services Mission, through which the first state-based satellite has been developed to supply data to government organisations responsible for managing human and natural resources. SmartSat is leading the development of Kanyini, a hyperspectral and IoT satellite in collaboration with the South Australian Government, telecommunications specialists Myriota and aerospace company Inovor Technologies. Kanyini will be launched into low Earth orbit where it will be enabled to detect and analyse terrestrial objects such as vegetation, soil and ground water flows.

The links to SmartSat's research run deep. The data provided by Kanyini is projected to support the CSIRO's AquaWatch mission to build an extensive network of purpose-designed EO satellites and ground-based sensors to monitor water quality across Australia's coastal and inland waterways using real-time data and predictive analysis.

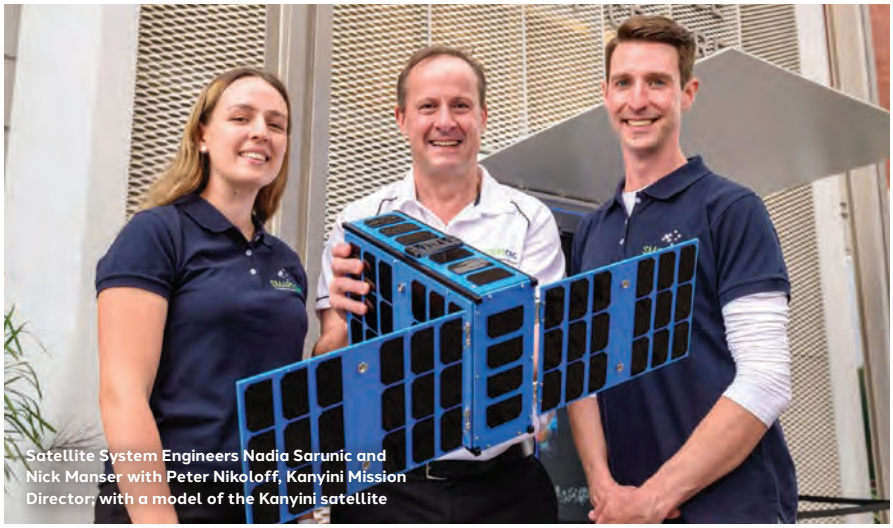
As the effects of climate change increase and bushfires continue to devastate communities across the country, SmartSat has launched the OzFuel mission, in partnership with the Australian National University, to improve bushfire preparedness, response and resilience. This project will use pioneering sovereign technology to gather real-time data to monitor potentially hazardous conditions specific to Australia's hot, dry and Eucalypt-dominant bushland.

Redefining and redesigning Australia's space workforce of the future

SmartSat is not only at the forefront of cutting-edge innovation and world-leading R&D, but is deeply committed to translating these elements into real-world applications and into a highly skilled workforce up to the task of advancing the national space industry. The organisation's unique position as independent from government or academia is the ideal conduit for effective collaboration with an industry that delivers projects at speed and at scale. This is essential for operating within a global space economy that is constantly changing, as is a skilled and adaptable workforce.

Together with the ASA, SmartSat has carried out extensive studies to identify the soft and technical skills across the workforce needed to propel the industry from strength to strength. These studies revealed over 300 specific skills and 86 high-intensity skill areas with identifiable training gaps, due in large part to soaring demand and/or insufficient capacity for knowledge sharing. SmartSat is combatting this through the Space Skills Database, which maps various skills to the courses and training providers equipped to provide them. SmartSat is also working with its extensive partner network to find innovative methods to reduce barriers for training providers, allowing them to develop courses and gain insight into training and education market demands.

SmartSat is creating a platform for government, academia, and industry to connect and collaborate with partners, as well as the broader space sector. Its research projects are developing intellectual property and specialist industry expertise that will not only produce new businesses, create export economic value, and generate new jobs but will provide a strong, evidence-based launchpad from which Australia's space industry can continue to propel.



Satellite System Engineers Nadia Sarunic and Nick Manser with Peter Nikoloff, Kanyini Mission Director; with a model of the Kanyini satellite

IMAGES: Supplied

Human spaceflight

To make the most of space you need to be able to live there: to explore, initially, and then to settle, especially if you are planning to establish significant exploration and mining infrastructure on the Moon or Mars or an asteroid. That means crewed spaceflight. The Australian Space Agency is already working towards sending the first Australian astronaut into space for some 20 years, but there are other crewed spaceflight options available to Australia from the private sector also, says **Gregor Ferguson.**

In February 2022, the Australian government announced a $65 million program to drive space industry investment and jobs, including a mission to put an Australian astronaut back into space. The last Australian to go into space was NASA astronaut Andy Thomas who made four flights aboard the space shuttle and International Space Station (ISS), the last in 2005. Before him came Paul Scully-Power who flew on the space shuttle in 1984 to become the first Australian in space.

But not many people know that the late Paul Chapman, from Melbourne, was the first Australian-born astronaut. He was selected as Mission Scientist for Apollo 14, but he left NASA before he could go into space.

Now Australia is looking to get back in the game. The rationale is simple: sending an Australian into space means backing him or her with serious investment in local technologies and jobs. And the opportunity exists thanks to NASA's Project Artemis which aims to achieve a long-term, sustainable lunar presence that serves as a stepping-stone for future crewed missions to Mars.

The Australian government's original announcement had two components. A framework for human spaceflight in Australia which could make Australia

IMAGES: Supplied

a regional hub for commercial human spaceflight, and the goal of putting an Australian astronaut in space. The Australian Space Agency was tasked to negotiate with international agencies to identify possible missions where an Australian astronaut could make a genuine contribution.

The Australian Space Agency has actually been working since 2018 with international partners on aspects of crewed spaceflight, says its Chief Technology Officer, Aude Vignelles. "It's very inspiring, everything you get from an astronaut space program has a lot of benefits," she says. The Agency's initial $19 million International Space Investment Expand Capability Grants seeded investment in 10 separate space projects including artificial intelligence, underwater virtual reality training for astronauts, space-sickness mitigation and the development of spacesuits.

The Agency's Joint Statement of Intent with NASA enables Australian participation in NASA's crewed Moon to Mars initiative, including injecting Australian expertise in space life sciences, human health and remote medicine. Why is the Agency investing in this? One of its forthcoming roadmaps—Leapfrog R&D—will address the issue of applied space medicine and life science, she tells *Australian Space OUTLOOK*.

"Anything we're going to develop to support life in space has a direct return improving health on Earth," she says. "And it turns out that Australia has a lot to offer on this."

The Agency is not blinded by the glamour of space exploration, Vignelles tells *Australian Space OUTLOOK*. It is looking at all aspects of a human spaceflight program and working with other space agencies that have a crewed spaceflight program. How do they work? What works and what does not work? How do you select astronauts? And crucially, how much does it cost?

The other question is why you would even bother. The answer is simple: there are significant mineral resources there to be utilised. The moon could provide the means for onward travel to other planets and to asteroids which are incredibly rich in minerals. Accessing even a fraction of those deposits could pay massive dividends.

Similarly, the benefits of manufacturing certain things in space are significant and could come within reach comparatively quickly—silicon chips manufactured in orbit could be 1,000 times purer with much greater performance. There are similar benefits achievable for fibre optics and for the manufacture of drugs.

Whatever the rest of the world does, the important question is: what makes sense for Australia? says Vignelles. She is very conscious that the Agency is spending taxpayers' money. "I can assure you that before investing in anything we're making sure that it has a value and it's going to deliver an outcome for every Australian."

In parallel, US company Axiom Space leads an industry partnership that is developing its own space station on a commercial basis which will start as an extension to the ISS before becoming an independent body that could replace the ageing ISS entirely.

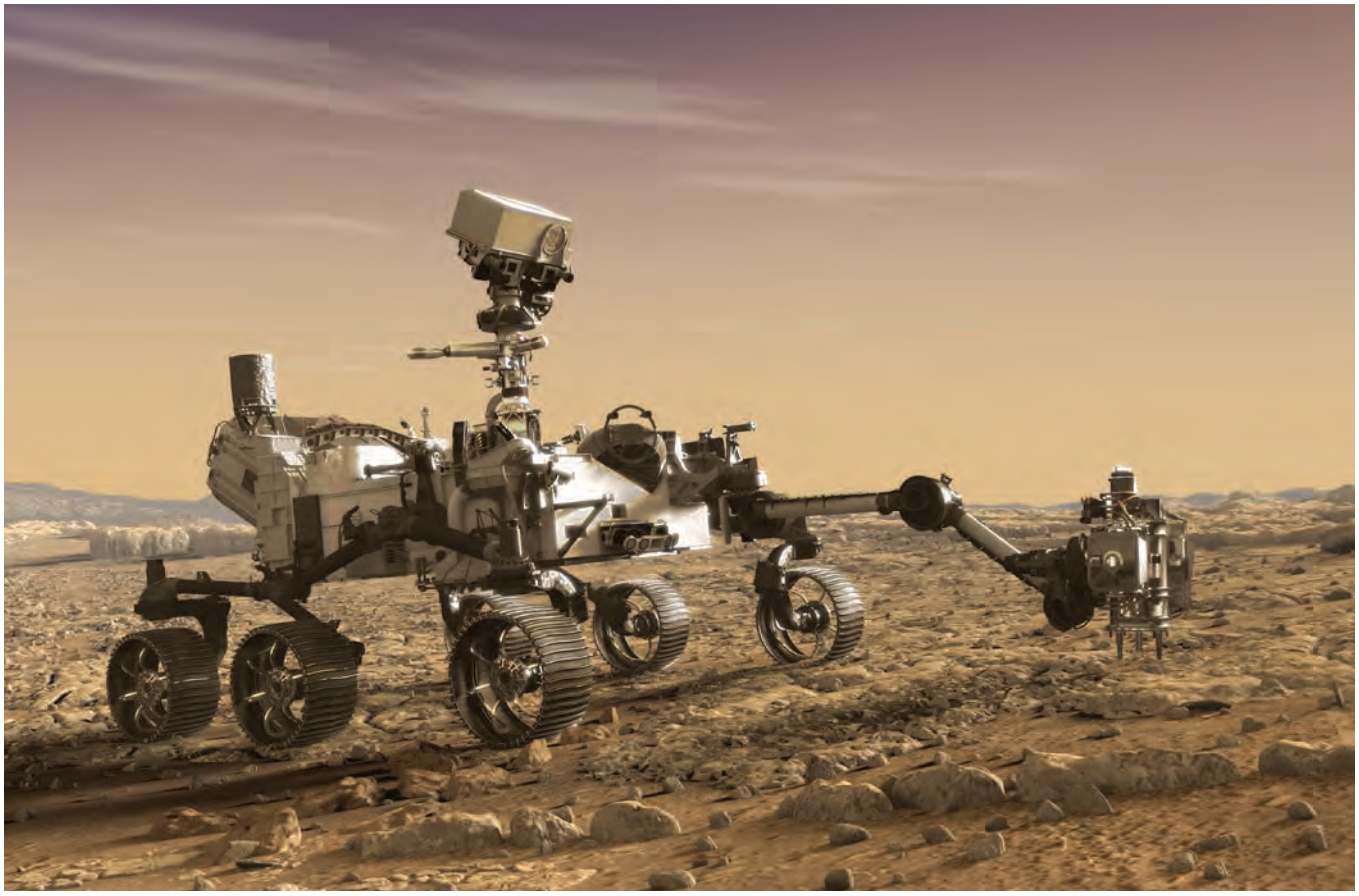
An essential part of any space-based manufacturing program is crewed spaceflight and Axiom Space aims to train and equip both public and private sector astronauts. Axiom Space has signed a contract with Australian company Saber Astronautics to make seats on future spaceflights available to Australians.

Saber Astronautics CEO, Dr Jason Held, says Axiom will likely begin by flying two astronauts per year, building up to as many as 100 a year by the end of the decade. One or two of those could be Australian, either private sector or sponsored by the Australian government. For most astronauts flights will last 30 to 60 days. Short enough that the potential health risks are manageable but long enough to complete a research project or to manufacture something. Preparation for each flight would take 6 to 12 months for a mission specialist with no astronaut training.

That is contingent on the development of a suitable spacesuit. Axiom Space, in September 2022, was awarded a US$228.5 million contract by NASA to develop the next generation Artemis spacesuit and supporting systems and demonstrate their use during the Artemis III mission to the lunar South Pole in 2024.

Future task orders under the contract will consist of recurring lunar landings, the development of spacesuits for use in low Earth orbit outside the ISS, and special studies.

So the prospect of an Australian going back into space is tantalisingly close. Australia can contribute expertise in things like remote medicine, artificial intelligence and training while reaping a significant benefit. Watch this space! ●



A new horizon for Australian space robotics

By Ali Buchberger, Director Industry Engagement, QUT

Humankind is going back to the Moon and on to Mars. Following a successful Artemis I launch, NASA plans to send the first humans back to orbit the Moon with Artemis II from 2024. In 2025, Artemis III will land astronauts—including the first woman—on the surface of the Moon for the first time in 50 years.

In September, NASA released its revised Moon to Mars objectives, which envisages international partners gradually building and maintaining a continuous presence on the lunar surface. We will build power generation and distribution infrastructure, communications systems, and advanced manufacturing and autonomous construction capabilities. New transportation systems will routinely operate between the Earth, Moon and Mars, and the habitats we build will enable humans to live in deep space for extended periods. Importantly, we will conduct multidisciplinary science that helps answer questions about the history and origins of life in our solar system.

The Moon to Mars architecture is underpinned by a vital tenet—robots and humans will work together. Robotic explorers will aid human explorers on and around the Moon. Robots will take on mundane or dangerous tasks so that astronauts are kept safe and focused on critical science and exploration activities.

Work has begun to advance these robotic concepts. In 2020, NASA issued an industry consultation for the Lunar Terrain Vehicle (LTV), an unpressurised rover that will transport astronauts around the lunar South Pole later this decade. Canada is embarking on phase 2 of its rover mission, a 20kg semi-autonomous vehicle that will advance key technologies including thermal control for lunar night survival. Concepts are also being developed for exploration. In late 2024, a Commercial Lunar Payload Services lander will deliver NASA's VIPER rover to the lunar South Pole where it will determine the location and concentration of water ice. NASA JPL/Caltech's Axel rover will extend planetary mobility to steep and rugged terrains such as the interior of

crater walls, pits, gullies, canyons, and crevasses and can be interoperable with larger vehicles.

Australia is also advancing efforts towards a national lunar rover mission. In October 2021, the Australian Space Agency announced that it would support the development of an Australian-made 'foundation services' rover to operate on the lunar surface from 2026 through its Trailblazer program. Envisaged as a collaborative effort between government, Australian scientists and companies, the semi-autonomous rover will collect lunar soil (regolith), which contains oxygen in the form of oxides. It will then deliver the regolith to a NASA instrument that will extract oxygen from the regolith. If the mission succeeds, it will bring the international community one step closer to establishing a sustained human presence, and position Australia as a leading provider of space robotics and automation services.

But will we succeed? Australia's terrestrial heritage in robotics and automation in harsh, remote and inhospitable environments is world-renowned and oft cited. Queensland University of Technology (QUT) automation technology helps drive Rheinmetall land vehicles and Caterpillar underground mining trucks, for instance.

What few realise, however, is that Australia also has rich space heritage. Australia is already contributing to NASA's Mars Perseverance rover mission, which aims to find signs of ancient life on the red planet. A 12-person QUT team led by Dr David Flannery helps drive consensus on the Perseverance rover's path during the US night. NASA also commissioned QUT to develop software that is crunching complex geochemical data captured by the rover's scientific instruments.

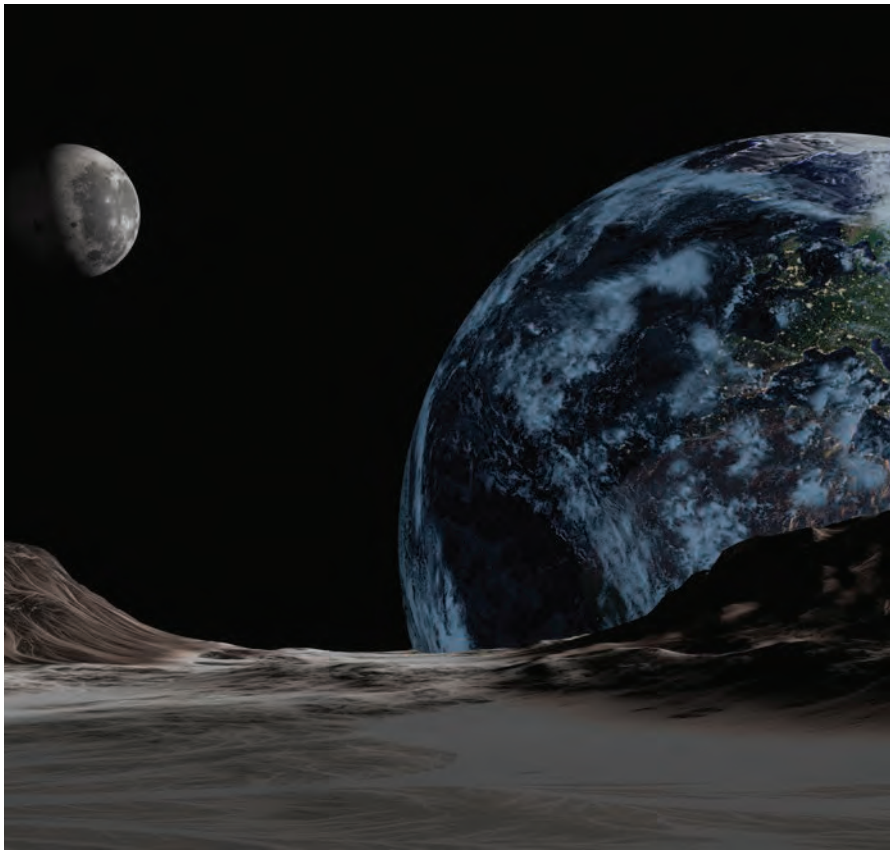
In December last year, QUT announced that it had developed a navigation and perception system to support a small, autonomous, 20kg rover as part of a broader partnership with Boeing. Importantly, Australia's testing and space qualification infrastructure—at institutions like QUT, CSIRO, ANU and UNSW—is world-leading.

Assuming Australia's first lunar rover mission does succeed, the question becomes what next? Space is a long-term game, so the time to plan for 'life after Trailblazer' is now. We have a unique opportunity to double down and diversify, delivering small rover missions on a regular basis. Think Australian rovers that provide lunar logistics, inspection and maintenance of key assets such as energy infrastructure, habitats and larger more expensive vehicles such as an LTV. They can support science—explore unchartered territory to detect deposits of lunar ice, which contain valuable stores of oxygen and hydrogen critical both to sustaining a human presence and reaching Mars. And these activities could be offered under a commercial model as space agencies push further into deep space and our commercial space sector moves beyond low Earth orbit.

As we push further into space, the technologies Australia develops for Artemis will improve life here on Earth. The lunar environment has no atmosphere; very fine, charged, and reactive dust that sticks to everything; temperature variations of up to 300 degrees and 200 times the radiation of Earth. Autonomous systems that can operate in this environment can be a game changer for our mining industry on Earth. Subsystems and components such as advanced batteries can help drive innovation and a pivot toward more sustainable operations.

This will lead to new industries, jobs and long-term economic growth. The growth of analytics and robotics capabilities in the resources sector alone is estimated to add $74 billion to the economy by 2030 and create 80,000 new jobs, according to the Australian Space Agency's Robotics and Automation Roadmap. Big missions mean big collaborations, which is a good thing, but it comes with the concomitant responsibility to ensure that companies can use and benefit from their contributions, so that the long-term jobs and growth benefits of our national missions remain in Australia.

As humans aspire to explore ever deeper into our solar system, the Australian space industry is entering its golden age. It is an exciting time for Australians as Artemis—and with it our national rover mission—discloses a new horizon. ●



IMAGES: Supplied

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Connecting Victoria to the global space sector

RMIT's Space Industry Hub is an industrial solutions provider that supports collaboration and innovation for the growth of Victoria's space sector.

The Hub

- Connects Victoria's world-class research capabilities with the opportunities of the global space sector
- Leverages RMIT's research infrastructure and global networks in innovation and entrepreneurship
- Leads community engagement and collaboration with industry, government and investors
- Partners with SmartSat CRC Victorian Node, the Victorian Government, Amazon Web Services and FrontierSI

Advancing Australia's defence, aerospace and aviation industries

RMIT's Sir Lawrence Wackett Defence & Aerospace Centre contributes to the growth and sustainability of Australia's globally competitive defence, aerospace and aviation industries.

The Centre

- Serves national defence and aerospace priority areas, including manufacturing, autonomous systems and cyber security
- Builds and supports cross-sector teams to deliver outcomes for aerospace and defence industries across Technology Readiness Levels 1-7
- Leverages RMIT's research capabilities to deliver end-to-end solutions to industry partners, from concept, prototyping, and testing to policy and implementation
- Partners with Australian and global organisations across government, education and private sectors, including the Australian Defence Force and the Defence Science and Technology Group

Space Industry Hub

Sir Lawrence Wackett Defence & Aerospace Centre

RMIT UNIVERSITY Space Industry Hub

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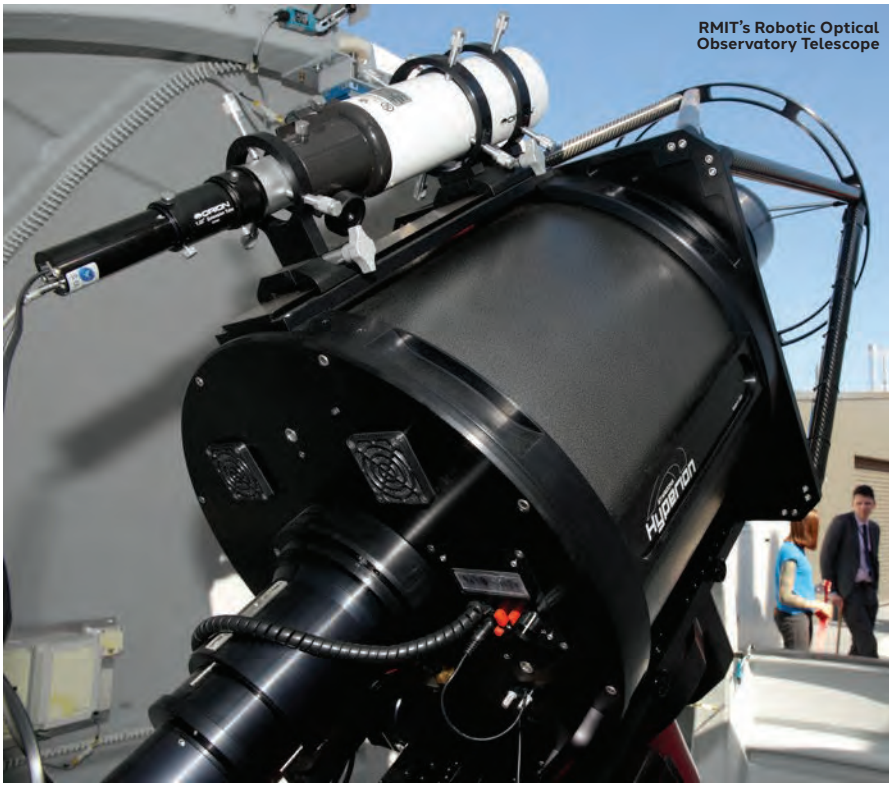


RMIT's Robotic Optical Observatory Telescope

RMIT meets workforce needs of industry

By Rosy Calabro

The paradigm shift of the Australian workforce created by the global pandemic has focused a spotlight on the education and training sector. Universities and TAFEs have spent three years analysing their operations, curriculum and students. Aside from the modes of education delivery, RMIT has used this self-examination period to scrutinise the relevance of its courses and programs against today's employment market and industry trends.

RMIT has a long-standing history of working closely with industry and government, with space and defence a strong focus. The University's dedicated defence entity, The Sir Lawrence Wackett Defence and Aerospace Centre, was expanded in 2019 to represent all disciplines spanning STEM, business, law, design and social sciences. RMIT's university-wide defence centre provides the defence industry, Department of Defence, defence agencies and industry bodies, a direct link to subject matter experts and their research.

This expertise is in high demand from the defence industry including primes, small to medium enterprises and start-ups to support and expand their own research and development, and to collaborate on projects funded by Defence.

RMIT's Space Industry Hub was launched in 2022, in response to the government and industry need to grow the space sector, with the aim of connecting local businesses and research capabilities with global opportunities in space technology.

The Hub brings together RMIT experts from cyber, data analytics, space manufacturing, space domain awareness systems, communications and sensors. It also hosts the Victorian node of the SmartSat Cooperative Research Centre (CRC), a national consortium of industry and research organisations developing game-changing space technologies.

Working closely with the Hub are geospatial scientists from the Satellite Positioning for Atmosphere, Climate and Environment Research Centre and the Robotic Optical Observatory Telescope at the Bundoora Campus (pictured) plus academics delivering the Bachelor of Space Science.

The synergy between The Sir Lawrence Wackett Defence and Aerospace Centre and the RMIT Space Industry Hub has strengthened the University's commitment to supporting the defence and space sectors aligned to Australia's defence and space priorities.

Recently, the two formed a partnership with Charles Darwin University to build an Industry 4.0 Test Lab for defence and aerospace industries. The Test Lab will boost Australia's sovereignty in uncrewed autonomous systems, manufacturing, and deliver a Diploma of Advanced Manufacturing.

Another consortium was created with the Royal Australian Air Force, Trusted Autonomous Systems, SmartSat CRC and the Bureau of Meteorology, to create the High-Altitude Pseudo Satellite Challenge, which aims to energise local Australian development of key technologies and bolster Australian sovereignty.

Across the University there are industry advisory boards with memberships consisting of senior and executive level professionals, and technical experts representing industry, government, not-for-profit organisations and industry bodies.

There are also formal partnerships with industry and Defence that provides students industry experience through capstone projects, work placements, internships and scholarships.

By collaborating with industry, RMIT, at both its higher and vocational education levels, is striving to meet the current skills and employment challenges faced by the space sector and its flow on industries.

IMAGE: Marc Morel RMIT

STEM and the future workforce

As Australia's space sector grows, one of the constraints it is facing will become more visible—the size of its workforce. Australia has world-class space smarts and the challenge now is to grow the workforce numbers in order to grow the sector as a whole. **By Gregor Ferguson**

IMAGE: ThisIsEngineering from Pexels

It is looking as if Australia will not achieve one of the goals it set itself a few years ago. Australia's Civil Space Strategy, published in 2019, aimed at creating an additional 20,000 jobs by 2030 and tripling the size of the country's space sector, to $12 billion a year.

The annual growth rate of Australia's space industry is close to 10%, says James Brown, CEO of the Space Industry Association of Australia which is the industry's peak representative body. But even this rapid growth will not deliver all of the jobs in the Strategy. He says, "We're not growing companies fast enough, we're not growing space jobs fast enough to meet that goal. That needs quite a high growth rate and we're not approaching that yet."

While the jobs target may have been aspirational rather than a firm target, companies still cannot expand without trained employees and Australians want their space sector to grow.

The Australian government now clearly understands the importance of space in the country's national infrastructure, including Defence, and it wants to see a stronger, sovereign space industry in this country. So, coming off a very low base, Australia is having to re-create the STEM (Science, Technology, Engineering and Mathematics) pipeline of enthusiastic young scientists, engineers, systems integrators and hardware specialists that make up a space industry ecosystem.

However, things may be better than they seem, believes Enrico Palermo, Head of the Australian Space Agency. The changes in just the past four years illustrate the recent dramatic growth of the sector and the positive effect this is having on jobs.

"I left Australia in 2005 to pursue a career in space, and that was hard. I had to leave my family," he tells *Australian Space OUTLOOK*. "You know, if I was coming out of uni or was an early graduate today, I wouldn't have to do that."

Nevertheless, the size of Australia's space industry workforce remains an issue, he acknowledges. "I don't think it's a speed bump because we're going to have to continue investing in workforce on a continual basis. It's like a hill we have to climb," he says, adding that it will take perseverance and endurance to reach the summit, and it will be a long journey.

And the demand for trained, experienced people will grow, predicts Brown. "Well I think Defence Space Command's needs are acute, so just for Joint Project 9102 (see p.xx) I think they need a new workforce of over 300 people for military satellite communications and, obviously, that's just one part of what they're doing."

It is clear that Australia's space industry players all recognise there is a problem, and it is one they all share. So what are they doing about it?

> **"Space is often the spark for people to pursue studies in science and maths and engineering, and the reality is not all of them go into space..."**

To grow Australia's space industry workforce will take three things: an efficient and effective STEM pipeline that begins at primary and secondary school level and extends up to post-graduate level; streamlining Australia's space industry so that a single industry base supports both the civil and defence sectors; and, in the short term, carefully targeted skilled migration.

The skilled migration issue is eased slightly, Palermo says, by the eagerness of highly qualified Australians to return home after spending years working in the space sector in Europe and North America. Not only do they have years of design and operational experience on a wide variety of projects, but they also have overseas experience. They understand how to do things differently, or better, and how important collaboration can be. Their contribution to the skill levels in Australia's space workforce as well as to the raw numbers is vital.

Brown agrees, noting many Australians operating in the space sector in this country also have years of valuable experience. "Our member Optus flies satellites for the government out of Belrose [in NSW]," he points out. Optus launched its first satellite with a dedicated Defence payload, the Optus C1, in 2003. The earlier Optus B3, launched in 1994, was also used by Defence. That is nearly 30 years of vital experience in space operations.

But long term, the pipeline begins at school. The Australian Space Agency's approach to developing the educational pipeline for STEM students is based on one of the Civil Space Strategy pillars: *Inspire*.

"We take our role to *Inspire* very seriously," Palermo tells *Australian Space OUTLOOK*. "We actually just brought on board a full-time Inspire program manager for that reason, realising we need to do more because space has that incredible capacity to inspire.

"Space is often the spark for people to pursue studies in science and maths and engineering, and the reality is not all of them go into space," he explains. "You look at the Apollo missions. They inspired generations of engineers and scientists and not all of them went into the space industry. I think we're going to see the same here. We've just about started the Project Artemis generation with a flight potentially in the next couple of weeks, which is really cool."

The Agency and the industry as a whole are reaching out to Australia's small but growing ecosystem of space-focused primary and secondary schools in an increasingly integrated way, believes Palermo. "There's some schools around the nation that are very forward-leaning, like Joseph Banks in WA or Hamilton Secondary College here in South Australia, so we're communicating with them," he says.

Hamilton Secondary College in Adelaide delivers the Mission to Mars program developed by the Victorian Space Science Education Centre (VSSEC). The Mission to Mars program has a simulated Martian crater and landscape with seven different geological zones, a mission control room, a briefing room and a space laboratory. Between them they provide an immersive learning experience for teams of STEM students that simulates real-life Mars missions to gather rock and soil samples.

The VSSEC, located near Melbourne's Essendon Airport, has 22 other STEM-related programs in total, all designed to engage and inspire students and

encourage them to participate actively in STEM. It is part of a network of 17 STEM-focused institutions in Victoria, says Michael Pakakis, its Director.

The network covers subjects as diverse as quantum science, biotech and Earth sciences; the VSSEC specialises in space. He tells *Australian Space OUTLOOK*, in part because it is inspirational. "When you use space as a topic, student engagement goes up 150%! And when you're dealing with up to 18,000 students a year that's a significant result." The VSSEC covers all ages from Year 3 to Year 12, using the experience of space to teach more general science and research skills, from robotics to analytical chemistry.

Echoing Palermo, Pakakis acknowledges graduates do not necessarily go into the space industry. When most people think of space they think narrowly about rockets and astronauts and not all are interested, but space is so much more than this. It is vital, he says, to promote the uses of space in everyday life—everything from navigation and online banking to Earth observation. And it is vital also to engage what he calls 'space tradies'—the men and women who can assemble a rocket, or wire up a control room, assemble a satellite dish and manage a space mission.

Another potential obstacle is the perception that space is 'something other people get to do'. Challenging that perception is the Australian Space Discovery Centre at Lot Fourteen in Adelaide, says Palermo. "One of the really neat things we do at the Australian Space Discovery Centre is say, it's not about NASA, it's not about the European Space Agency, it's about Australia's role in space. And so, if you walk around, you see diverse professionals working in this sector so the youth that come through can say, hey, look what these Australians are doing—I could be doing that!"

Brown believes that for older school and university students there is a role for something akin to Australia's National Shipbuilding College, only attuned to the needs of the space industry. "I think JP9102 will be a big driver for that and no doubt all of the different bidders have a sense of some sort of workforce program that they will include in their bid," he tells *Australian Space OUTLOOK*.

"This problem has been faced in other industries before, so there are some good models out there for what we can do. But space skills are in shortage across all of our allies and partners at the moment," he adds, pointing to an ongoing problem with skilled migration. "There's no one who has the space workforce they want or need right now."

It is important to recognise that the range of skills needed is incredibly broad, says Palermo who has his eye on the long-term needs of the sector as well as the more immediate short-term needs. Australia's space community needs to challenge some entrenched misperceptions and modernise current school and university curricula. You do not really need a PhD or Master's degree to work in the space sector.

"I know first-hand from experience in the US you don't," says Palermo emphatically, echoing Pakakis's call

IMAGE: Kindel Media From Pexels

> **The university sector is important, you're having graduates coming out with actual design and build and operating experience with space systems. I see a lot of promise coming out of the way the universities are leading.**

for increasing TAFE engagement in the space sector. "Certain roles definitely do, but if you're building and operating hardware not all those functions have to be at that level." It takes vocational skills to manufacture rockets and satellites and build satellite dishes and put cables through an entire ground station.

Nevertheless, an increasing number of universities are developing complex space programs to meet emerging demand, with many having orbital missions. The University of NSW Australian Centre for Space Engineering Research is case in point; so is the Centre for UAVs and their Applications (CUAVA) at the nearby University of Sydney. In Canberra, the Australian National University's Institute for Space has become a key player as is UNSW Canberra Space which worked with Defence to develop the M2 satellite mission, Australia's first to explore formation flying in orbit. This went into orbit in 2021 and is part of the ongoing process of teaching Australian military and civilian personnel about designing, launching and commanding a space mission successfully.

"The university sector is important," emphasises Palermo. "You're having graduates coming out with actual design and build and operating experience with space systems. I see a lot of promise coming out of the way the universities are leading."

Something that the entire space ecosystem has grasped is the need for a single industry base to service both the civilian and military sectors. Both use similar technologies. Defence is increasingly using technology that was developed by and for the civil sector which is driving much of the technology investment and development. Arguably, the only difference between many civil and military payloads is the level of classification applied to the final application of the technology concerned, so the majority of space industry skills are transferable.

Being pragmatic, Australia can only afford one industry, believes Brown and for two reasons. "One is we're starting this so late in the game and from such a small base that we just can't afford to have duplicated efforts. And secondly, we're going to see movement between industry and Defence, with people moving between those two entities over their careers. So the more streamlined the workforce can be the better."

In the short term, skilled migration is part of the answer, he believes. But the long-term solution is for Australia to create its own educational and training pipeline of trained, experienced personnel with a proper career structure in the space industry.

Compared with even just four years ago, Australia offers many more opportunities to its space industry professionals, and these opportunities will expand with the space sector itself, believes Palermo. "I think a career in the space industry is now entirely possible in Australia." ●

IMAGE: Pixabay From Pexels

STEM: The view from Academia

Australia's space sector workforce needs to grow—and the need for STEM skills remains a constant. The pipeline for young talent begins at primary school and continues right through post-graduate study at university. Two of Australia's space universities describe how they are tackling the STEM skills and workforce challenge. **By Gregor Ferguson**

The Australian Civil Space Strategy's goal of tripling the space sector workforce by 2030, creating an additional 20,000 jobs, was rhetorical and aspirational, believes Dr Cassandra Steer of the Australian National University (ANU) Institute for Space. That said, she believes that achieving 20,000 jobs is doable, perhaps in an extended timeframe, and this is the focus of what is now called the National Space Plan which looks out to 2040. After all, she asks, "How do we grow a sector without people?"

Professor Brian Falzon, Director of RMIT University's Space Industry Hub, agrees adding that every high-technology industry sector is short of people at present and that the global tussle for talent, as he terms it, is a very real thing.

The National Space Plan incorporates a National Space Workforce Plan and the space sector's workforce needs were addressed at the National Space Workforce Forum in Sydney in August 2022, which fed into September's Australian Jobs and Skills Summit. The Australian Space Agency has identified the need for 900 space engineers to be trained each year over the next decade (in addition to 300 scientists and 800 non-STEM graduates) at a time when the number of school students studying STEM subjects in Years 11 and 12 is falling.

The space sector's needs are not just for rocket scientists and satellite designers, says Dr Steer. Most of the value chain in the space sector lies upstream or downstream from actual spaceflight—building ground stations, doing systems engineering and then data analysis and space law, to name just a few of the hundreds of skills needed.

Professor Falzon adds that the vocational sector also needs to be included. So-called 'space tradies' coming out of the TAFE sector are essential to building everything from ground infrastructure to rockets and satellites—you need practical skills to actually build a rocket or satellite, or a ground station.

So how are Australia's universities tackling the STEM problem? Dr Steer points to ANU's Aerospace Cluster within its College of Engineering and Computer Science, and the fact that ANU is strong on space law and governance: these are some of the less-heralded skills demanded by Australia's burgeoning space sector

But ANU is also home to InSpace. The ANU Institute for Space is a banner head for all the multidisciplinary space research across the ANU, and is spearheading a multi-university consortium, the Australian University Space Institute Forum. This promotes collaboration between its founders—the ANU, Swinburne University, the University of South Australia, University of Western Australia and University of Southern Queensland.

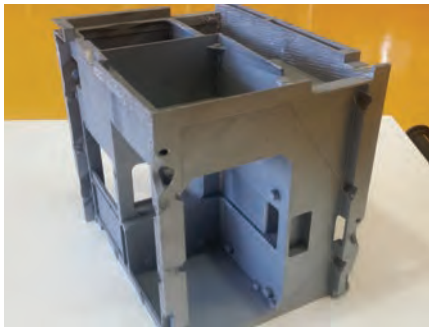
This collaboration is designed to tackle difficulties created by the university funding and accreditation model which does not encourage universities to collaborate on research or integrate their undergraduate courses. No university within the consortium has a fully comprehensive space syllabus. Dr Steer points out they all teach parts of a fully integrated space science or engineering syllabus and need to collaborate to ensure that students can cover all the topics needed for an undergraduate degree, even if this means doing particular modules at a different university.

At RMIT University, which has long been Australia's leading aeronautics and aerospace educational institution, a Bachelor of Space Science is now offered which is unique in Australia.

Dr Cassandra Steer of the Australian National University (ANU) Institute for Space

Brian Falzon, Director of RMIT University's Space Industry Hub

ANU's InSpace team at The International Astronautical Congress 2022 in Paris



The aim is to get children enthused and interested in science and engineering. Dr Steer agrees and adds that the inspiration provided by space is a wonderful way to support girls and ethnic minorities who are interested in STEM topics as well—every sector does better when it embraces diversity.

A recent restructure of the undergraduate degree program is designed to make graduates more employable. For example, every student on every course will be exposed to future technology skills—artificial intelligence, cyber security, sustainable development and the like, all highly relevant to a career in space. The university is also looking at flexible learning options including internships which Professor Falzon considers a vital part of maturing students by exposing them to the realities of working on live projects with commercial partners.

Australia's universities are often criticised for not doing industry-relevant research, but Professor Falzon points out that a large majority of his own department's PhD students are working on industry-defined R&D problems. The university actually ring-fences a number of PhD positions to enable industry partnerships if the research project involved is sufficiently valuable. Proof? Several PhD and post-doctoral projects are funded by the Defence Science and Technology Group. More generally, the whole issue of industry collaboration is important, and even final-year undergraduate projects are increasingly seeing industry and students working closely together.

At school level, Professor Falzon acknowledges that reaching out to students in Years 11 or 12 is too late. To stimulate interest in STEM topics, RMIT academics are engaging with primary schools and the university has a team that focuses purely on outreach to schools. The university is also working closely with the One Giant Leap Australia Foundation in Sydney (see p.47) and its patron, former NASA astronaut, Greg Chamitoff, on the new International SpaceCRAFT Exploration Challenge.

RMIT University has just announced the 'Mission: Sustainability' program with the Foundation, Moonshot Space Company and Australian former NASA engineer Chris Boshuizen, who flew into orbit in 2021 aboard Blue Origin's space capsule. The program has four categories, starting at kindergarten and going up to Year 12.

Realistically, not every student who participates will subsequently follow a career in the space industry and that is true of every STEM program that uses the excitement of space as a drawcard. But that does not matter, says Professor Falzon. Space is an inspirational gateway into STEM, he says. The aim is to get children enthused and interested in science and engineering. Dr Steer agrees and adds that the inspiration provided by space is a wonderful way to support girls and ethnic minorities who are interested in STEM topics as well—every sector does better when it embraces diversity.

On the principle that a rising tide lifts all ships, both academics agree that anything that is good for the STEM sector as a whole is good for the space sector in particular. And who knows? One day those STEM students may end up working on an upstream or downstream space-enabled program—they will be space industry players without planning it. ●

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How an Australian start-up is democratising access to outer space

Space Machines Company is an Australian start-up working in collaboration with UTS Tech Lab to develop space transportation capabilities.

As the only space logistics company in Australia, Space Machines Company (SMC) is currently seeing a material increase in the demand for space logistics services, not just on a local but a global scale.

According to SMC's Head of Strategic Business Development, Helene Baron, because Australia has a relatively new space ecosystem, it is unencumbered by what she calls "old space" mindsets. As a result, she says space industry start-ups, such as SMC, can adopt a faster, more agile "new space" mindset that means they can prove their value far sooner with less capital.

"Working in this mindset, I believe Australia will be ideally placed to take advantage of the shift from government space into commercial space over the coming 5 – 10 years," Baron says.

SMC's purpose is to democratise access to space by providing a crucial missing service in orbital logistics. Their 'Optimus Space Tug' will deliver a customer's satellite to LEO by any one of a number of launch providers, which will then place it in its correct final orbit—from LEO to GEO to deep space.

"This 'peace of mind' in space logistics and services are part of our sustainable, reliable, safe and cost-effective approach," Baron continues.

In 2020, SMC decided to relocate to UTS Tech Lab because they needed a place to accelerate the assembly, integration and testing phase of their space tug, Optimus.

"With direct and low-cost access to prototyping and testing facilities, offices, labs and the high bay warehouse we needed—all at the same site—we saw nowhere else that could apply UTS's 'Industry First' approach," Baron continues.

"We also have direct access to world-class researchers from various engineering domains, which contributes to the development of our team and mission, and we're already hiring UTS students and working with them to go after grants and contracts together."

SMC is located in the heart of the UTS up-and-coming Space and Defence Hub and there is not only lots of space for SMC to grow, there is plenty of room for other space companies to co-locate there too.

"The fledgling space industry in Australia can, and should, share their talents, complement each other's capabilities and mitigate risks together, at various levels of the value chain," Baron says.

"I believe we are now perfectly placed to start taking the pain out of accessing space for a wide variety of customers that include research and science, commercial, government and launch service providers. In delivering the above we intend to create a critical mass of sovereign capability in Australia and a global capability that can be accessed by all."

IMAGE: Supplied

One Giant Leap for EOS scholarship recipients

The Australian owned and operated space, defence and communications company Electro Optic Systems (EOS) has partnered with One Giant Leap Australia (OGLA) to provide scholarships for the science, technology, engineering and mathematics (STEM) workforce of the future. **By Jackie Carpenter**

Early in 2021, EOS and OGLA announced the establishment of the EOS Scholarships for Future Excellence in STEM, to be awarded to university and high school students who have demonstrated outstanding achievements in STEM.

The EOS Scholarships are part of the ASX listed company's commitment to growing Australia's future space workforce. EOS and OGLA are particularly championing the development of women in STEM through these scholarships and other workforce programs.

Given the challenges school and university students have faced during the pandemic, it is more important than ever to invest in the next generation of STEM practitioners—and investment in the future is something OGLA knows a great deal about.

Founded in 2015 by Jackie and Bob Carpenter, the One Giant Leap Australia Foundation creates unique learning experiences to develop and enhance STEM literacy as well as the important skills of problem-solving, critical analysis, creative thinking, communication and collaborative teamwork.

OGLA was established to prepare the next generation to thrive in an increasingly technologically complex and competitive global economy.

The Carpenters themselves have a rich history in STEM and STEM education. Jackie has an extensive background in STEM education, while Bob is a former RAAF flight engineer with an exhaustive history of combat and peacetime service.

Jackie Carpenter says of the program, "We are honoured to partner with EOS on such an inspirational and life-changing initiative that links education and industry to skill the STEM workforce of the future.

"This scholarship program aligns perfectly with the immersive opportunities that OGLA delivers. Our programs are unique, focused and equitable, supporting participation from regional, rural and remote communities."

In a statement, an EOS spokesperson said, "As a leader in our industry, we acknowledge the important role we can play in inspiring students to pursue future careers in STEM. We also recognise that women are under-represented in STEM fields and are committed to supporting gender equity in the Australian workforce.

"As such, we are proud to be encouraging early career STEM practitioners through the EOS Scholarships for Future Excellence in STEM."

IMAGE: Nicole Avagliano from Pexels

The confidence to embrace new challenges

While the 2021 scholarships were officially announced at the Australian Space Forum, the recipients themselves were informed in a surprise online meeting, much to their delight.

The inaugural winners to be awarded scholarship funding were Lisa Rheinberger, Francesca Dobbie, Jessica Kreskay and Olivia Widjaja, who was awarded an EOS Space Systems internship in addition to scholarship funding.

The funding has been made available to the students for a two-year period and may be used in any way that will support recipients' STEM education activities.

The enthusiasm of these talented young women is not only palpable but infectious. Olivia says, "If I had told my 18-year-old self that I would be a scholarship recipient, I wouldn't have believed it."

As Olivia explains, her STEM career has not always been smooth sailing thus far.

"When I was a first-year aerospace engineering student, my excitement for university quickly washed away when my male peers 'recommended' I drop out of engineering." The experience affected her greatly. "I struggled to stay on top of the content," she says. "However, things began to change by second-year."

The scholarship has "changed my life", Olivia says, "in many ways I couldn't have imagined.

"It has given me the opportunity to fully immerse myself in the Australian space industry and the confidence to embrace new challenges. My experience as an EOS astrodynamics intern in 2020—before returning to work casually for the company in 2021—pushed me out of my comfort zone, allowing me to learn new skills not even my degree could teach me.

"Now, I get to collaborate with EOS and UNSW Canberra as part of my undergraduate thesis. I'm excited to see where the thesis will take me."

Olivia says that if she had to pinpoint what has been the most valuable aspect of the scholarship, it would be "the opportunity to connect with other like-minded women and girls".

"My journey hasn't been smooth, but I can only hope that, by being a part of the OGLA community and being supported by EOS, I can continue to

EOS Scholarships for Future Excellence in STEM recipient Jessica Kreskay with James Bennett (Vice President, Space Systems at Electro Optic Systems Pty Limited) and One Giant Leap Australia Director Jackie Carpenter

Scholarship recipient and EOS intern Olivia Widjaja.

IMAGES: Supplied

inspire girls to consider a career in STEM—no matter what their peers tell them."

Jessica says the award "is a reminder that there is opportunity around every corner". She says the EOS scholarship has given her "the confidence and drive to be an active participant in The Gadget Girlz [a student-led OGLA program], mentoring other young girls in practical workshops".

Jessica is "excited to continue working with other scholars to form a network to support each other on our STEM pathways."

"I am thankful to be part of such a brilliant team and look forward to continuing with EOS and working beside the next scholarship recipients to strengthen and diversify Australia's STEM workforce."

I want to be an astronaut

These talented women understand the importance of professional networks and have all kept in contact. As Lisa notes, the scholarship has given the recipients "opportunities to connect with like-minded individuals who also have a passion for STEM, allowing us to share common interests and goals and enabling us to learn about each other's unique passions".

This scholarship is particularly important to students from regional Australia, like Lisa, since connecting with like-minded individuals creates "social proof" as well as encouragement to pursue their goals.

Lisa says, "As I further my studies, I look forward to continuing to champion the ideals of EOS by encouraging others to pursue careers in STEM. I am also excited to meet the next recipients of this award and to further aid in the diversification of our field."

Meanwhile, Francesca—'Coco', to her friends and colleagues—has her eyes on space travel.

"I want to be an astronaut," she says. "Until about two years ago, I wouldn't admit my dreams because to me, then, they were just dreams. I thought, 'There's no way a girl from a small Australian town would ever get to be an astronaut.' Now, I've completely changed my way of thinking."

Prior to winning her scholarship, Coco had the opportunity to visit Space Camp in Huntsville, Alabama (US) thanks to OGLA.

"I experienced seeing rockets and telescopes, but most importantly, I experienced meeting people who believed in me. I owe my self-confidence to this experience and my future success to Jackie Carpenter and OGLA, who recognised the importance of broadening the minds of young people," Coco says.

The COVID-19 pandemic disrupted plans for recipients to visit the EOS Canberra headquarters in person to undertake a three-day program that was to feature presentations to school students and other guests. However, plans are underway to incorporate the in-person aspect of the scholarship program in the next round.

The power to change lives

The significance and impact of the EOS Scholarships for Future Excellence in STEM should not be underestimated, especially when one hears the testimony of its recipients.

That is why plans are already afoot for the next round of scholarships. Soon, both groups of student recipients will be able to support each other as they continue to diversify the space workforce both at EOS and across Australia generally.

At a recent get-together, where the recipients reflected on their experience, Francesca encapsulated the benefit of the scholarships.

"One of the most important things I have realised in receiving this scholarship is the importance of networking and making connections with people in the real world. Initiatives like the EOS Scholarships have the power to change lives and build futures for young women, astronauts, engineers and scientists."

Francesca also sees value in passing opportunity forward.

"It is my goal to be able to direct young people into a STEM future, as I was directed myself," she says. "I am so grateful to EOS for supporting young women and allowing me the opportunity to push myself and make connections. I am excited to see where the future leads me, and I can't wait to introduce others into the beautiful world of science and technology." ●

Scholarship recipient and budding Astronaut, Francesca (Coco) Dobbie.

Scholarship recipient Lisa Rheinberger

For more information, visit:

www.eos-aus.com

www.onegiantleapfoundation.com.au

IMAGES: Supplied

Scots connecting minds

The issue of diversity vs inclusivity

By Jackie Carpenter

Diversity in the workplace refers to a workforce comprised of individuals of race, ethnicity, gender, age, religion, physical ability, and other demographics. But is diversity enough?

Global research by Deloitte shows that organisations with inclusive cultures are six times more innovative and agile, eight times as likely to achieve better business results, and twice as likely to meet or exceed financial targets than organisations with less diversity in the workplace.

If the advantages of diversity and inclusivity in business are so obvious, how is the Australian space sector creating a workforce that has all these advantages? PwC Australia research from 2016 pinpointed that to be globally competitive on the world stage, Australia needs to increase the STEM workforce from 10% to 25% by 2025. How are we going with that?

One Giant Leap Australia (OGLA) has always had a strong focus on diversity and inclusivity since its inception. Statistically, we have a 65% female audience and engage with younger people with new, immersive programs that are equitable, rich in experiences and connecting diverse professionals and students across the globe. Programs and workshops are successfully delivered nationally and internationally. OGLA engages with formal and informal education as well as the community.

Just changing the name of a program, targeting the students who are already in STEM in Year 9 to 11 and cannibalising each other's staff is not going to create the workforce required by the new space sector. We also need to change workplace culture as it is not enough to just give money for more women to enrol in a university or TAFE STEM course.

Space, by its very nature, must be innovative. The workforce required brings new ideas, experiences and perspectives. OGLA believes there needs to be a strategy of inclusivity in the industry so that we welcome the diversity into the STEM workforce that global industry


Women in space

> Space, by its very nature, must be innovative. The workforce required brings new ideas, experiences and perspectives. OGLA believes there needs to be a strategy of inclusivity in the industry so that we welcome the diversity into the STEM workforce that global industry needs. In order to create this community, not only do we have to identify what skills the Australian space industry actually requires but we need to change existing cultures and 'how it has always been'.

needs. In order to create this community, not only do we have to identify what skills the Australian space industry actually requires but we need to change existing cultures and 'how it has always been'. It is very obvious that the new space industry requires true innovation. In fact, now, more than ever, Australian industry must step up and actually action what it is talking about.

OGLA is proactive by participating in local, national and international major conferences and events as well as running its own events and programs. The programs are inclusive, flexible and agile—benefitting the participants and the Australian space sector. A sample of these programs illustrate this approach.

Space Teams

This six-day program developed by Dr Greg Chamitoff, former NASA astronaut, who spent six months on the International Space Station and was responsible for installing the last components in the initial construction on one of his Space walks, (extra vehicular activities), is open to students aged 12 and up. Forming teams of two to four, these budding interstellar explorers are treated to lessons on topics ranging from planetary science, orbital mechanics and robotic exploration. Participants learn about spacecraft systems, a subject that Dr Chamitoff has literally written a book on. Through the program, these subjects bring all aspects of space exploration to an understandable level for young students who, through experiential learning, explore concepts firsthand. The program aims to inspire young explorers to further pursue STEM (science, technology, engineering and mathematics) subjects in school and ultimately enable them to join the international community of scientists and engineers exploring the final frontier. Through scholarships, aided by institutions such as RMIT, OGLA is able to offer participation of students from low socio-economic and cultural backgrounds that might otherwise be overlooked.

Mission Oz!

Mission Oz! was the only high school space mission program delivered in World Space Week. OGLA gave scholarships to a team of four students from Kathmandu (Nepal), 24 girls from Caroline Chisholm College in Western Sydney and eight students from Mudgee High School as well as two individual students from the Hawkesbury Local Government Area. There were students competing from other countries as well—Egypt, Indonesia, Bangladesh, USA, UK and Canada. **https://onegiantleapfoundation.com.au/mission-oz/**

The Gadget Girlz

This program developed from a few discussions with a number of girls who had life-changing experiences from initial programs with OGLA. A series of events and programs have been developed to allow the girls to 'pass it forward' to younger female students. OGLA currently provides a program that is free. It provides podcasts and teleconferences with successful women from around the world. The podcasts are recorded and provided for ongoing reference by the Gadget Girlz. These events are facilitated by the girls with mentoring by OGLA.

The Gadget Girlz Roadshow is a spin off from the initial program and aims to shatter the myth that boys alone are technically minded or, indeed, interested in such things. The Gadget Girlz is 100% a participatory program. It is not only aimed at young girls, but it is also developed, facilitated and mentored by young girls, providing a multi-layered educational experience. Participants are learning about robotics, drones and space while the mentors are learning valuable leadership skills that are experiential and not intellectual. The Gadget Girlz has a Support Crew made up of all genders. Dads, brothers, friends, parents and supporters. They are part of the program. This allows not just diversity, but models and shows inclusivity. The Support Crew assist the Gadget Girlz by aiding their workshop presentations (i.e., ensuring batteries are charged or resources ready when required). You can sign up here: **https://gadgetgirlz.com.au/**

The Connecting Minds Project

This is a hybrid event that allows students to collaborate interculturally

and globally. The Connecting Minds Project is a flexible, purpose driven education program that focuses on networking, problem solving and cutting-edge space STEM research across countries where educators partner globally and their students work collaboratively on their 'space missions'. Their innovative projects focus on STEM skill development, team work, interpersonal and intercultural communication, building international networks and collaboration.

The overarching objective of The Connecting Minds Project is to build the STEM skills capability and capacity of students and educators between countries (and ultimately further afield) to improve the global uptake of space and high-tech STEM careers. The process has promoted diversity, problem solving, critical and creative thinking, innovation, team building and cooperation in the workforce of tomorrow. Support and guidance for each project was provided by OGLA to students and educators.

Women in space

The programs and events provided by OGLA are not only for students. To encourage knowledge and participation, OGLA conducts Women in Space events. These events invite not only industry and STEM students but also members of the local community. This opens participation and representation to people who might otherwise perceive barriers to the industry. The evenings feature industry panellists followed by practical rocket, satellite and rover building workshops in a completely social environment. These are fun activities that break the ice and are truly team building all with a sense of fun.

EOS Scholarships for Future Excellence in STEM

By providing funding for students to pursue their goals of STEM and space careers, joint initiatives like this leave a lasting impression that cannot be underestimated. It can literally change lives.

As a university space engineering student who gained a scholarship, Olivia said, "The work of OGLA is incredibly admirable. I wish that I knew it existed when I was in high school because I would've loved being a part of a community of aerospace enthusiasts. But I guess it's never too late because I got to meet you, and see what you and your girls are achieving, and I'm forever grateful that you gave me the opportunity and confidence to challenge myself. Thank you."

It is important to value, forge and nurture workforce diversity. We solve challenges together, build a stronger sense of team identity, and support individual and group wellbeing. The space industry, if truly diverse and inclusive, will have better education and career pathways at its disposal if diverse strengths, abilities, interests and perspectives are understood and supported. ●

Women in space

Australian International School Connecting Minds

We see further

Advancing Australia's space capabilities to create an enduring sovereign space industry

EOS Space Systems, a major division of the Australian high technology company Electro Optic Systems (EOS), has been creating innovative space and communications technologies since 1983.

From the start, innovation and ambition were at the core of EOS Space Systems' operations – and, as the company's IP base expanded to include optics design, gimbals, laser ranging telescopes, beam directors, optical coatings, precision mechanisms, ruggedised assemblies and more, a genuine technological lead was established in several areas.

EOS Space Systems operates as three entities:

- Space Technologies forms the nucleus of research and development across the EOS group and applies EOS-developed optical sensors to detect, track and classify objects in space.
- EM Solutions creates state-of-the-art global satellite communications systems and services.
- SpaceLink is launching a constellation of Medium Earth Orbit satellites to build the communications superhighway for the space economy.

Supporting STEM

EOS Space Systems is an active member of the domestic and international space communities and is passionate about advancing Australia's sovereign space capabilities and about the whole-of-nation benefits onshore innovation brings.

The organisation employs highly skilled workforce of engineers, scientists and other expert personnel and is a strong supporter of the domestic STEM ecosystem, and undertakes a range of activities to ensure the ongoing health of Australia's STEM pipeline.

EOS champions women into the future STEM workforce through its *Scholarships for Future Excellence in STEM*, in conjunction with One Giant Leap Australia. Furthermore, through a partnership with the Andy Thomas Space Foundation, the *EOS Space Systems Research Awards* form an important component of the company's broader program of support, which includes internships, PhD supervision and a range of collaborations with leading universities.

Dr James Bennett, Executive Vice President, EOS Space Systems says, "It's only by investing in the nation's best and brightest young researchers that we will achieve the ambition of advancing Australia's space capabilities and creating an enduring sovereign space industry. EOS is deeply committed to building an Australian space industry, and we take pride in the significant financial and career support we've been able to provide to our talented Australian STEM practitioners over many years."

EOS-AUS.COM

EOS

Arnhem Space Centre Takes Off Into the Future

The future is bright for the Arnhem Space Centre in the Northern Territory, with a goal of up to 50 launches a year by 2025.

IMAGE: Supplied

The successful launches of three NASA rockets at the Equatorial Launch Australia (ELA) spaceport on the elevated and uninhabited Dhupuma Plateau 35km south of Nhulunbuy, in the Northern Territory in June and July 2022, were a major landmark for the Australian space industry. ELA Chief Executive Michael Jones says that while this was cause for celebration, there is "no rest for the wicked".

Jones is referring to the work which lies ahead for ELA as it looks to become a leading centre and location of choice for equatorial launches for customers around the world.

"We are really proud to have achieved a very rare feat—three successful launches in just 15 days—even more so given the challenging and unseasonal wind conditions," Jones said.

"We obviously as a commercial entity want to have more customers, so we are furthering our discussions with

Michael Jones, Executive Chairman and Group CEO

all the rocket companies from around the world to try and get them to come to Nhulunbuy."

When your first commercial customer is NASA, which committed to its first-ever commercial launch outside of the US with ELA, the initial outlook is nothing but positive.

Jones described NASA as "unbelievably generous" in its support, and said ELA is a "much better organisation" as a result of working with the famous space agency.

The Arnhem Land launches were also the first by NASA in Australia since 1995, when a Black Brant IX rocket was launched from the government owned Royal Australian Air Force Woomera range.

In addition to the ELA NASA launches, which saw a 30-person NASA team spend eight weeks at the site setting up in October 2021, with another 80 NASA personnel deployed on the site working with ELA at the time of the mid-year launches, the Arnhem Space Centre site on the Dhupuma Plateau has major advantages for equatorial launches.

Australia's Northern Territory—and East Arnhem land in particular—is ideally placed to host key infrastructure and services for the global space industry with competitive advantages in launch services for rockets and stratospheric ballooning, ground stations and space technology development and testing.

Launching from the Arnhem Space Centre takes full advantage of the Earth's rotation to gain extra velocity improving payload to fuel ratios.

Jones said that the Northern Territory location had world leading advantages because of the orbits it enabled.

"The benefits as far as space dynamics is concerned are massive," he said.

The facility has been initially equipped with three launch pads and accommodates both orbits and sub orbits all in small and medium-sized satellite launch vehicles, and its design allows for support of all current and future launch and recovery technologies.

The facility has distinct areas, such as the launch pad with its 46m high weather tower and a telemetry hub featuring two telemetry dishes and one radar dish.

According to Scott Bissett, the NASA Sounding Rocket Program operations manager, who oversaw the launches, these dishes were integral to the project and key to the capacity of the facility.

"These dishes are central to retrieving the data a rocket will gather, without them we can't record any of the information from space we hope to collect," Bissett said.

"There are two telemetry dishes, a primary dish, which is about seven metres in diameter, and a secondary dish, which is slightly smaller, to ensure all the data is collected and nothing is missed."

The telemetry dishes track the rocket after launch to collect all the necessary data captured while in flight. This

includes the rocket's live video that is captured in real time, motor pressure and GPS coordinates, which is then processed and sent to a section on the space centre called 'read out' where NASA scientists can analyse it.

The launch facility, however, does not exist in isolation.

There is also a regional service hub equipped with a high quality airport, deepwater port, hospital, schools accommodation and optical fibre connectivity.

The Nhulunbuy facility has been some time in coming to fruition, and the vision goes back to 2015 when ELA was first formed.

The company then leased the 275ha parcel of land in November 2017.

ELA was awarded its launch facilities licence and the launch permit for the NASA campaign following a two-year evaluation by the Australian Space Agency. The final approval was delayed by the federal election, with Deputy Prime Minister Richard Marles signing off on the plan in May 2022.

The land lease was taken out with the Gumatj Corporation, representing the traditional owners the Yolngu people, and the project has been very much a collaboration with the local indigenous community.

"We want to create a bright future for our Yolngu families and take up new opportunities," said Gumatj Corporation Chairman Djawa Yunupingu.

"We are active partners in the Arnhem Space Centre and with ELA, helping to construct the infrastructure and supporting its operations.

"We want our young people to see and take up the jobs and business opportunities that come from the growth of the Arnhem Space Centre over time."

The Yolngu people have long been keen observers of the stars going back thousands of years, and their unique understanding and approach is acknowledged in the culture centre only kilometres from the launch site.

Yunupingu says his father painted astronauts coming to Yolngu land in the 1960s and the artwork will also be displayed at the culture centre.

NASA's Scott Bissett said the agency personnel had enjoyed their collaboration with the local indigenous community.

"We had a welcome meet during the site set up when we got to meet a lot of the local folks, and we did a lot of outreach there," he said.

A third partner at the Arnhem Space Centre has been the Northern Territory Government, which has contributed $5 million and has some equity in the ELA business.

Overall, ELA has so far raised more than $23 million from investors and has plans to raise up to a further $50 million as it reaches sustainable profitability and a potential stock market listing in the future.

The goal is for up to 50 launches per year at the site by 2025.

The Northern Territory Government sees space launch as a major driver for economic development.

It has identified that the Australian space launch market could be worth around $1.2 billion over the next decade,

and believes the Northern Territory is well positioned to capitalise on this.

Northern Territory Chief Minister Natasha Fyles was at the launches in June, and she described the event as "an incredible milestone for Australia".

"Working with the Gumatj people in launching the rockets into space combines one of the oldest cultures in the world with some of the most advanced technology ever," Fyles said.

"The Arnhem Space Centre is set to be a pre-eminent multi-user commercial space launch facility, with ELA providing world-class launch services supporting testing, launch and recovery of space vehicles and payloads flow to and from all space orbits.

"ELA and NASA are rocketing East Arnhem Land into the global spotlight for investors, and this will help our industry grow, create more jobs for locals and more opportunities for businesses to expand," Fyles said in a statement.

Since the history making NASA launch, the ELA team has visited Japan where the company says it had some "very productive meetings" with potential partners, such as the Japan Aerospace Exploration Agency.

An ELA team also went to the International Astronautical Conference in Paris in September, where there was great interest in the facility and in the wider Australian space industry.

Also in September, ELA announced it was headquartering its operations in Adelaide, putting it closer to the Australian Space Agency and the growing ecosystem of space businesses in the state.

While staff will remain on the ground in the Northern Territory , corporate functions such as business development and engineering roles and support functions will be based at Lot Fourteen in Adelaide's CBD, close to other innovative space companies.

Soon after the announcement was made, ELA advertised a number of roles with the company, including multiple roles for engineers.

"Adelaide and South Australia will be an essential base for our world-class space engineering in support of our planned high tempo space launch operations," said Jones, who has a long history in the aviation industry as founder of the Regional Express—Rex—airline. He took an advisory role with ELA and then an executive operational role in June 2021.

"We look forward to taking a leading role in the development of the Australian space capability as we work towards achieving our mission to deliver world-class launch services supporting testing, launch and recovery of vehicles and payloads.

"We intend to build strong working relationships with the local universities and other space companies clustered in South Australia with a clear plan to foster emerging talent." ●

"We look forward to taking a leading role in the development of the Australian space capability as we work towards achieving our mission to deliver world-class launch services supporting testing, launch and recovery of vehicles and payloads.

IMAGES: Supplied

Australian launches help search for habitable planets

The three NASA launches at the Arnhem Space Centre in June and July 2022 were not only hugely significant for Equatorial Launch Australia (ELA) and the Australian Space Industry, but were also important for NASA and for the understanding of space.

Of the over 5,000 exoplanets we know about across the galaxy, only Earth is known to host life. In the search for other exoplanets that could host life as we know it, astronomers have focused on planets that orbit in the habitable zone—defined as the distances from a star where a planet's surface temperature could support water.

The NASA astrophysics studies could only be conducted from the Southern Hemisphere, and ELA was chosen as the location for NASA's first ever launch from a commercial spaceport.

The three successful launches enabled experiments conducted by US universities, with the rockets achieving an altitude of more than 250km before descending by parachute and landing southwest of the launch site.

The X-ray Quantum Calorimeter, or XQC, experiment from the University of Wisconsin was successfully launched on June 26. Then the Suborbital Imaging Spectrograph for Transition region Irradiance from Nearby Exoplanet, or SISTINE mission, from the University of Colorado was conducted on July 6.

The third of the three NASA space science missions was the DEUCE mission—or the Dual-channel Extreme Ultraviolet Continuum Experiment—from the University of Colorado, launched with the ASA Black Brant IX suborbital sounding rocket on July 11.

"Ultraviolet radiation from the Sun played a role in how Mars lost its atmosphere and how Venus turned into a dry, barren landscape," said Brian Fleming, astronomer at the University of Colorado, Boulder, and principal investigator for DEUCE.

"Understanding ultraviolet radiation is extremely important to understanding what makes a planet habitable.

"But that's a rudimentary way of characterising habitability."

While water is one part of making a planet hospitable, for a planet to support an Earth-like biosphere, it also

needs an atmosphere. If the habitable zone is bathed in too much ultraviolet radiation, any water vapour in the upper atmosphere could escape, quickly drying out the planet.

Atmospheres can also be eroded by radiation and extreme flares from a planet's host star, exposing the surface to harsh ultraviolet radiation, which can break apart molecules like DNA.

But just how much ultraviolet radiation is emitted by different types of stars is poorly known. Without accurate knowledge, astronomers cannot accurately predict which planets might host life.

"We need to understand the stars so that we can understand any planets we find there," said Kevin France, astronomer at the University of Colorado, Boulder, and principal investigator for the SISTINE mission.

The DEUCE and SISTINE missions took important measurements of ultraviolet light to help narrow the search for habitable planets.

The researchers selected Alpha Centauri A and B because they can serve as a useful reference against which to calibrate observations from the Sun—the only other star for which we have complete ultraviolet measurements.

"Looking at Alpha Centauri will help us check if other stars like the Sun have the same radiation environment or if there are a range of environments," France said.

"We have to go to Australia to study it because we can't easily see these stars from the northern hemisphere to measure them."

Ultraviolet light is absorbed by dust and gas in space. This makes it nearly impossible to measure ultraviolet light from more distant stars at the level needed for these types of analyses. The Alpha Centauri system, however, is just 4.3 light-years away, close enough that much of its ultraviolet light reaches us before being absorbed.

Ultraviolet light is also mostly blocked by Earth's atmosphere, so researchers have to send instruments into space to measure it.

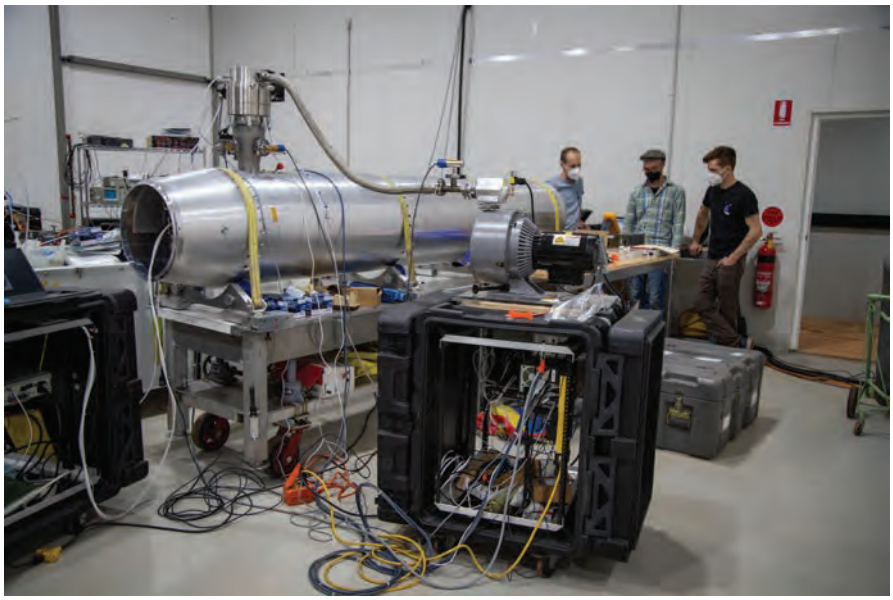
Since the full range of ultraviolet light cannot be measured with a single instrument, DEUCE measured the shorter, extreme-ultraviolet wavelengths and SISTINE measured the longer, far-ultraviolet wavelengths. The wavelength coverages should slightly overlap so that the collected data can be calibrated and used as one dataset.

This information will then be used to create models that can help astronomers assess which other star systems could support habitable environments.

"This commercial launch range in Australia opens up new access to the Southern Hemisphere's night sky, expanding the possibilities for future science missions," said Thomas Zurbuchen, NASA Associate Administrator for the Science Mission Directorate.

"In addition to furthering our science goals, this science campaign builds on recent collaborative efforts with Australian organisations including the Artemis Accords, NASA's Climate Absolute Radiance and Refractivity Observatory Pathfinder mission, and the development of a lunar rover that could launch as early as 2026."

"We're excited to be able to launch important science missions from the Southern Hemisphere and see targets that we can't from the United States," said Nicky Fox, Director for NASA's Heliophysics Division at NASA Headquarters in Washington, DC. ●



IMAGES: Supplied

KBR's Principal Partner. Rob Hawketts, VP Government Solutions APAC, giving the welcoming speech at the 2022 Australian Space Awards.

KBR brings a 65-year space heritage to Australia

The scale of Australia's ambition in space, and the creation of the Australian Space Agency as an international portal to the marketplace, means that a growing number of international companies is showing an interest in Australian space operations. Some of them are long-established hardware manufacturers with a proud heritage. Others, like KBR, bring a different focus to the business. The company's Australian Business Development Executive for Space, Phil Randerson, spoke to **Gregor Ferguson.**

IMAGES: Supplied

> **One of KBR's strengths is that it can reach back for the skillsets that supported NASA as well as current US Government and military programs. That gives KBR in Australia the skills and expertise needed to understand and then enhance the missions of both the Australian Space Agency and Defence Space Command.**

KBR, or Kellogg, Brown & Root Pty Ltd to use its historic name, is a global science, technology and engineering company that boasts proudly it has supported every crewed space mission NASA has ever conducted and supported every US astronaut since 1968. Today it provides command and control, communications, telemetry and tracking for more than 170 military satellites operated by the US government and its allies, many of them involved in Space Domain Awareness (SDA).

That is the company's heritage in space, says Randerson.

Its Australian space operations, though nascent, are built on the Australian government's stated ambition and on the growth of Australia's space industry, which is composed mainly of small-medium enterprises (SMEs) and startup companies. While Defence has a $7 billion pipeline for approved space projects, the Defence space shopping list is closer to $19 billion, and that quantum has game-changing potential.

Many of the SMEs operating in Australia's growing space sector lack the size and structure to work effectively through the Australian government's procurement processes. But pursuing the Australian market alone will not allow them to grow. If they face these troubles in the Australian market, they will face even greater challenges trying to work with the governments of other space-savvy Five Eyes nations such as the USA and UK, believes Randerson.

"The space industry in Australia is made up of a number of organisations, including cutting-edge innovators, but ultimately there are numerous small businesses that need support in order to be able to work and contract with government," he tells *Australian Space OUTLOOK*. "And that's where KBR has the ability to help bridge the gap for those companies and help them to deliver their capabilities to government in support of the Australian space mission."

KBR is a largely product agnostic company, he points out, so has the flexibility to work with different companies and government agencies without any risk of competing with itself or compromising a partner's IP.

The company's footprint in Australia is extensive enough to support its ambitions. It employs 1,800 people and is established in the defence market as a systems integrator and innovation partner. Space is a new direction for the company in the Asia-Pacific region, says Randerson.

"We're really in the early days of building out a strategy in terms of how we want to support the space industry and space domain within the Asia-Pacific region," he says. KBR in Australia can reach back to a 65-year US space heritage. Its military space organisation is very much focused on capabilities that support SDA, and integrated space missile defence, and it runs multiple sites around the world directly supporting both US Government and Defense, and NASA space missions.

"There's a lot of expertise in the US business in terms of scientific research and development of future capability," he tells *Australian Space OUTLOOK*. "So in terms of our footprint here in Australia, what we're trying to do is access those capabilities and skillsets so that we can adapt them to best support the Australian space mission, whether that be civil or defence."

Australia's lead in space is set by the Australian Space Agency, but it has a significant defence focus as well, and organisations seeking to work with the Agency need to understand this, he believes. One of KBR's strengths is that it can reach back for the skillsets that supported NASA as well as current US Government and military programs. That gives KBR in Australia the skills and expertise needed to understand and then enhance the missions of both the Australian Space Agency and Defence Space Command.

KBR Australian Business Development Executive for Space, Phil Randerson

The capabilities of Defence Space Command are critical to protecting our space assets, he adds. "Obviously assuring access to space is critical for any mission that launches, whether it be commercial, government or military. Without that assurance of access it makes it very difficult for companies within Australia to invest with confidence. Of equal importance is protecting the existing capabilities that we all rely on, even things like the GPS in our cars."

So, is KBR an above the line company (that is working for the government), or below the line (working as a supplier)?

"In the space context right now we're neither because we're very much in the early days of developing our space strategy," says Randerson. "We are really beginning the journey of approaching the market. So we have both options available to us. There are so many different aspects of support that are required at the moment, that sometimes the best thing we can do is to work with the government; for example, to help scope requirements, and that really plays into that above the line space.

"Using the skills that we have across our business and the breadth of work that we do, we're naturally positioned to pivot and to support the space mission in that way." ●

Air Vice-Marshal Catherine Roberts AO, CSC

DEFENCE SPACE COMMANDER

Air Vice-Marshal (AVM) Catherine Roberts AO, CSC became the inaugural commander of Defence Space Command on 18 January this year, the culmination of a journey that began, for her, the day that Neil Armstrong walked on the moon. She has a history of breaking new ground. In 2018 she was appointed Australia's inaugural Head of Air Force Capability, responsible for imagining, designing and shaping the needs and future requirements of both air and space power for the joint force, not just the RAAF.

An engineer by training, AVM Roberts joined the RAAF in 1983 and has worked in Engineering in Acquisition, at the Aircraft Research and Development Unit in Edinburgh, SA, and in the UK as part of the Hawk Lead-In Fighter in-country team and as Assistant Air Adviser at the Australian High Commission in London. She commanded the Tactical Fighter and Training Aircraft Systems Program Offices in Australia before becoming Head of Aerospace Systems Division at what is now CASG, responsible for acquiring and sustaining all of the RAAF's fixed-wing assets. She answered questions from *OUTLOOK's* Gregor Ferguson.

Why has Space become so important to the ADF? Is it possible to plan the ADF's future capabilities nowadays without taking the Space dimension into account?

Space is essential to Australia's critical infrastructure and to our military operations. Space effects underpin almost every aspect of contemporary military power. In fact, space-based assets have become so ubiquitous to land operations and modern warfighting that almost every digital system in use today is reliant on the data that space-based assets provide. From precision guided weapons and long-range strike missiles to navigation and geospatial intelligence—connection to space is crucial to the effectiveness and accuracy of these systems. No modern military can effectively plan future capabilities without accounting for access to the space domain.

From a civilian standpoint, our critical and commercial infrastructure is reliant on space, from GPS systems and communications to e-commerce and traffic management. Entire systems and cities are reliant on space communications. Losing access to space would impact not just the national security of Australia but would fundamentally change our way of life.

The ADF has considered its Space capabilities to be of growing importance for a number of years, so why was it important to stand up Defence Space Command at this particular point?

The decision to launch Defence Space Command was not a spontaneous one—we have been developing the blueprint for this enterprise for a considerable amount of time. Space was recognised as an operational domain in its own right in 2019, with the Chief of Air Force as Space Domain Lead. At this time, it was recognised that transformational change was needed to support the delivery of new space capabilities for a congested, contested and competitive space domain. The establishment of Defence Space Command in 2022 is a major step towards a centralised, coordinated and structured Defence space enterprise to support joint operations and national security.

How many people does Defence Space Command employ today and what are the goals for, say, 2024 and 2030?

Defence Space Command brings permanent and part-time members of the Royal Australian Navy, Australian Army and the Royal Australian Air Force as well as Australian Public Service personnel and industry into an integrated headquarters within Air Force. There are over 130

IMAGE: CPOIS Cameron Martin

Commander of Defence Space Command, Air Vice-Marshal Catherine Roberts, AO, CSC, addresses a question during a panel discussion at the 2022 Air & Space Power Conference at the National Convention Centre, Canberra.

personnel currently working within Defence Space Command (as of May 2022) and we plan to significantly grow the workforce over the next few years. A key preliminary objective for us is to raise, train and sustain this space workforce to ensure we can meet the needs of the rapidly developing space domain.

Although it is hosted within the RAAF, is Defence Space Command a joint command?

As Commander Defence Space Command, I report directly to the Chief of Air Force. However, our personnel are drawn from across the three Services, the Australian Public Service as well as industry experts. This provides a unique diversity of backgrounds, perspectives, and expertise across the organisation, and ensures a holistic approach to coordinating space priorities across ADF, as well as the government, research and space industry sectors.

What do you want Defence Space Command to look and feel like, especially for allies and friends looking to work with the ADF's Space specialists?

Space is acknowledged to be an especially challenging domain, and our mission requires a mindset that is comfortable with ambiguity, a curiosity that is never satisfied, and a resilience that keeps you trying through failure and succeeding through adversity. In environments like ours, where the one constant is change, culture is incredibly important because it keeps us true to who we are. Culture helps us know which way is up in the zero-gravity environment of the newest, largest and most complex domain. I'm keenly focused on making sure that our culture enables us to deliver on our mission. We need a culture that empowers us to be bold—to develop our workforce, to develop capabilities for Australian space power and to contribute to operations.

I see Defence Space Command as a constellation, and our success will be defined by the connections between us and our connections with our many partners. By working together we will achieve our vision of assured Australian civil and military access in space, integrated across government, and in concert with our allies, partners and industry.

You went to the 37th Space Symposium at Colorado Springs in April this year. This was the world's first real look at the scale of Australia's ambition and emergent capability in Space. How did you find it and how do you think our allies found Australia—Defence Space Command, the RAAF and ADF, industry, Australia's research sector?

With over 12,000 attendees, and all the major international players present, this was a truly incredible opportunity to demonstrate the breadth of Australia's space ambitions. The conference had great representation from Australian industry as well as Defence Space Command—you could just feel the excitement for what Australia has to offer. Meetings with key Combined Space Operations leaders further reinforced the message that Australian contributions to the allied capability network are indispensable.

Australia's Defence Space Strategy identifies five principal lines of effort—why have you chosen those five?

The lines of effort in Australia's Defence Space Strategy were developed in collaboration with all three services, government, space industry experts, allies and international partners. The lines of effort serve to highlight the areas we need to focus on as we grow our capabilities, workforce, infrastructure and partnerships, as well as helping to

IMAGE: LAC Samuel Miller from Air Force database

enhance the national understanding of the criticality of space.

Many of the lines of effort have a time horizon within the next five years. The immediate priority for Defence is to evolve the space enterprise and better integrate the many diverse elements of space capability.

Some space technology is developing incredibly quickly. How will Defence Space Command work effectively with such a fast-moving sector while, at the same time, looking to establish more enduring capabilities such as communications satellite constellations and ground stations that may remain in orbit or established on the ground for as much as two decades?

I am really excited about getting our own Australian space capability and working with Australian industry. We are enhancing our sovereign capabilities so we can be self-reliant in the detection of threats and collection of information for the defence of our nation. This is crucial to gaining timely, accurate information for the safety and capability of our forces. This evolution of our operational capability will ensure we can efficiently and effectively respond when required.

To reach our 2030 space vision, we are focused on delivering space capabilities to assure access to space; enabling situational awareness; and delivering real-time communications, navigation and timing. We are working with our partners to define a space architecture with a constellation on the ground and a constellation in space that will leverage Australia's space advantages as we contribute to our global efforts.

It is incredibly important for us to know what is happening in space and using space to let us know what is about to happen on Earth. Space domain awareness is one of the top priorities of our newly established Space Command.

It is becoming apparent to many observers (and I think also to the ADF) that Australia needs a single Space industry that's sustainable because it serves both the defence and civil sectors. How will Defence Space Command work with the civil sector?

We have seen over the past few years that the space sector is advancing at an incredible speed. This presents an exciting opportunity to rapidly develop Australia's space future in cooperation with experts from multiple sectors. To ensure our capability advancement stays ahead of the curve, the Australian Government has committed $7 billion over the next decade to transition the Australian Defence Force from a consumer to a sovereign controlled contributor in space.

Many of the technologies being developed for space are dual use, having both civilian and defence applications, including space-based intelligence, surveillance and reconnaissance, weather, navigation and timing.

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A coordinated approach to the development of sovereign space capabilities, particularly with Australian industry partners, is required to ensure unity of effort. We are developing and aligning our roadmaps very closely with the Australian Space Agency to develop key technologies that provide a level of viability for Australian companies.

We are also exploring new avenues for cooperation. Defence Space Command personnel recently joined space experts from over 100 companies, start-ups, and universities around the globe to take part in the Commercial Sprint Advanced Concept Training series – a week-long experimentation event coordinated by the United States Space Force that aims to test the combat readiness of its space forces. Initiatives like this enable the osmosis of knowledge and expertise among the defence, civil, and commercial space sectors, which benefits everyone. ●

Commander of Defence Space Command, Air Vice-Marshal Catherine Roberts, AO, CSC.

IMAGE: LAC Samuel Miller from Air Force database

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Connecting everyone and everything – unlocking opportunity to give everyday Australians a stake in space

By Peter Girvan and Rob Teasdale

The unprecedented expansion of Australia's space industry since 2018 presents a fantastic economic and social opportunity for Australia. Intuitively, one of the key challenges posed by this opportunity is the need to tie the benefits of space capability back to our everyday lives. Put another way, how do we unlock these opportunities to give everyday Australians a stake in space? Viasat, as a global communications company, sees connectivity as the answer to this question.

At Viasat, we believe everyone and everything can be connected. And when everyone is connected, the possibilities are limitless.

Here in our Australian business, when we talk about those limitless possibilities, we are thinking about how Australian businesses can increase productivity through network technology and equipment innovation in the broadband satellite market. Or how secure and seamless connectivity and networking can enable the Australian Defence Force and the National Intelligence Community across air, land, maritime, space and cyber domains. Or how high-capacity inflight internet can deliver an exceptional connected experience for Australian travellers, while unlocking new possibilities for Australian airlines.

Solving high-value, challenging problems is in our DNA. And we are experts in making a difference by delivering valuable communications and connectivity experiences. Our innovations have helped shape how consumers, businesses, governments and militaries around the world communicate, even in the hardest-to-reach places. We are driven by our ability to redefine what is possible, and deliver bold results to our customers, partners and shareholders worldwide.

So how can we help to unlock opportunity and give everyday Australians a stake in space?

Later this year we will launch the first-ever terabit-speed broadband satellite, ViaSat-3. Two more high-capacity Ka-band ViaSat-3 satellites will follow, comprising a global constellation that will increase the coverage and capacity of our network to bring high-quality, low-cost connectivity where it is needed most, almost anywhere in the world.

With the ViaSat-3 constellation, Viasat anticipates being capable of delivering bandwidth economics superior to that of any other space-based provider. This will allow us to offer unprecedented bandwidth productivity that helps us keep pace with growing marketplace demand and fuels innovation. This includes extensive investment in Australian ground infrastructure to support the ViaSat-3 Asia-Pacific satellite.

Also, we expect to conclude our acquisition of Inmarsat, creating a global communications innovator with enhanced scale and scope to affordably, securely and reliably connect the world. The spectrum, satellite, and terrestrial assets of the combined company will enable a global high-capacity hybrid space and terrestrial network, capable of delivering superior services in fast-growing commercial and government sectors. This advanced architecture will deliver higher speeds, more bandwidth, and greater density of bandwidth at high demand locations, at lower cost.

For over 35 years we have been on a mission to connect the world. We turn challenges into opportunities, headwinds into tailwinds, powering millions of connections on land, in the air, and at sea. We are looking forward to providing the connectivity to help unlock opportunity to give everyday Australians a stake in space. ●

Peter Girvan is Viasat Australia's Vice President for Space & Commercial Networks, and Rob Teasdale is Viasat Australia's Vice President for Government Systems

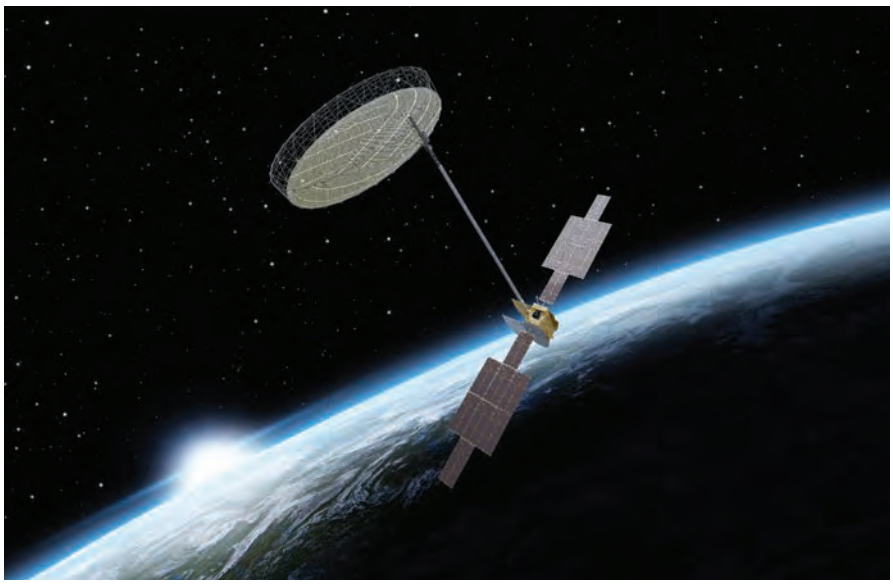

IMAGE: Supplied

Defence Space Command

If you were forced to distinguish between ‘air’ and ‘space’, you would probably argue that ‘air’ ends at the altitude where air-breathing engines run out of breath; space is everything above that, says **Gregor Ferguson.**

For the Royal Australian Air Force (RAAF), which is the Australian Defence Force’s space domain leader, the distinction is relatively unimportant. Almost anything that flies or goes into orbit is the RAAF’s responsibility.

As everything Defence does nowadays is also essentially ‘joint’, it follows that Space needs a joint organisation to help ensure ongoing access to what is increasingly a highly competitive environment. Hence the standing up, on 18 January this year, of Defence Space Command (DSpC).

Although its commander, Air Vice-Marshal (AVM) Catherine Roberts AO, CSC, reports directly to the Chief of Air Force (see p.60), DSpC is very much a joint operation. The colour of the uniform does not matter—assured space access is now a critical enabler of Australian military power across all domains.

When it was stood up DSpC published Australia’s Defence Space Strategy, a 40-page document that begins by acknowledging Australia’s needs and shortcomings. The ADF is critically reliant on space access, but space is increasingly crowded and becoming

IMAGE: Pixabay from Pexels

more dangerous. Defence has only limited sovereign capabilities at present, so significant government investment is needed to address the gaps in Australian military space capability.

The Strategy identifies five lines of effort to:

1. Enhance Defence's space capability to assure joint force access in a congested and contested space environment.
2. Deliver military effects integrated across the whole of government and with allies and partners in support of Australia's national security.
3. Increase the national understanding of the criticality of space.
4. Advance Australia's sovereign space capability to support the development of a sustainable national space enterprise.
5. Evolve the Defence Space Enterprise to ensure a coherent, efficient and effective use of the space domain.

DSpC is organised in three branches: Strategic Plans, Capability Development and Operational Coordination. The first provides essentially a Chief Operating Officer function; the third delivers the crucial 'Raise, Train and Sustain' function and is responsible for certifying competency in this most demanding of all technology domains.

The second is of most interest to industry. It is the Capability Development Branch's responsibility to work out what capabilities the ADF will need in the future and then to engage with industry to deliver that.

One of the biggest challenges facing DSpC and AVM Roberts is workforce. Skilled people are in short supply and DSpC has to develop a career development framework with a proper career path for space professionals

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to deal with the challenge, not just into the future but in the here and now. Workforce is a limiting factor on the speed of Australia's space capability growth (see p.36) and DSpC is looking at novel ways of dealing with this challenge and of using its existing workforce as efficiently and economically as possible.

In the meantime, it has pulled together a cadre of 160 (and growing) motivated and enthusiastic people, some of them relatively unskilled, others highly skilled space specialists who have trained overseas.

The internal culture that AVM Roberts is trying to establish within DSpC is one that values expertise over seniority and that embraces risk and speed of entry into service. Technology development and growth result in rapid change, and Defence as a whole needs to alter its culture and attitude towards risk in order to field space capabilities at the speed of relevance while they are still relevant and effective.

To this end, DSpC is using innovation contracts awarded by the Defence Innovation Hub to fund some rapid prototyping by a number of smaller firms in Australia. The recent history of closer collaboration between the end user and the developer has resulted in successful projects such as the MQ-28A Ghost Bat (formerly the 'Loyal Wingman') and the M2 satellite developed with Defence by UNSW at ADFA. The DSpC needs to embrace that closer relationship along with faster development because technology growth will not slow down.

> **Many of the technologies being developed for space are dual use, having both civilian and defence applications, including space-based ISR, weather, navigation and timing,**

The sharp end of space capability delivery is the the Australian Space Operations Centre, or AUSSpOC, within Joint Operations Command in Canberra. This is the focal point for the generation of space domain awareness (SDA), the planning and execution of space control measures, and the integration and coordination of other space operations in support of the joint force. The commander of AUSSpOC is the Director General Air and Space and the Centre is permanently assigned to the ADF's Commander Joint Operations.

The ADF's immediate priority is to better integrate the many diverse existing strands of Australian space capability. But it does not seek to stand alone in this domain. Although Defence is by far the biggest investor (at present) in Australian space capability, DSpC acknowledges that a sovereign military capability needs a partnership between the civil and military sectors. Why? For two reasons. Firstly, Australia is a small market so it cannot afford undue industry specialisation, because that is simply uneconomical; and secondly, much of the technology that Defence needs was developed originally for the civil sector anyway and that will remain the case.

"Many of the technologies being developed for space are dual use, having both civilian and defence applications, including space-based ISR, weather, navigation and timing," acknowledges a Defence spokesperson.

The civil space sector's existing strategy, Advancing Space: Australian Civil Space Strategy 2019-2030, aims to triple the sector's size to $12 billion dollars and create as many as 20,000 extra jobs by 2030. Defence would benefit from much of that growth but, in March 2022, the Government announced that this strategy would be subsumed and expanded into an all-embracing National Plan for Space which will look right across the civil and defence sectors. This will be released in mid to late 2023 by the Australian

Head of Air Force Capability Air Vice-Marshal Catherine Roberts AM, CSC (right) alongside Defence Space Command representatives, outside the Electro Optic Systems (EOS) facilities at Mount Stromlo Observatory, Canberra.

IMAGE: LAC Adam Abela form Air Force database

Space Agency, with significant input from Defence personnel, and will look out to 2040.

The National Plan for Space will ensure that as Australia develops its sovereign military and civilian capabilities, the industry base is there to deliver and support it, from research and design through to manufacture. It will also provide the whole-of-sector insight that the government needs to ensure any money spent is complementary and not duplicated. Arguably, the only difference between a civil space industry and a military one is the level of classification the customer applies to some of the stuff they buy, and the level of sovereignty needed to assure the capability: the technology remains almost exactly the same.

The change of government in May 2022 did not change that policy trajectory.

Internationally, Defence is a participant in the Combined Space Operations (CSpO) initiative which consists of Australia, Canada, Germany, France, the United Kingdom, New Zealand and the USA. Under a common vision, the CSpO nations agree upon guiding principles and lines of effort to foster cooperation and coordination and to collectively promote responsible behaviour in space.

Australia has a long history in space, DSpC points out, "Australia has historically been a high-level contributor to global space efforts," says a spokesperson. "Our national space research output is world-class, and our unique geographical location and vast open land in the Southern hemisphere mean we are well positioned to continue to grow and mature our space capability."

Against this background, the DSpC has set itself four main jobs:

1. Develop and advocate for space-specific priorities across whole-of-government, industry, allies and Australia's international partners.
2. Allow Defence to establish an organisation to create, train and sustain its people and assign trained space specialists to the Chief of Joint Operations when needed.
3. Conduct strategic space planning, assist in the development of refinement of space policy, guide scientific and technological space priorities and define a resilient and effective space architecture in close collaboration with Australia's allies.
4. Ensure the design, construction, maintenance and operation of Defence space capabilities are in accordance with Defence standards and limitations.

Some of the items on this very high-level job list will be addressed by the National Plan for Space (see p.40). But others are a direct follow-on from the 2020 Force Structure Plan (FSP), which acknowledged the criticality of the space domain and "committed $7 billion over the next decade to transition the ADF from a consumer to a sovereign controlled contributor in space," a DSpC spokesperson said.

Actually, it will be considerably more than $7 billion, according to some in the industry. The 2020 FSP lists seven space-related projects worth more than $20 billion if you take the highest estimates of their potential worth (See Table 1). They range from Military Satellite Communications (MILSATCOM), Earth Observation (EO) and Surveillance to extensive ground infrastructure. And that does not include service-specific Army, Navy and Air Force space-enabled communications and navigation upgrades.

The projects that occupy DSpC's attention in the short-medium term are:

1. Joint Project 9102, which will give Defence its first ever sovereign constellation of up to four MILSATCOM satellites covering all of its communications bands—UHF, VHF, X-Band and Ka-Band—along with a Satellite Operations Centre. A choice of prime contractor will be announced early in 2023 and five industry teams have been shortlisted for this role, led by:
    a. Boeing Australia which is teamed with Leidos, ViaSat, Blacktree Technology, Clearbox Systems, Saber Astronautics and Titomic
    b. Lockheed Martin Australia, which has a supply chain of smart Australian companies including Blacktree Technology (see p.72), DXC Technology, Calytrix, EM Solutions, Clearbox Systems, Shoal Group and Ronson Gears

TABLE 1 – Force Structure Plan Space Projects

PROJECT	TIMELINE	VALUE ($BN)
JP 9120 Satellite Communications	2020-2030	4.6 – 6.9
Satellite Communications Assurance	2028-2038	1.7 – 2.5
Terrestrial Operations in Contested Space	2027-2038	1.4 – 2
JP 9360 Space Situational Awareness	2020-2033	1.3 – 2
DEF 799 Satellite Imagery Capability (Access)	2020-2031	0.4 – 0.5
Sovereign Satellite Imagery Capability	2020-2035	3.2 – 4.8
Additional Sovereign Satellites (Imagery)	2031-2040	1.2 – 1.8
Total – up to		**$20.5 Billion**

   c. Northrop Grumman Australia, which is teamed with Inmarsat, L3Harris and Blacktree Technology
   d. Airbus, whose 'Team Maier' is offering a version of the UK's Skynet constellation and includes Microsoft, Clearbox Systems, Blacktree Technology, UGL and Willyama
   e. Optus's Team AUSSAT which includes Blacktree Technology, Thales Australia and Mitsubishi Electric who built the Optus C1 satellite currently used by Defence.

2. Joint Project 9360, which consolidates six previously separate SDA projects into a single, much better integrated program that will deliver enhanced capability in a series of two-yearly 'tranches'. Between them, they will provide Defence with a sovereign and robust SDA capability based on a range of space-based and terrestrial sensors. The rapid growth of both space debris and constellations of up to several hundred satellites in low Earth orbit makes the risk of collision very much greater. Continuous SDA is vital to ensure that satellites are put into orbits that do not expose them to the risk of collision with orbiting debris or other space vehicles. The six consolidated projects are:
   a. AIR 3029 Ph.2, the relocation of an ex-USAF C-band space surveillance telescope to Exmouth, WA.
   b. JP9350 Ph.1, the development of an ADF Space Situational Awareness (SSA now SDA) mission system.
   c. JP9351 Ph.1, the development of a suite of indigenous Australian SDA sensors.
   d. JP9352 Ph.1, the replacement of Defence's space surveillance radar.
   e. JP9355 and JP9356 which focus on the delivery of space-based Infrared imagery.
3. Defence Project 799, which will enhance Defence's access to commercial satellite imagery and is linked to a US project, possibly a National Reconnaissance Office program which got underway early in 2022. Defence often needs rapid access to commercial satellite imagery and Phase 1 demonstrated how useful this could be during the 2019-20 bushfires where commercial imagery was used as a planning and resource management tool in Operation BUSHFIRE ASSIST. Under this project, says Defence, there will be more opportunities for commercial imagery suppliers with relevant capabilities to support Defence missions.

Australia's National Space Mission was announced in March 2022 and funded in that month's budget to the tune of $1.16 billion to 2038. This will deliver an EO capability based on a sovereign constellation of four satellites designed and built in Australia. Defence will be an investor in this project which will be led by the Australian Space Agency.

And the future? The need to develop a specific Space career framework for DSpC's workforce is an acknowledgement that space is a very specialised technology and operational domain and that it needs highly trained enthusiasts. It also almost presupposes there will be a separate space service at some point that offers newcomers a career in this domain. However, DSpC has refused to be drawn down that speculative path.

"The establishment of Defence Space Command, and the recognition of Space as an operational domain, reflects the ongoing importance of Space to Nation Security," says a spokesperson. "Considering our size, resources and nascent space capabilities, Defence Space Command, in its current form, is appropriate at this time for Defence."

However, the spokesperson adds, "The space domain is in a constant state of rapid evolution—new technologies, new learnings, new threats and new requirements emerge every day."

So never say never. ●

Head of Air Force Capability, Air Vice-Marshal Catherine Roberts AM, CSC, inside the Electro Optic Systems control room at Mount Stromlo Observatory, Canberra.

IMAGE: LAC Adam Abela form Air Force database

Blacktree Technology lines up for JP9102

One of the world's leading UHF SATCOM systems specialists is based in Perth, WA, and it has been sought out by every contender for the Australian Defence Force's Military Satellite Communications (MILSATCOM) program, Joint Project 9102, **says Gregor Ferguson.**

Joint Project 9102 (JP9102) will give the ADF its first ever sovereign constellation of up to four MILSATCOM satellites along with a ground-based Satellite Operations Centre. Defence will select a prime contractor in 2023 from five industry teams that have been shortlisted for this role, that include Airbus, Boeing, Lockheed Martin, Northrop Grumman and Optus.

Whichever team wins, Blacktree Technology will be involved in the JP9102 High Mobility Ground and Control Segment—the Ultra High Frequency (UHF) SATCOM portion of the final package, says Director and co-founder Joel Nevin. Not only is Blacktree Technology a sovereign technology provider, which is increasingly important for foreign owned firms looking to do business in Australia, the company is also a world leader in the development of radio frequency (RF) SATCOM systems.

"It is a privilege to be selected on all five teams," Nevin tells *Australian Space OUTLOOK*. "This is an acknowledgement that the High Mobility segment is a complex area and one in which Blacktree has a proven capability. We deliver vertically integrated systems that work and which we can support."

Given the complexity of mobile UHF SATCOM, Blacktree Technology's experience makes it a genuinely low-risk member of each of those teams as well as a trusted partner of the customer. The company emphasises that it provides a turnkey vertically integrated RF capability that embraces both antenna systems and signal management—says Nevin and it takes responsibility for every part of the acquisition and support program: systems engineering; support system design; implementation; and integrated logistics support.

To underline its credentials as an in-service support player as well as a provider of innovative technology, earlier this year the company won a five-year, $36 million contract from the Department of Defence's Capability Acquisition and Support Group (CASG) to provide support for the ADF's UHF SATCOM system in the Narrowband Systems Support Contract. This is a full-scope support agreement incorporating all of the constituent functions required to sustain the UHF SATCOM system which provides narrowband voice and data SATCOM services in support of ADF missions. The contract will see the Blacktree support network control sites and ancillary services.

Blacktree Director and co-founder Joel Nevin

So, selecting Blacktree Technology for the mobile UHF SATCOM element of the program was a logical choice for the teams shortlisted for JP9102.

Blacktree Technology has been quietly designing, building and sustaining entire mission-critical communications systems for Defence as well as for civilian and export customers for 20 years, Nevin tells *Australian Space OUTLOOK*. It was formed in 2002 to design, deliver and sustain critical communications systems. Its Defence history includes UHF SATCOM ground stations in Perth, Canberra, Darwin and at 13 other sites.

IMAGE: Nicole Avagliano from Pexels

The company's 'secret sauce' also includes its knowledge of current and future technical and customer requirements, she adds. It is a player in multiple MILSATCOM programs in Australia and overseas, so it has a keen sense of where technology is going. It also, therefore, understands evolving customer needs.

However, its DNA goes back another decade or more. In 2015 Blacktree Technology acquired the intellectual property and, importantly, the supply chain of another long-established company, fellow Perth-based antenna manufacturer Spirit River, which had been instrumental in introducing UHF SATCOM to the ADF in the earlier phases of JP2008. Previously, Spirit River had also supported UHF SATCOM systems on the RAN's ANZAC-class frigates (they are still there) and to a range of export customers, both governments and prime contractors.

The company's MILSATCOM systems are now in service with the ADF, Five Eyes nations and other NATO customers supporting MILSATCOM constellations across the globe.

In the near future, the RAN plans to issue a request for tender to realign its maritime communications systems in Project SEA 1442 Ph.5. Blacktree plans to be part of this and potential future opportunities overseas that require systems for the ground and control segment to support communications satellites with a UHF SATCOM capability. The current global growth of MILSATCOM capabilities provides plenty of opportunities for subject matter experts such as Blacktree Technology.

Why is Blacktree Technology successful? There are four reasons, believes Nevin. It offers a vertically integrated, end to end system that is radio-agnostic and supportable; it offers proven technology that consistently exceeds customer expectations; the company's equipment, both electronic and mechanical, continuously exceeds its planned life of type, which reduces life cycle costs and uncertainty for its clients; and as a result its technology is trusted by its users.

The company's 'secret sauce' also includes its knowledge of current and future technical and customer requirements, she adds. It is a player in multiple MILSATCOM programs in Australia and overseas, so it has a keen sense of where technology is going. It also, therefore, understands evolving customer needs. And its work with overseas technical partners, combined with ongoing internally funded R&D and continual staff development, help keep the company up at the leading edge of RF technology.

Blacktree Technology also aligns with the first-term priorities of Defence Industry Minister, the Hon Pat Conroy MP, who is determined to support Australian SME's like Blacktree Technology graduate to the next level from small to medium sized enterprises. It is a world-leading, sovereign capability that sits right at the heart of an important technology growth area for the ADF. Conroy wants to see Australia build on such companies to develop an advanced, sustainable, resilient industry that can support its defence sector and, more broadly, the national economy. His emphasis, he has said it repeatedly, is on developing Australian industry capability, not just low-grade Australian industry content.

The growing importance of communications to the ADF, along with that of supporting products in-service, has resulted in significant growth—from five staff four years ago, Blacktree Technology now employs 30 staff. It is just about to open expanded premises in both Belmont, WA, and Fyshwick, ACT. This reflects the company's achievements in both the domestic and export markets, says Nevin. It has been a quiet technical success story for more than 30 years. ●

Cyber-defence inadequacies – the stuff of nightmares

By Simon Galbally, Senetas Corporation

Recent catastrophic ransomware attacks and resulting data breaches should be a wakeup call for all commercial and government organisations, but continuing cyber-crime successes suggest otherwise. What lessons have been learned by targeted industries—from technology and telecommunications to critical infrastructure industries? Not enough it seems.

It is clear three fundamental cyber-defence inadequacies prevail. First, many organisations appear wedded to 'legacy' solutions that are no longer fit-for-purpose. Second, too few organisations protect, with encryption, their intellectual property, customer privacy and other sensitive data to ensure it is meaningless in unauthorised hands. Third, their data networks and data they carry are exposed to data theft and ingress of harmful nefarious data. Yet, the looming main event, the threat of quantum computing, in the hands of today's more sophisticated and well-resourced cybercriminals and nation state bad actors, approaches quickly. Today's sensitive long-life data must be protected in a post-quantum world. What proportion have heeded advice to plan their 'quantum resilience' now?

The Australian space industry is growing rapidly as it develops new technologies and collaborations, such as with NASA. Space organisations and their supply chains have much more to lose than just valuable intellectual property through successful malware attacks and breaches of unencrypted data. There are also huge costs of reputational damage; harm to shareholders' value; and catastrophic damage to launch and control systems and space communications.

In 2020, a single cyberattack reported to be among the worst cyber-espionage incidents in history, attributed to Russian state-sponsored cyber gangs, breached at least 200 major organisations including US government agencies, NATO, the European parliament, Microsoft, various other government agencies and commercial enterprises. It successfully exploited software systems including SolarWinds, Microsoft and VMware. The attack's nine-month duration and data breaches highlight:

- Failures of 'legacy' malware detection and prevention solutions
- Failures to encrypt sensitive data when stored and in motion across networks
- The consequences of software systems' security vulnerabilities.

Zero Trust Cybersecurity

While global cyberattack statistics highlight the need for 'zero trust' cybersecurity strategies, many 'legacy'

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> The Australian Cyber Security Centre highlighted 25% of 67,000 reported cyber-attacks focused on critical infrastructure and that a cyberattack occurs every eight minutes.

anti-malware/anti-ransomware cybersecurity solutions relied upon today are not fit-for-purpose, and enterprise business software systems are often vulnerable. Data networks, from Ethernet to Internet protocols and even satellite communications are not inherently secure. They are all exposed to eavesdropping and ingress of nefarious data.

Advanced technology industries such as the Australian space industry are among cybercriminals' prized targets, whether by state-sponsored or other bad actors. Now the COVID driven world of remote worker collaboration and the continuing growth of Cloud computing and storage have increased cyber-threat exposure.

Technology driven organisations' vulnerabilities are exploited—not just for financial gain and theft of intellectual property, but also to cause business disruption and catastrophic harm. Data breach threats arising from hacking and ransomware/malware attacks, zero-day exploits and network ingress demand a zero trust cybersecurity approach. That in turn requires state-of-the-art 'fit-for-purpose' cybersecurity solutions.

Fit-for-Purpose Solutions

The continuing failures of anti-ransomware/malware solutions highlight they are no longer fit-for-purpose—being detection-based and signature dependent. They are ineffective against today's signature-less 'undisclosed' malware and zero-day exploits.

Enterprise software systems proven to be vulnerable to cyberattacks are dependent upon customers' implementing growing queues of frequent software security patches. That takes time and resources, and delays in updates just add to risks of successful attacks. Networks carrying datacentre and Cloud compute and storage traffic are exposed to eavesdropping and nefarious data ingress targets leading to breaches and hack-attacks such as Denial of Service and flooding. Both require state-of-the-art solutions for maximum protection.

The world of cybersecurity has changed significantly in just a few years, reflecting new cybercriminals—better resourced and more skilled than ever, including globally connected cyber gangs and state-sponsored syndicates.

The Australian Cyber Security Centre highlighted 25% of 67,000 reported cyberattacks focused on critical infrastructure and that a cyberattack occurs every eight minutes. The Office of the Australian Information Commissioner reported significant cyberattacks and breaches in technology sectors. However, the critical questions are: were the cybersecurity solutions effective, and what percentage of breached data was protected by encryption?

The Looming 'Main Event' – Quantum Computing

In the face of today's cybersecurity threats, the 'main event' is looming—quantum computing. It is considered the biggest cybersecurity threat in history.

Although quantum computers may be five or more years away, the reality is that today's conventionally encrypted data will be 'backward vulnerable' to future quantum computing attacks. To be safe, data requires quantum-resistant encryption protection now.

Why a threat now? The highest value data targets—including intellectual property and management control systems—have a long life of 10 or 20+ years making it backward vulnerable today to quantum computing's arrival tomorrow. It demands long-term data protection now for a quantum-safe future.

Fortunately, quantum-resistant encryption technologies exist today that may be implemented to protect data against both quantum and conventional cyberattacks—'hybrid encryption'.

Strong encryption begins with the algorithms. While today's public key algorithms are all vulnerable to quantum computers, quantum-resistant algorithms are designed to be secure in a post-quantum world. From the NIST shortlist of candidate algorithms, a draft standard algorithm is expected as soon as 2024. NIST and ANSSI guidelines recommend adopting a 'hybrid' classic/quantum approach today in anticipation of the new standard.

Then, Quantum Key Distribution is necessary to allow encryption keys to be distributed in a way that guarantees forward secrecy.

Finally, a source of genuine number randomness is required where numbers are used to seed the keys so they are not vulnerable to prediction or bias. Randomness will become more crucial because quantum computers will be able to ascertain patterns much quicker than classical computers.

A Zero Trust Quantum-Safe World

Like all crime, cyber-crime is a reality and here to stay, making a zero trust approach to cybersecurity a necessity. As quantum computing approaches it is vital organisations understand today's conventional encryption standards will not be as secure in a post-quantum world.

Organisations must plan now for the impact of quantum computing by ensuring their data at rest and data-in-motion encryption solutions are cryptographically-agile—fit-for-purpose. The world has changed making cyber-defence inadequacies the stuff of nightmares. ●

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Foreword:
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DEPUTY PREMIER OF SOUTH AUSTRALIA
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As a new era in space dawns, South Australia is leading the charge in accelerating innovation and growth in the sector.

Advances in technology over the past decade have opened up access to space like never before. More private companies and start-ups are entering the sector, driving growth and collaboration in the industry.

South Australia is home to the Australian Space Agency, Australian Mission Control Centre, Australian Space Discovery Centre, headquarters of the SmartSat CRC and launch facilities.

The Malinauskas government's mission to make South Australia a leader in the global space economy, to capitalise on NewSpace opportunities and push the frontiers of innovation is gaining momentum.

Our state's space industry is growing rapidly with more than 100 space companies now operating here which are underpinned by world-class research and education capability.

South Australia's expertise spans the entire breadth of space capabilities, including the design and manufacture of small satellites, components and sensors, launch operations, mission control and ground stations, connectivity and bespoke applications, as well as data analysis and processing.

Recent investment in state-of-the-art infrastructure, including the future Australian Space Park, will drive added growth in the industry and help advance the nation's sovereign space capabilities even further.

South Australia is now embarking on a bold quest to advance the nation's capabilities in Earth Observation (EO), which has the potential to lift the broader economy and improve the lives of all Australians.

EO data can improve the productivity and competitiveness of virtually every sector of our economy and delivers decision-critical information to governments and industries facing escalating challenges, including the very real and imminent threat of climate change.

The Malinauskas government's action on climate change and building our nation's sovereign EO satellite capability is critical to supporting our country's efforts in monitoring deforestation, rising sea levels and greenhouse gas emissions in the atmosphere.

South Australia is playing a leading role in the development of this sovereign capability. From machine learning and data processing to Internet of Things and developing the satellites and sensor packages, our state offers a broad range of expertise that supports the country's EO needs.

By investing in the development of our state's innovative and world-class space capabilities, we will advance Australia's standing as a prominent player in the global space economy and drive the nation's space sector forward into a new era. ●

HEADSHOT: Supplied • IMAGE: Pixabay from Pexels

The launch of Kanyini—Australia's first state satellite—will be a game changer for the state's space sector.

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Building a new space industry ecosystem

By Lachlan Colquhoun

South Australia had a strong history of involvement in the space industry in the 1950s and 1960s through the facility at Woomera, but this was only a small base to build on when Australia was looking to revitalise the industry in the 21st century.

Richard Price, chief executive of the South Australian Space Industry Centre, says that while the state had the space heritage in the 20th century, it had to reinvent itself and start over again in its efforts to make itself a viable contemporary hub for the industry.

Those efforts were kickstarted in 2017 at the International Astronautical Congress in Adelaide, which led to a commitment from the Federal Government to create an Australian Space Agency which was officially announced in 2018.

The location of the agency in Adelaide was a major boost, but Price acknowledges that it could only succeed if it existed alongside a strong research and industrial space ecosystem which could attract international talent and deliver concrete results.

"I think the creation of the Agency was part of an understanding that space is now critical infrastructure," says Price. "But from that understanding it takes a lot of focus and work to make a viable industry.

"And there can be a lot of advantages in starting again with a blank sheet of paper, because you can look around and see what has worked and what hasn't."

Price has long been involved in the defence industry and has held the role of Chief Executive of both Defence SA and the South Australian Space Industry Centre for four years.

Over that time the South Australian Space Industry Centre has been a significant catalyst in helping grow the industry to the point that it now comprises over 100 companies employing more than 1,500 people, many of whom have moved to South Australia specifically to be part of the space industry.

The modern space industry has many facets, says Price. It not only supports national security and critical infrastructure but enables the "monitoring of the planet" which is crucial from an environmental perspective.

It is also about data, and providing the connectivity to communicate and control the exponential number of Internet of Things devices which are part of the so-called fourth industrial revolution. From such IoT data sets this can flow a whole downstream industry working on solutions and applications which come through the new generation of satellites.

"The challenge in all of this was to create a sustainable ecosystem and that involves not just government agencies but a manufacturing centre, and research and development linked to tertiary institutions," says Price.

There are several key components in the ecosystem. One is the SmartSat Cooperative Research Centre based at the vibrant Lot Fourteen site in Adelaide's central business district, and the future Australian Space Park. The Space Park will be a purpose-built facility for the manufacturing of small next generation satellites and their payloads, rockets, electric vertical take-off and landing vehicles, and supporting componentry and technical systems.

The South Australian Government has invested $20 million in the park and this has been matched by the Federal Government. In a major announcement in August 2022, global aerospace company Airbus announced its commitment to the project, with the company set to establish a dedicated satellite assembly facility.

Richard Price, South Australian Space Industry Centre Chief Executive

To complete the end to end supply chain, South Australia is also developing launch facilities through Southern Launch and its two sites on the Eyre Peninsula at Whalers Way and Koonibba. These are complementary, and not in competition, with other launch facilities in the Northern Territory and Queensland, which offer different orbits.

While South Australia may be the "hub", Price says the ecosystem also includes many other companies and researchers located throughout Australia, all of them contributing to the national effort.

"A lot of these things are quite small in their own right to start with, so the idea is that you need to create scale and that has been a major focus," he says.

"And we also realised that it doesn't make sense to build satellites in South Australia if you can't launch them from here because otherwise you have to ship them halfway around the world to launch them.

"So the answer is that we need the whole value chain, and that means looking not just at each piece in isolation but understanding how all these smaller pieces can work together for something which is collectively much bigger.

"We need to create that critical mass and that is extremely important because no individual company can

IMAGES: Supplied

create an industry and attract all the talent and the skills we need."

Price mentions the capability of companies such as nano satellite producer Fleet Space Technologies and Internet of Things company Myriota, which has expanded and created a subsidiary in Canada.

There is also the June 2022 memorandum of understanding between Southern Launch, ATSpace Australia, Asension and Inovor Technologies as an example of how the ecosystem is growing and working.

"In some ways we are replicating the model we used in naval shipbuilding over a decade ago, where you create a common use facility that all of the industry can use as it scales," he says.

"And in that common user facility at the Space Park we're going to have that hard to find test equipment that doesn't get utilised highly enough for one company to justify buying it in their own right, but making it available to the whole ecosystem can then justify that investment."

Price says many of the startups have grown rapidly and become destinations for young people inspired and energised by the potential of the industry.

He acknowledges that, being startups, not all of these new companies will succeed, but their efforts are unlikely to be wasted if the ecosystem is sustainably in place.

Skilled staff will go on to work in other space focused companies as the skills capacity builds, while the ideas, technology and intellectual property of even failed startups can feed into other, larger more successful companies.

Often, the people who start companies "work brilliantly" in small teams which are fired by a common purpose and enthusiasm, but it is very different when these people move from an organisation with a headcount of 20 or 30 people to 200.

"But I think the reality is that in the early days, when these companies are resource limited, many of them find ways to work together even if they overlap a bit," says Price.

"By and large there is more cooperation and collaboration than competition because everybody understands the final goal, and that we need more talent, more capital and more infrastructure.

"The key thing to building an ecosystem is that you don't put all your eggs in one basket, and you build resilience as you build competition so there's a balance to be had between concentrating investment and understanding that some of the companies you support may not turn out to be winners even though they may make a contribution to the wider effort."

Helping build the ecosystem is the fact that South Australia is also a centre for the defence technology industry, where skillsets are common even though defence and civilian applications are often very different.

"Space and defence both attract talent into science and technology," says Price. "So together it's a way to build up a bigger talent pool for innovation which can be used in other parts of the economy.

"We do a lot of outreach through organisations such as the Andy Thomas Space Foundation and Hamilton Secondary College, and the scholarship programs often get kids interested in space careers, but they also get more kids doing science and technology subjects so they can end up contributing to the economy more broadly."

Asked how far South Australia has progressed, Price says his view is that the project is "never finished".

"If you say we've done all this and ticked these boxes then you're on the road to failure in my opinion," he says.

"We're probably getting to the stage now where it starts to get a bit harder, because we've come so far and now we want to see results."

In the next few years, Price believes that the larger companies will begin to emerge from the ecosystem and these will be the ones to take the industry forward to its next stages.

"I believe we will also start to see some significant achievements in terms of the nature of the satellites we are launching the applications they are using and the way that data is going to be used in industries such as agriculture, mining and even health care," he says.

Through the South Australian Space Industry Centre, the State Government is also taking things forward after committing to a contract for its own satellite, Kanyini.

In 2023, the South Australian Government will embark on a mission to launch its own state satellite, Kanyini.

IMAGES: Supplied

"This initiative was a way to help some companies get through the COVID pandemic because even though there were a lot of companies on the cusp of putting something into space that was in danger of slowing down," says Price.

"So we said 'ok, let's find a way to support this' and it quickly became clear that this was actually a great opportunity to put some technology into schools.

"The schools can use the South Australian satellite to run experiments or develop their own applications, and what a great opportunity for the State Government to try out some applications to lift the productivity of the state and save money as well. So it is about us buying services and delivering outcomes, and creating revenue for companies in our ecosystem."

While that satellite is likely to be launched outside of Australia, it might be one of the last satellites forced to look offshore for launch as the local ecosystem matures and the value chain is completed. ●

International Astronautical Congress returns to Australia in 2025

The Renaissance of Australia's space industry is often dated to Adelaide hosting the International Astronautical Congress (IAC) in 2017, and when the international space community returns to Australia for the 2025 congress, Richard Price is keen to show them all the changes that have taken place since then.

The 2025 IAC will be held in Sydney, not Adelaide, but Price—chief executive of the South Australian Space Industry Centre—believes that for South Australia this is the next best thing.

"It's quite unusual for it to come back to Australia so quickly, less than 10 years after the previous congress," he says.

"I think that's great recognition of the progress Australia has made in its journey into space, so I'm very pleased that it's coming to Australia again."

Price recently returned from the 2022 IAC in Paris, where he says there was great interest and goodwill towards the Australian and South Australian exhibitors.

"There was a large presence of Australians and we had a reception which was amazingly well attended," he says.

"Pam Melroy was one of the guests, a former NASA administrator who has been a good friend of the Australian space industry, and I think the numbers and the quality of the attendees sent a clear message that we do have international support to build this industry."

In addition to his time in Paris, Price and some of his South Australian team also visited the United Kingdom where they inspected space facilities there, comparing them to the Australian Space Park proposed to be developed adjacent to the Adelaide Airport.

"We were able to see a couple of those facilities which enabled us to visualise what we are building and it confirmed that we are on the right track," he said.

One theme that emerged, and which Australia's space industry is embracing, is the idea of sustainability, with much discussion on the management and minimisation of issues such as space junk as the number of satellites increases.

"I expect we'll build on those discussions in 2025, and Australian delegates were very much part of these discussions in Paris," says Price.

In 2025, Price anticipates that a number of the visitors who go to Sydney for the IAC could also then visit Adelaide. With eight years between the 2017 congress and 2025, it presents as an opportunity for the industry to measure the progress of South Australia's space sector.

"We will have the Space Park up and running by 2025, and the visitors will be able to see the progress at Lot Fourteen," says Price.

"When people came to Adelaide in 2017 our space industry was an idea, and by the time they come back in 2025 we'll have an extensive ecosystem of companies. We'll have satellites being manufactured at several sites and launched from our state.

"That is a great story and amazing progress over only eight years." ●

AT Space Kestrel I rocket at Whalers Way Orbital Launch Complex

South Australian launch ready for lift off

By Lachlan Colquhoun

Launch capabilities are a critical and ultimate piece in delivering the entire space value chain, and in South Australia this crucial role is being led by Southern Launch.

The Adelaide based company has been one of the early movers in launch infrastructure and its two facilities on the Eyre Peninsula and the state's far West Coast are ready for launch, and for the next phase in the growth of the South Australian space industry.

Southern Launch Chief Executive, Lloyd Damp, explains that the two facilities have been designed for different uses.

The Koonibba range is a testing facility which covers around 10,000 square kilometres where rockets and payloads can be retrieved, while the 1,600-hectare facility at Whalers Way is for sub-orbital and orbital launch. The two sites complement each other and provide customers with a unique offering in that they can test their rockets at Koonibba and ensure all the systems work correctly. They can then move to a commercial sub-orbital or orbital launch from the Whalers Way complex knowing their systems have been tested under the pressures of launch.

A rocketry veteran with 15 years' experience at the Department of Defence, Damp assisted with launching rockets at the facility in Woomera. Southern Launch searched far and wide for the ideal launch site and evaluated land in Western Australia and Victoria before choosing the Eyre Peninsula, which is only a 45-minute flight from Adelaide.

Damp believes that 2023 and 2024 are the years when the program of launches is likely to ramp up, as local satellite manufacturers move into production and international organisations come to South Australia for their own launches.

"We've already got our first couple of orbital launches contracted, so it's only

IMAGES: Supplied

In terms of local launch, Australian rocket manufacturer ATSpace has received Australian Government approval for two sub-orbital Kestrel I rockets to be launched from Whalers Way.

a matter of time before we're able to demonstrate our capabilities beyond these test launches," says Damp.

"As at September 2022, we are in the final steps of concluding the development approval process and when we get the thumbs up we'll be able to start further developing both our Whalers Way and Koonibba sites. We are working towards orbital launches as well as a number of sub-orbital flights starting from next year."

Southern Launch received a $1 million grant in 2022 as part of the Australian Space Agency's Moon to Mars program. These funds are being used to engage two South Australian companies—Feretti International and Hydroil—to build a transportable launch rail which can be used across the two sites.

The project is the first time that both Feretti, a pipe fabrication and structural steel company with 100 employees in Adelaide and Whyalla, and Hydroil have ventured into the space industry. Hydroil will design and build the hydraulic system for the rail.

"This is one of the key pieces of infrastructure for the site, and the grant from the Australian Space Agency has been a fantastic help," says Damp.

"And we are getting very close to cutting the first pieces of steel for the rail, so that project is getting close to reality."

In terms of local launch, Australian rocket manufacturer ATSpace has received Australian Government approval for two sub-orbital Kestrel I rockets to be launched from Whalers Way.

The launches are designed to test the experimental Kestrel I rockets under different operating conditions, with the ultimate plan to build later generation Kestrel V rockets in Australia for local launch.

A memorandum of understanding signed in June between Southern Launch, ATSpace, Inovor Technologies and Asension means that the upcoming VS03 mission for the Kestrel I rocket will be entirely South Australian with the four companies collaborating on rocket, launch and payloads.

The Kestrel I rockets are 10 metre, two stage sub-orbital launch vehicles which will ascend to over 200 kilometres above the Earth.

For ATSpace, the launches provide the company with valuable data to validate the design of future rockets. The tests are an essential milestone in developing the technology and helping ATSpace become a leading player in the Australian and international space industry.

ATSpace was set up as the Australian sister company of Taiwanese company TiSpace, following a successful campaign by the SA Government and support from the Global Australia program within the Australian Trade and Investment Commission to attract the business to Australia.

While the two Southern Launch sites are essential for the viability of the South Australian space ecosystem, they are also proving attractive to international organisations looking to launch.

In May, Southern Launch hosted a team from the German Aerospace Centre (DLR) ahead of a launch program expected to begin in 2024.

DLR will be using the reusability flight experiment—or ReFEX—rocket, a 2.7m long vehicle with a wingspan of 1.1m and weighing 450kg flow atop a two stage VSB-30 rocket. The ReFEX vehicle will achieve speeds of Mach 5, or more than 6,000km/hr, during re-entry.

"The German launch is about the next generation of reusable rockets, and demonstrating that in flight they can perform with the manoeuvrability of an aeroplane," says Damp.

He says that the presence of international customers in South Australia will add to the momentum of an industry which is developing fast, with government support.

"We're starting to see a seismic shift in the Federal Government's approach to space and starting to see more narrative around contracts, which suggests to me that they've moved on from seed funding to get things moving and now it's going to be more contracted work," Damp says.

"Add these international customers to what is becoming a full manufacturing capability in Australia and we have a more integrated and deeper supply chain, which is exactly what we as a nation need for a sustainable space industry."

In yet another endorsement of the state's supportive approach to space, Equatorial Launch Australia (ELA) has recently announced it will establish its corporate headquarters in Adelaide.

ELA's experience and technical services span across astrospace, commercial enterprise, regulation, asset development and complex project management along with space strategy and systems engineering.

After successfully delivering Australia's first commercial space launch for NASA in July, ELA is growing and commencing development of the next stage of the Arnhem Space Centre. The new headquarters puts them closer to the Australian Space Agency and is also set to become the company's hub for launch preparation and safety assessment activities.

Executive Chairman and Group CEO of ELA, Michael Jones, says the company is excited about the future of South Australia's space industry.

"Adelaide and South Australia will be an essential base for our world-class space engineering in support of our planned high tempo space launch operations from our Arnhem Space Centre in the Northern Territory," says Jones.

"We look forward to taking a leading role in the development of the Australian space capability as we work towards achieving our mission to deliver world-class launch services supporting testing, launch and recovery of vehicles and payloads flown to and from all space orbits."

Beyond the space industry, Damp adds that the launch facilities will have a spin off in the tourism industry, attracting tourists to Eyre Peninsula and providing further stimulus to the local economy.

The company is also working with the Koonibba Community Aboriginal Corporation, which is a stakeholder in the Koonibba facility. During a recent launch campaign the Koonibba community provided traffic management support, onsite security, catering for the launch crew, the lease of on-range equipment, and local indigenous artist Kevina Ware designed the mission patch. ●

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Contributing to a new framework for space law

After not setting foot on the Moon since 1972, humans are expected to return there by the end of the decade and look at the feasibility of extracting resources.

When humans do return, there is likely to be a new legal framework in place for the nations and commercial companies who venture to the moon and beyond.

Australia is a contributor to the ongoing debate on space law, with a number of leading academics involved in the international negotiations.

The US-led Artemis Accords, signed by 21 space agencies around the world including the Australian Space Agency, currently provides some guidance on establishing a framework for cooperation in the civil exploration and peaceful use of the Moon, Mars, and other astronomical objects.

While the 1979 Moon agreement, to which Australia is also a signatory but the US is not, states that no country can own any part of the moon and that mining would require a regulatory regime, the Artemis Accords state that resource extraction can lawfully occur.

At Adelaide's Flinders University, Professor Melissa de Zwart is a thought leader in space law both through her role as Professor of Digital Technology, Security and Governance and as deputy chair of the Space Industry Association of Australia.

"As the industry has evolved, the regulatory mechanisms have had to evolve and I've worked very closely with the start-up and launch sectors, predominantly in South Australia, providing input on how the legislation and the rules should be crafted to really facilitate the support of the space industry," Professor de Zwart said.

Historically, Australia's role in space was seen as a launch site for international operators, but now the vision is for an end-to-end space industry and this required an updated legislative approach to reflect this. Australia also has its own space legislation, with the Space Activities Act introduced in 1998 and then considerably revised in 2018.

"Those amendments were done following an inquiry into the space industry which led to the establishment of the Australian Space Agency, but also due to the recognition that there was a need to update the existing domestic legislation," Professor de Zwart said.

"The way in which you craft the domestic legislation really sets the conditions for the kind of space industry you have."

Internationally, says Professor de Zwart, there are "gaps" in space law on the issue of resource extraction, and also on space debris.

"It's like no one wants to absolutely stop you from doing something because you actually might want to do it yourself," she says.

"So there are a lot of gaps in space law which we are trying to fix."

It is a busy field, and in September 2022 a United Nations working group held a meeting in Vienna to look at "developing norms of responsible behaviour in space," including the disruption caused by space debris.

"A lot of the pressure comes from commercial operators who need their investors to feel that they are operating in a safe and secure business environment, and that requires good laws," says Professor de Zwart.

"But it is a changing area because space law needs to be fit for purpose, but at the same time there's no point developing these things until the technology exists and we can better understand how things will really look.

"I think things are developing to the point where we will develop laws which will be respected and which apply to the technologies of the time." ●

HEADSHOT: Supplied • IMAGE: Alex Andrews from Pexels

Head of the Australian Space Agency Enrico Palermo being shown the University of Adelaide's Exterres Lab at its opening. L-R: Nick Larcombe, Robotics, Remote Operations and ISRU, Australian Space Agency; Enrico Palermo,; Professor Anton Middelberg, Deputy Vice-Chancellor (Research), The University of Adelaide; and Associate Professor John Culton, Director of the Andy Thomas Centre for Space Resources, The University of Adelaide.

IMAGE: Supplied

Simulating the Moon and Mars in Adelaide

By Lachlan Colquhoun

At the time of the first lunar landings in 1969, astronauts used one module in which they returned to the spacecraft that ultimately took them back to Earth.

In the 21st century, however, the idea for future landings on the Moon, and even Mars, looks very different. The current thinking is around establishing more permanent bases where people may ultimately live for periods of time, and to create these bases will require a significant effort in the area of civil engineering.

Long-term space exportation and off-Earth habitation is the driver behind the creation of the Exterres Laboratory at The University of Adelaide. Located at the university's North Terrace campus, the Extraterrestrial Environmental Simulation (Exterres) Laboratory is a simulated testing environment where issues of civil engineering on the Moon and on Mars can be tested, along with other technologies such as space rovers.

"NASA's Artemis program plans to return repeatedly to the same location on the Moon and they are going to have to bring in more and more equipment

with them and leave it behind and slowly aggregate the infrastructure they would need for a base," says Professor John Culton, who is the university's Professor of Off-Earth Resources and director of the Andy Thomas Centre for Space Resources.

"So a lunar civil engineering lab is something that would be quite unique in the world, and at the same time incredibly important.

"This idea was first hatched back in 2010 and was proposed for many places around the world and we've been really fortunate that The University of Adelaide had the vision to see that this was a strategic investment in the future. This facility is really attractive to researchers, to industry and to governments and it's always interesting to students, so it's a catalyst for more STEM education."

Professor Culton says the mission of the Exterres Lab is to create the robust tech needed to make long-term human settlement in space a reality.

The moon's surface is entirely different from that of Earth. Astronauts who visited the moon in the 1960s and 1970s reported that a major problem in setting up anything permanent on the moon was the prevalence of so-called moon dust, also known as regolith.

So one of the issues being tested in the Exterres Lab is how to develop technologies that can deal with the effects of the regolith—which is the layer of loose material covering the bedrock of the planet. While some of the research is applicable to both the Moon and Mars, there are also significant differences between the two surfaces which will also be tested in the simulators.

Much of the testing will be done in the Exterres Regolith Thermal Vacuum Chambers, comprising a sealed lunar regolith simulation pit of 9 metres square, and a second sand pit of 27 square metres which can simulate specific off-world environments.

The chambers use a 3D motion capture system which enables detailed analysis of the capabilities of robotic devices, controlled remotely from Exterres Mission Control or operated autonomously.

"We can simulate lunar or Martian conditions in terms of gravity for the robotics," says Professor Culton.

"And we have a regolith pit filled with a lunar highlands simulant which is the material covering the South Pole of the Moon, and is NASA's initial destination.

"There are issues like, how can we anchor 100 metre plus tall towers into this material, and we are basing this on what we know from geo-technical information taken in 1972 when the last astronauts were there, and their equipment wasn't ideal."

The lab's facilities also include a high-power laser, a vacuum furnace, box furnace and a large-scale 3D printer. Using the equipment, lunar masonry bricks will be made for use in construction trials of structures including equipment shelters, habitats, roads and landing pads.

"We're looking at both the Moon and Mars and our lab can simulate both of those environments, and it's the first lab of its kind in the southern hemisphere which can do that," Professor Culton says.

"We also have a number of engineering and science challenges that are right in our face and which NASA really needs answers to and we're helping work on some of those things."

The University of Adelaide is also planning an analogue site at its Roseworthy campus, where researchers and industry experts will be able to test technology at full-scale in highly controlled field environments, capable of replicating a range of extra-terrestrial and terrestrial settings.

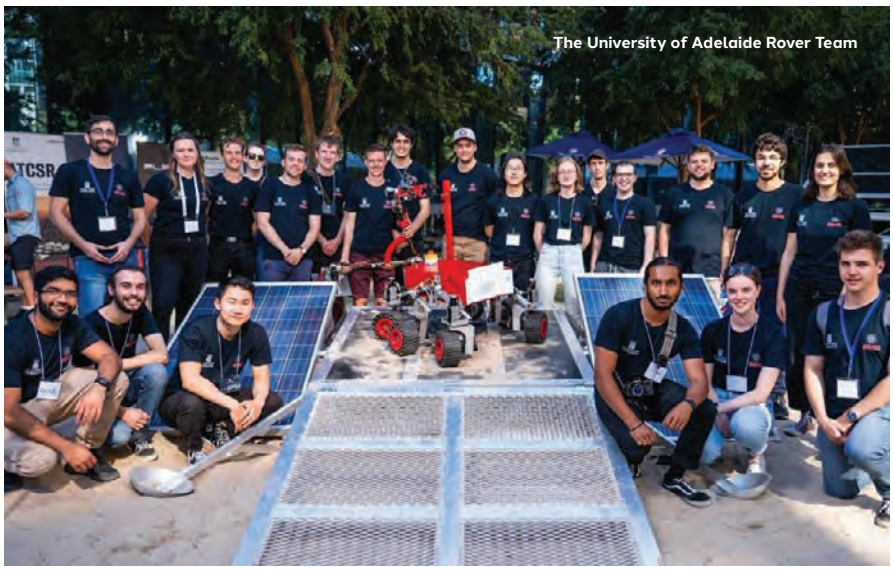
Professor Culton cites three key areas where the university is supporting the space programs—off-Earth construction, artificial intelligence and machine learning in space, and space agriculture.

The space agriculture effort is being led by The University of Adelaide's Waite Institute Campus, which brings together researchers from a range of disciplines including plant biology, genetics, soil sciences and agronomy.

"The Waite is one of the top one or two agricultural technology institutes on the planet, and they've actually assembled the world's best space agricultural team that has ever been brought together and it includes international space agencies, including NASA," says Professor Culton.

"Agriculture really is a showstopper for a Mars mission, and the work at the Waite aligns really well with Australian national expertise."

"Professor Culton cites three key areas where the university is supporting the space programs—off-Earth construction, artificial intelligence and machine learning in space, and space agriculture.



The University of Adelaide Rover Team

IMAGE: Nelson DaSilva

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Satellite industry scaling up

By Lachlan Colquhoun

Flavia Tata Nardini and Matt Pearson come from opposite ends of the Earth but have come together to become leaders in the emerging satellite industry in South Australia.

Nardini was born and educated in Italy, where she completed a Master's Degree in Space Engineering. Pearson is originally from South Africa but since moving to Australia has become a major driver of excellence in space and advanced aerospace technologies creating Airspeeder, the world's first racing series for electric flying racing cars.

The two combined as co-founders of Fleet Space Technologies, a leader in the rapidly developing South Australian satellite industry.

With a mission to "connect the Earth, moon and stars and unlock the power of universal connectivity" with small satellites, Fleet Space was founded in 2015, has grown into a company with a headcount of 90 and growing, and has a presence in the US.

With key executives being hired in early 2022, Fleet has completed three successful rounds of funding which took place in 2015, 2017 and 2021, receiving a total of AU$52 million from investors including InQtel, Blackbird, Grok, Horizon Ventures and Alumni Ventures.

IMAGES: Supplied

There is an incredible opportunity to build global centres of excellence and we as an ecosystem have grasped this, enabled by the strategic importance governments have placed on the development of this multi-billion dollar industry and the sovereign capability being developed

"We want to create applications for this technology that creates better outcomes for people on Earth, and enables our exploration of worlds beyond," says Nardini.

Fleet has already launched seven commercial satellites and is working towards a fully 3D printed satellite, Alpha, along with the rest of the company's pioneering series of Centauri satellites.

In May 2022, Fleet launched its most recent satellite, Centauri 5, through SpaceX. This satellite used 3D printed all metal patch antennas. As results proved successful, Fleet will use the in-house 3D printing capabilities to 3D print metal patch antennas for the growing constellation.

The company is headquartered in a new state of the art facility in Beverley, near the future Australian Space Park proposed for the Adelaide Airport, which is being supported by the State and Federal Governments. This is where Fleet intends to eventually mass manufacture their satellites.

"This isn't just growth in offices and laboratory space but also to accommodate more highly skilled jobs," says Nardini.

"We are on a long-term path to establishing a hyper factory, with government support, in the Australian Space Park and this represents an incredible evolution for the state to its rightful place as a global centre in the rapidly expanding space industry."

Nardini gives the South Australian Government credit for its role as a catalyst in developing a growing space industry ecosystem, combining start-ups, growth companies and institutions.

"There is an incredible opportunity to build global centres of excellence and we as an ecosystem have grasped this, enabled by the strategic importance governments have placed on the development of this multi-billion dollar industry and the sovereign capability being developed," she says.

Fleet is evolving its technology rapidly, and its Alpha-1 Satellite will be the world's first fully 3D printed satellite weighing around 40kg, and will be the first of the constellation of 288 satellites the company plans to launch to deliver connectivity to all areas of the globe.

The company's in-house capability was significantly boosted in September, with the unveiling of the new 3D printer at Fleet's expanded manufacturing facility.

The printer will initially be used to print radio frequency (RF) patch antennas, which are in use in the company's existing satellite constellations.

The antennas receive and transmit signals between the constellations in low Earth orbit, and portals and modems on the ground. In future, engineers will use it to produce structural parts for next generation Alpha satellites to optimise weight and increase vertical integration.

Supplied by Konica Minolta, the new machine reduces turnaround times and enables low-risk prototyping and more efficient research and development in areas such as filters and other passive RF componentry.

"The new metal 3D printer underlines our commitment to domestic manufacturing," says Nardini.

As is often the case, space technology has on-Earth applications, and Fleet has also focused its expertise on the exploration industry. The company has been developing a fast and scaled 3D exploration solution to pinpoint high value critical minerals and reduce unnecessary drilling .

ExoSphere is an end-to-end service offered to mineral exploration customers that will decrease the time it takes to find a deposit. Contracts have been signed with over 20 customers based in North America and Australia, including Core Lithium and Oz Minerals.

With ExoSphere, Fleet's sensors are deployed in a survey area and leverage real-time passive seismic methods to scan the land beneath looking for critical minerals. Nardini says ExoSphere is consistent with Fleet Space's core mission which includes sustainability.

"ExoSphere is enabling the global exploration industry to find faster, more efficient and more sustainable routes to critical minerals that will drive the transition to clean-air mobility," she says.

"We do this by reducing the requirement for invasive drilling by scanning the ground and rapidly processing the data through our constellation of satellites.

"Solving problems at this scale is core to Fleet's purpose and mission."

Nardini says ExoSphere will play a key role in the challenge of finding the more than US$13 trillion in critical metals the world needs to meet soaring global demand.

South Australian residents are also benefiting from Fleet's technology. In the summer of 2021, the company partnered with South Australian water authorities to build a network of more than 250 soil moisture and air temperature sensors across 17 parks.

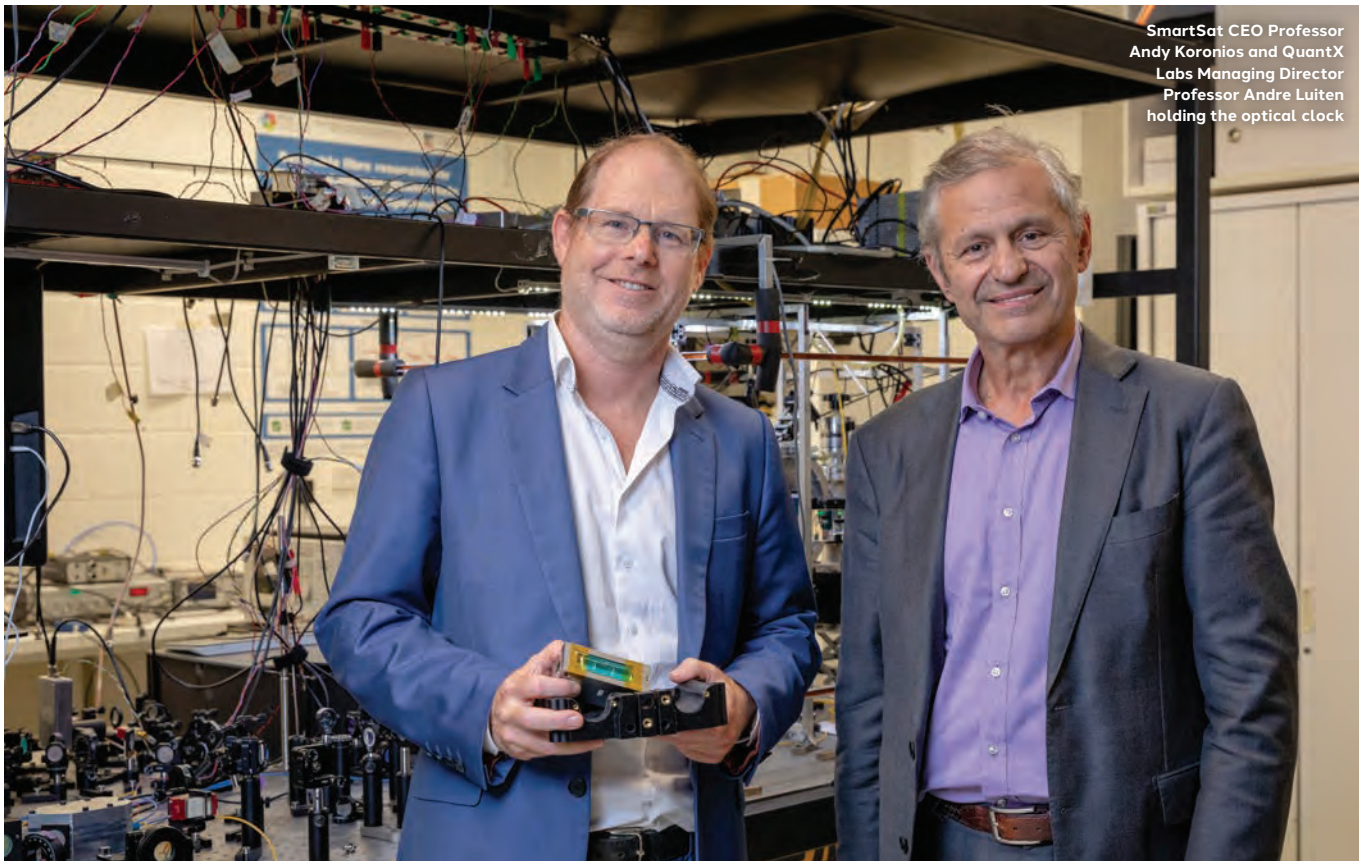
These sensors used Fleet's micro satellite technology and the public network, feeding real-time temperatures to the SA Water website where the public could track the coolest places to visit, and local authorities could know the best time for watering.

Fleet is developing rapidly, but is not the only player in the South Australian satellite industry.

Adelaide is also home to the SmartSat Cooperative Research Centre (CRC), which is a consortium of universities, other research organisations and industry.

The SmartSat CRC was funded by the Australian Government to develop know-how and technologies in advanced communications and Internet of Things (IoT) connectivity, intelligent satellite systems and next generation Earth Observation data services.

The CRC was developed in collaboration with around 100 partners, including 40 space start-ups and collaborators such as the Australian Space Agency and Defence.



SmartSat CEO Professor Andy Koronios and QuantX Labs Managing Director Professor Andre Luiten holding the optical clock

An example of the SmartSat CRC's work was a $1 million grant, announced in May, to assist QuantX Labs develop a new optical atomic clock satellite payload.

The clock developed by QuantX is a quantum leap in timing performance using high-precision lasers to interrogate a specially prepared vapour of Rubidium atoms.

The new technology behind the optical clock was created by the Precision Measurement Group at The University of Adelaide, and developed into a product in a collaboration between QuantX Labs, The University of Adelaide and the SmartSat CRC.

"This latest project with SmartSat CRC is crucial to accelerate progress as we plan to trial the compact optical clock in space within the next 24 months," said SmartSat CRC CEO, Professor Andy Koronios.

"This latest funding builds on SmartSat's ongoing support, having supported the research and development through the Aurora Space Cluster, as well as facilitating connections with industry and government partners to help us bring the space clock to market."

"In just a few years, QuantX transformed an idea to a product—from research to breakthrough technology. The optical space clock project is an excellent and powerful example of the important role that the SmartSat CRC is playing in catalysing collaboration between universities, industry and defence and helping to build military industrial capability."

Another satellite company in the South Australian space ecosystem is Myriota, based at Adelaide's Lot Fourteen, which offers commercial scale IoT data solutions across a range of industry sectors.

Launched offshore in a partnership with Spire Satellites, headquartered in San Francisco, Myriota has become a leading player in IoT technology.

Myriota modules on low orbiting satellites transmit data directly to the cloud, where it can be used in a wide variety of applications.

In the agricultural sector, for example, Myriota is working with Goanna Ag to unlock the power of remote monitoring to create a suite of products which can be installed and monitored from anywhere on the planet.

Using Myriota's network, Goanna Ag has created a product called GoSense which allows farmers to monitor widely distributed water assets and set up instant, real-time information and alerts.

Ping Services is a company working in the renewable energy sector, offering services which monitor the health and performance of wind turbines using advanced acoustic analysis.

An alumni of the University of South Australia's Venture Catalyst Space startup incubator program, Ping is partnering with Myriota to transform the maintenance of wind farms. The company estimates that leveraging Myriota's network could save wind farm operators up to 25% off the cost of wind turbine maintenance, a potential saving of US$500 million in the next year alone.

With the number of turbines growing at 10% year on year, Ping estimates its Myriota-enabled technology could save global operators more than US$800 million by 2025. ●

IMAGES: Supplied

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Manufacturers alert to the space opportunity

By Lachlan Colquhoun

When Michael Sharpe visits one of the 4,000 companies or institutions which are members of the Advanced Manufacturing Growth Centre (AMGC), one of the last comments he often makes is to say, "Have you thought about space?"

In some cases, the question can lead to surprising and positive outcomes.

Sharpe, AMGC National Director for Industry, gives the example of Sydney company Omni Tanker, whose core business has been in the development of strong, lightweight composite transport vessels.

Where tanks for the transport of substances such as chlorine have traditionally been made of steel, Omni Tanker developed a lighter solution from carbon composite with the aim of entering the North American road haulage market.

> Now the growing need to decarbonise the energy industry, and the reusable low Earth orbit satellite market, have the potential to drive major utilisation for these new technologies.

"We were able to back that project, and I then had the conversation with them," said Sharpe.

"I mentioned the space and aeronautics industries and asked them 'what else can you do?'"

The result was a collaborative partnership between Omni Tanker, a company with 70 employees, researchers from the University of New South Wales (UNSW) and US defence prime Lockheed Martin, with co-investment provided by AMGC.

The partnership will develop and commercialise world-first compositive tank technologies, utilising two Australian-developed technologies to solve the challenges of using composites for the transportation and storage of liquid hydrogen, with potential applications in the air, under water and also in space.

"We need our manufacturers to look at diversification as a way of creating resilience, and that means having a diversity of customers and products," said Sharpe.

"So with Omni Tanker here is a company which never thought they'd be involved in the space industry, and yet here they are working with one of the global primes."

This example also shows the way in which the AMGC can link university research with innovative manufacturers and vice versa.

The project builds on research conducted by UNSW's Professor Chun Wang, which enables carbon fibre composites to withstand liquid hydrogen temperatures without matrix cracks. This is a challenge which, until now, has been a barrier to the mass adoption of these materials for such applications.

Professor Wang said Omni Tanker's significant experience in the development of strong, lightweight composite transport vessels made the company a natural partner to commercialise the technology.

In announcing the partnership, Omni Tanker Chief Executive Officer, Daniel Rodgers, described it as a "landmark development" for the company as it entered the aerospace sector.

"The OmniBIND technology has made inroads to revolutionise the safe and efficient movement of challenging liquids within the chemical transport sector," said Rodgers.

"Now the growing need to decarbonise the energy industry, and the reusable low Earth orbit satellite market, have the potential to drive major utilisation for these new technologies."

Lockheed Martin's Regional Director Australia and New Zealand, David Ball, said OmniBIND had particular relevance to the space industry, which needed linerless composite tanks for their weight efficiency and durability.

"These advances have the potential to support the growth of Australia's sovereign space capabilities, strengthen exports to spacefaring allies and partner nations, and make an important technological contribution to future space missions particular in on-orbit storage, launch and deep space exploration," Ball said.

AMGC, which assisted with a $1.4 million co-investment from its Commercialisation Fund, played a role which Sharpe said showed the organisation's ability to "connect people".

"It's the power of being able to make those connections to show people what is possible, bring them together, and help Australian industry thrive," he said.

Another example is Nicholas Hacko, a small, ultra-precision manufacturer of watches based in Sydney's northern suburbs.

"They are perhaps the only watch manufacturer in Australia, a small father and son based company," said Sharpe.

"When I visited them about four years ago I had the same conversation with them, on what they could do to diversify."

Michael Sharpe, AMGC National Director for Industry

Sharpe then arranged some meetings with a range of space companies, and the result is a new company called NH Micro which produces ultra-precision parts and instruments for a range of industries, including space. The company's capabilities span complex geometry and small turned parts, small hold drilling, micro wire EDM and micro gears.

"They've completed several space projects now, including for local companies such as Gilmore Space," said Sharpe.

"The good news is that during the COVID pandemic the company actually expanded, just because of what they have achieved in the space industry."

Sharpe's message to small and medium manufacturers is that Australia's record levels of defence spending, at $48 billion in the 2022 budget, is a major opportunity for them to innovate, collaborate and integrate into large defence supply chains with products which could ultimately have applications in the nation's rapidly developing space industry.

"This is not our grandfather's manufacturing industry anymore," he said.

"You're not seeing the smokestacks and the dirt, and when I visit factory floors they are usually so clean you can eat your lunch off them.

"We need to communicate and encourage the young people in Australia in this direction, because if they can operate a PlayStation they can operate a robotic welding machine, and right now we have a big shortage of welders so there is an opportunity."

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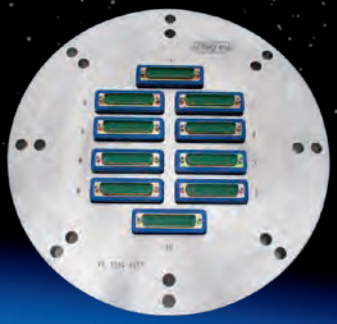

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Large carbon fibre composite pressure vessel constructed using Omni Tankers OmniBIND technology

Success will come from collaboration and partnerships, and creating a supply chain ecosystem where these small but growing companies can work with major primes and contribute their innovation and vision to the national effort at scale.

The AMGC was established in 2015 as a key plank of the Federal Government's Industry Growth Centre Initiative, with a goal to drive innovation, productivity and competitiveness across the Australian manufacturing industry.

It is an industry led, not-for-profit organisation governed by industry experts and connected to a nationwide network.

The AMGC has fully committed $30 million in grants through its commercialisation fund, and has another $7 million to foster advanced manufacturing in the Northern Territory.

To date, the organisation has committed to $135 million in projects, including industry and in-kind contributions, and these have created over 4,200 jobs and generated estimated revenue of $1.52 billion.

Sharpe pointed out there are 47,000 manufacturing enterprises in Australia, representing around 10% of the national workforce.

"At AMGC we have around 4,000 members, so I like to think they are the cream of the crop, the companies which are reaching out to us and saying, 'can you help us?'" he said.

"They are asking who they can collaborate with, which university can help them the most."

In most cases, AMGC involves two companies collaborating together at a minimum, and most often there will also be a research partner.

"It might be a university, it might be the CSIRO, because we know through our research that if we can get more university partners into the industry that is where the magic happens," said Sharpe.

"It is really good when I can get the professors to come out of the university and walk the factory floor with me.

"I think it would be fair to say that a large cohort of manufacturers have not been to university, so they see it almost as a foreign country, and when I bring the professors out they actually learn something new, which is always good."

Most Australian manufacturing companies have 20 employees or less, so the opportunity lies in building scale. AMGC looks to the model of Germany, which has built a globally leading manufacturing economy on the back of "hidden heroes" among small and medium sized enterprises—or Mittelstand.

Australia's opportunity is in encouraging micro manufacturers to scale up to be medium sized, which is the sweet spot for innovation and growing revenue.

Success will come from collaboration and partnerships, and creating a supply chain ecosystem where these small but growing companies can work with major primes and contribute their innovation and vision to the national effort at scale.

This was the message AMGC delivered at the Federal Government's Jobs and Skills Summit held in August 2022, that advanced manufacturing is one of the keys to Australia's economic future prosperity.

"I take it as a mission to show people what good looks like, and to demonstrate how manufacturing has transformed and how much opportunity there is in manufacturing today," said Sharpe.

"If we can demonstrate the best practice case studies and show how Australian companies are getting involved in high value production for defence and aerospace then it gets exciting.

"At AMGC we are just so excited about what has been achieved in the last seven years, and to see the good news keep coming out it's just terrific for Australia."

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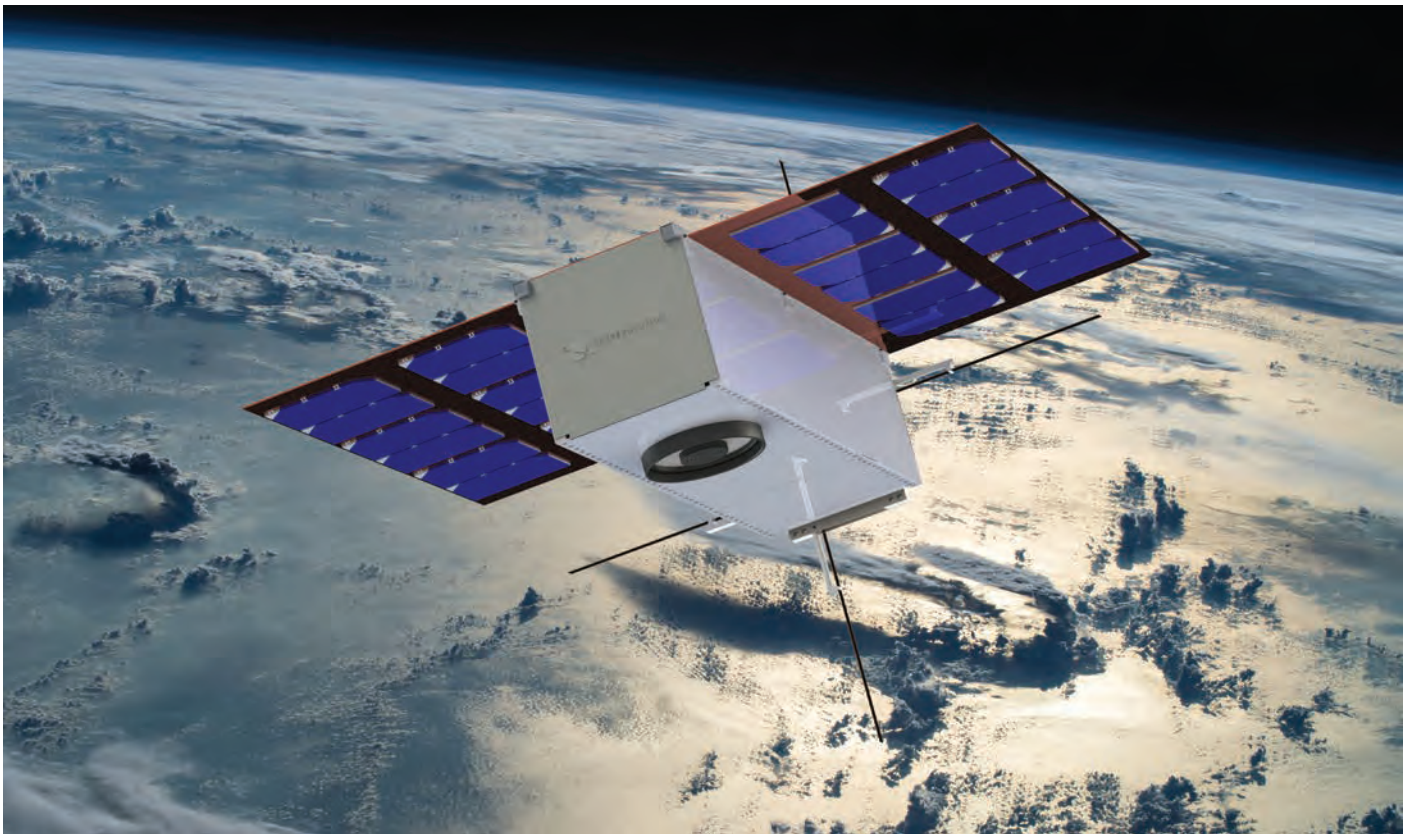


Space technology with on-Earth applications

By Lachlan Colquhoun

Taofiq Huq studied aerospace engineering at the University of NSW for his undergraduate degree and had started his PhD when something more compelling came up—the opportunity to found his own company.

The result was Spiral Blue, founded by Huq and two colleagues with a mission of developing in-space processing of satellite imagery for use across all industry sectors, including Defence.

"I finished my undergraduate year in 2014 and I wanted to work in space, but back then we didn't have the Space Agency or much in the way of a space industry," says Huq.

"So I started the PhD at around the same time as Spiral Blue, and I was fortunate I was able to get some early success with Spiral Blue, so I've put the studies on hold."

Based in Sydney, Spiral Blue was named as one of Fast Company magazine's "Ten Startups to Watch in 2022" and in February was awarded the latest round of co-investment from the Advanced Manufacturing Growth Centre (AMGC).

The AMGC's Commercialisation Fund contributed $578,000, which was part of a total commitment of $2.97 million for the company that included funds from Esper Satellite Imagery and Dandelions.

The funding was for Spiral Blue's Project Rainbow Python, an integrated hyperspectral instrument and onboard computer which enables chemical

Taofiq Huq

analysis of any location on Earth, delivering data and information for use in agriculture, forestry, mining and for environmental monitoring.

As part of the project, Esper will launch two of its hyperspectral imagers

IMAGES: Supplied

in two separate payload missions, while Spiral Blue's Space Edge 1 Hyperspectral computer will fly alongside and process the images onboard to minimise cost, time and complexity.

Huq says the grant accelerates Spiral Blue's roadmap to mature Rainbow Python and makes hyperspectral data more accessible to industry.

The company is also receiving a grant under the Australian Space Agency's Moon to Mars Supply Chain Capability Improvement Grant program to support its Spiral Edge Space Edge Services Program.

By 2023, Spiral Blue expects to be operating an operational constellation of Space Edge computers, while by 2024 it plans to join Australia's first mission to the Moon to prove the performance of its computers in deep space.

The goal for 2025 is to make Project Nebula a reality, described as the "crystallisation of our overall vision for Earth observation and space".

While Spiral Blue is a space company, Huq explains that its ambitions and motivations are squarely centred on the Earth.

"Like most people, I started looking at space in the realm of astronomy, but I have also personally been looking at new ways of environmental protection," he says.

"So while I had an interest in space, it was always about how we could use it to actually make the environment on Earth safer, and use technologies to monitor not only the environment, but activities like illegal fishing and piracy."

In 2021, Spiral Blue launched two of its Space Edge Zero image processing computers on rockets launched by Richard Branson's satellite taxi service, Virgin Orbit.

This enabled Spiral Blue to begin testing its technology, which processes satellite imagery in space itself. A third was launched on a SpaceX rocket.

"The computers that had been launched to that point were not really powerful enough to do the sort of processing that we were looking at," says Huq.

"Satellites have been collecting imagery for a long time, and that process won't be changing, but we saw that instead of using the bandwidth the satellites used to send down images, we could send down insights.

"We also acquired some images on the commercial market and started building out our algorithms, and we are continuing to add to that."

Huq gives an example of images of ships, which take up a very small area on the ocean's surface. Instead of pulling down images from the satellite to Earth for analysis, Spiral Blue's technology allows for the monitoring of much larger areas from space, which means more ships can be located faster.

"It's really turning one satellite with a computer on board into something which can do the work of 10 or 100 satellites today using our algorithms," he says.

Monitoring ships at sea has several applications.

Spiral Blue can identify suspicious vessels at sea so they can be avoided or intercepted. The company's technology can deliver information on incidents such as oil spills and illegal dumping faster than other methods, so action can be taken before pollution gets out of hand.

It can also monitor and track vessels so that fewer people are lost at sea, even if they have no AIS (Automatic Identification System) beacon or have it turned off.

In forestry, Spiral Blue's insights can prevent illegal logging and theft, notifying authorities if areas have been targeted. They can manage and monitor the risk of bushfires, and in urban areas can measure the effects of urban tree planting on urban heat islands.

Growth has been rapid at Spiral Blue, and from the current headcount of 11, Huq says he expects this to reach around 30 next year as the company continues to expand.

"The sheer amount of opportunity at the moment in space is really fantastic, and space manufacturing is key to Australia's sovereign capability," he says.

"And we just don't have enough people right now to follow up on a lot of things."

As for the PhD, it may be on hold for a while longer.

"I'm probably not so much an academic type but someone who likes to solve problems rather than create knowledge," says Huq.

"So I've officially put the PhD on hold. I might go back to it at some point but right now there is too much happening with Spiral Blue."

Australia invests in sovereign capability in composites

Next generation intelligent materials are one of the keys to the 21st century space industry, and developing this capability in Australia was one of the business cases behind the creation of the Sovereign Manufacturing Automation for Composites Cooperative Research Centre, or the SoMAC CRC.

It was funded with a $69.9 million grant from the Australian Government's Cooperative Research Centres Program, along with $189.3 million of partner contributions. The SoMAC CRC was announced in early 2022 and is set to be one of the world's largest research centres for composite materials.

The goal of SoMAC's 10-year program is to transform Australia's composites industry into a key sovereign manufacturing strength through intelligent automation, technology development, and the reskilling of Australia's composites engineering and manufacturing workforce.

The initiative to create the SoMAC was led by a consortium of university and industry partners and is a joint effort between six leading Australian universities, Australia's Nuclear Science and Technology Organisation and 29 industry partners.

The partners will use the grant to progress Australia's capabilities in manufacturing and high-value industries not just in the space industry, but also in green energy production, and civil and marine infrastructure.

University of New South Wales (NSW) Engineering's Professor Gangadhara Prusty led the successful bid to create the SoMAC.

"The composites industry has a fast-growing, $100 billion international market. This grant will support projects that will benefit a wide range of our flagship sovereign industries including space, defence, energy and infrastructure," Professor Prusty says.

Composites refer to manufacturing materials that are formed by combining two or more materials together to form overall structures that are less expensive, lighter, stronger or more durable than other common materials.

Space vehicles, aircraft, automobiles, defence vehicles and high-pressure energy storage all rely on advanced manufacturing and engineering of composites.

SoMAC research programs will also develop circular economy technology, incorporating the recycling approaches and reusable material systems in demand from industry and consumers internationally.

At the UNSW, Professor Nicholas Fisk, Deputy Vice-Chancellor, Research & Enterprise, said Australia

IMAGE: Jasen Wright from Shutterstock

had a unique opportunity to embrace automation and emerging onshore industries in the next decade through this collaborative investment in manufacturing and engineering.

"Australia's composites industry is dominated by small-medium organisations; therefore, collaborative approaches such as the SoMAC CRC are vital to build broad industry capability, as well as to provide the development environment to bring industry together in major projects," Professor Fisk says.

"We are seeing Australia contemplate massive investment into the hydrogen economy, take a clear step forward in space, and rebuild its automotive presence in electric buses and cars. Composites are essential for these and other major industries to be competitive and position Australia at the forefront of global technology."

Andrew Beehag is the interim Chief Executive of the SoMAC, appointed in January 2002.

The vision for SoMAC is to place Australia as a first choice for rapid prototyping, enabling decentralised composites production capacity and building sovereign independence.

> "It is very much about sovereign manufacturing for Australia, but at the same time we will be collaborating extensively with international partners. This is about a global supply chain we want our composite manufacturers to really start to get involved with.

Under Beehag's leadership, its mission is to enable composites R&D to meet Australia's national self-sufficiency priorities, servicing the rising demand for just-in-time localised composites innovations, automation and digitisation.

The incubation formula for the SoMAC CRC draws on international best practice to maximise value added benefits to Australia's diverse supply chains.

Two private sector companies involved in the SoMAC program are advanced composites manufacturer Quickstep and low emissions transport developer Nexport.

According to *AuManufacturing,* "Quickstep said its efforts in the drone sector, in particular industrialising the manufacturing of airframes, will benefit from the multiplier effect of world-class R&D capability brought by research partners. These could also have a potential application in space.

"The companies said that leveraging CRC support to develop lighter and more efficient structures and advanced onboard energy storage systems, whether hydrogen or battery powered, creates synergetic opportunities to develop dual-use structures, where hydrogen pressure vessels, battery packs, and airframes are integrated into a joint, more efficient component.

"Nexport and the Quickstep Group are committed to working together to become leaders in providing integrated clean mobility solutions, and servicing the industry towards a zero-emission future.

"The future of Australian sustainable mobility is zero emissions, composites driven, and electric, and Quickstep and Nexport are driving the revolution with SoMAC."

Another SoMAC participant is Victorian based Carbon Nexus, a purpose-built research facility spun out of Deakin University for the diverse needs of international manufacturing organisations which require the cost-effective resolution of carbon fibre-related projects that are strategic and complex.

Carbon Nexus is the culmination of more than a decade of research into improved fibres and carbon composites at Deakin University.

"We certainly expect to have a global impact," says Professor Russell Varley, a Director at Carbon Nexus.

"It is very much about sovereign manufacturing for Australia, but at the same time we will be collaborating extensively with international partners. This is about a global supply chain we want our composite manufacturers to really start to get involved with."

With the world's only open-access carbonisation pilot line, Carbon Nexus offers the unique ability to deliver on an industrial pilot scale for product development and process optimisation.

Professor Varley says his team of researchers and students are eager to get involved and will work with industry partners to come up with the best raw material for any given application, optimising a composite material structure and making flat coupons to measure the properties in a pure format before use in prototype moulds.

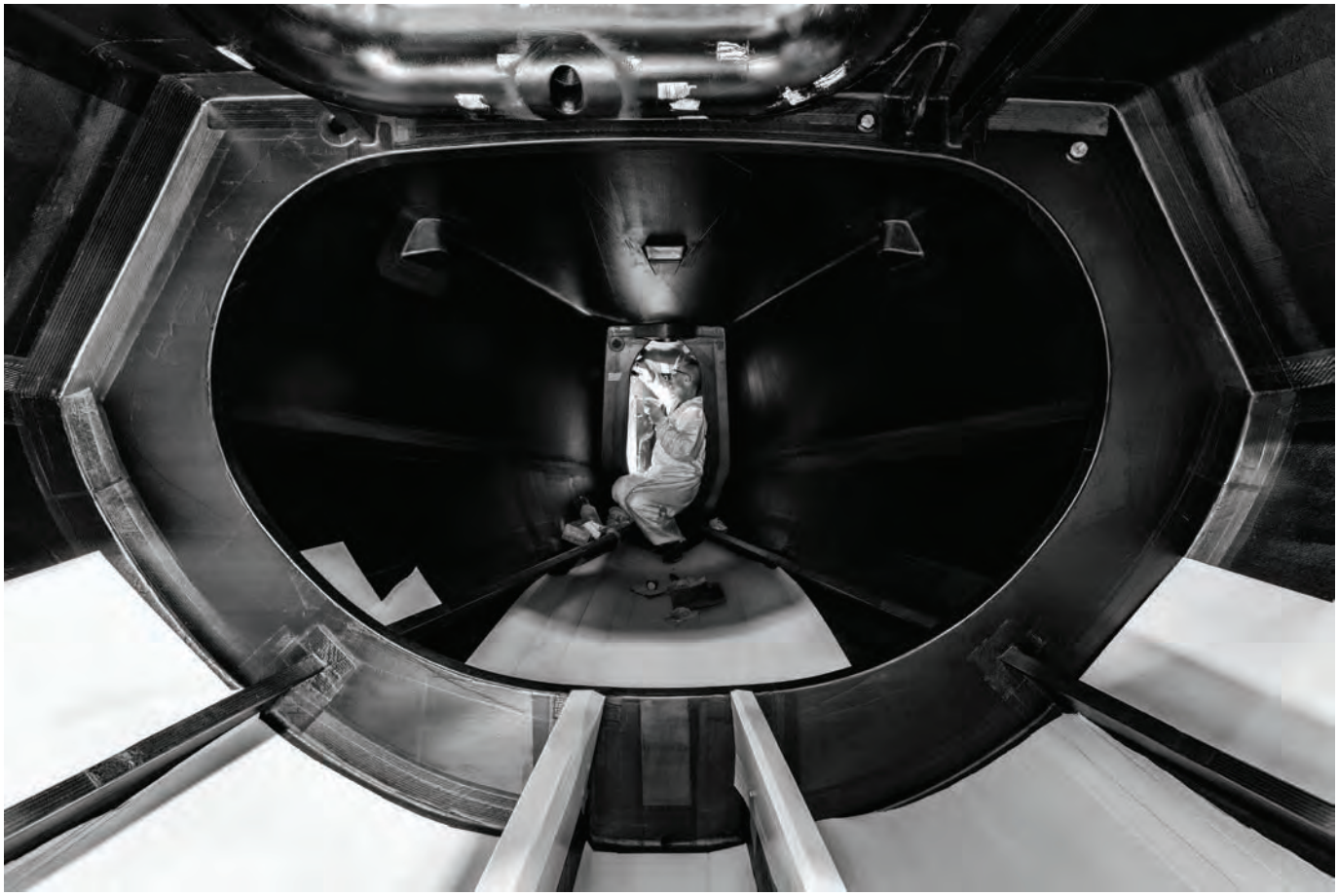
"We might suggest some configurations and the right resin system to use, and the industry partner will make the components and do their own in-house testing," he says.

"It is a great opportunity to really establish a major centre of composite materials, composite manufacturing, automation of manufacturing, and development of high-performance materials with composite and carbon fibre."

While carbon fibre composites are both lightweight and strong, Professor Varley says those benefits are only part of their potential.

"Composites offer more than that. The Carbon Revolution wheel is a perfect example of a complex component designed in a way that other materials find it difficult to replicate," he says.

"The combination of manufacturability, complexity, volume, performance and cost of carbon fibre composites is second to none."



Leveraging 50 years of composite experience

By Lachlan Colquhoun

Composite structures manufactured by McConaghy were used in a submarine piloted by filmmaker and adventurer James Cameron to descend 11km to the bottom of the Mariana Trench in 2012—the deepest oceanic trench on Earth.

Today, the Gosford-based McConaghy continues to build high-performance composite prototypes and structures for marine and industrial applications, and is also venturing upwards into the space industry where it is looking for new collaborations to leverage its 50 years of experience.

"We are composite specialists and have all sorts of inquiries from people who come to us with technical challenges, and we help them with bespoke solutions," says Eric Desjardins, McConaghy's General Manager.

"Many space applications will require highly sophisticated lightweight structures which will be purpose-built. We think companies can use our knowledge and experience with composites to arrive at solutions much faster than they would if they began their composite R&D journey from scratch."

The McConaghy story began in 1967, when John McConaghy founded the company based on his passion for yacht racing and using novel materials which had never been used before in marine applications.

Originally, John McConaghy concentrated on building small racing yachts such as skiffs, Tornado and A-class catamarans.

By the 1970s, the company was one of the first to apply prepeg carbon to yacht construction, using materials previously used only in aerospace. McConaghy's first 18 foot prepreg carbon skiff was a revelation that set performance benchmarks for many years.

In the 1980s, the company moved into manufacturing maxi yachts, constructing the first prepreg nomex

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cored maxi yacht engineered by Giovanni Belgrano and SP Systems which was the largest composite structure in the world at that time.

In the year 2000, McConaghy employees, Jono Morris and Mark Evans, took over the company reins from founder John McConaghy and his long-time business partner, Steve Moxham. In 2014, the company partnered with Tiger Group, a prominent commercial marine company led by keen yachtsman Graham Porter, and received capital investment in state-of-the-art facilities, machinery and equipment. Today, McConaghy operates from facilities in Australia, China and Hong Kong, and continues the tradition of building lightweight, strong and reliable vessels such as the maxis Wild Oats XI and Blackjack—some of the most successful racing yachts in the world.

McConaghy has also manufactured architectural projects, such as making a typhoon resistant composite radome for the new Kai Tak Cruise Terminal in Hong Kong, and—closer to home—an innovative curved roof for the Sydney Opera House. There were also unique projects such as a bespoke case made of composite materials for a rare 100-year-old viola, a solar race car Sunswift for the University of NSW, GRP components for navy projects, carbon components for the train industry, and the list goes on.

Not all of McConaghy's projects are above the water. In 2010 the company was approached to assist James Cameron in the construction of the Deepsea Challenger submarine planned to venture to the bottom of the Mariana Trench in the western Pacific Ocean.

"That was quite a challenge," says Tony Johnson, Production Manager.

"There was a lot of R&D involved in that project, because they needed something that could compress under the extreme pressure (1,100 Bar) and then come back into shape, so we had to research new materials, and that involved some experimentation."

During a three-month period, McConaghy developed a solution for bonding more than 250 sections of the submersible's core buoyancy material, an extremely hard and high-strength composite foam called ISOFLOAT® which formed the main structure of the vessel.

McConaghy fabricated and assembled 95% of all composites in the project, including the main beam, thruster units, doors, access panels and battery housings.

One of the unique requirements was that when the submarine was under intense pressure at 11km deep, at the bottom of the trench, it was 60mm shorter than at sea level.

At the end of the project, James Cameron said, "It's safe to say we couldn't have done this without the McConaghy team."

For its involvement in this project, McConaghy was awarded the Australian International Design Award in 2012.

McConaghy first ventured into the space industry through the Astronomy Branch of the CSIRO when it produced some prototype components for the Australian Square Kilometre Array Pathfinder radio telescope built in Western Australia. But it was the creation of the Australian Space Agency in 2018 that has given the company a fresh focus on being part of the Australian space ecosystem.

"Our expertise is in creating very specialist and bespoke parts suitable for telescopes, satellites and also for rockets," says Desjardins.

Compact, lightweight structures made from composite materials are being developed for future deep space small spacecraft missions, and McConaghy has the expertise to manufacture these solutions.

"We have the skills to build components such as the nose cone of a rocket as well as internal structural elements," says Desjardins.

"We could do any part which is highly curved and highly loaded but needs to be lightweight.

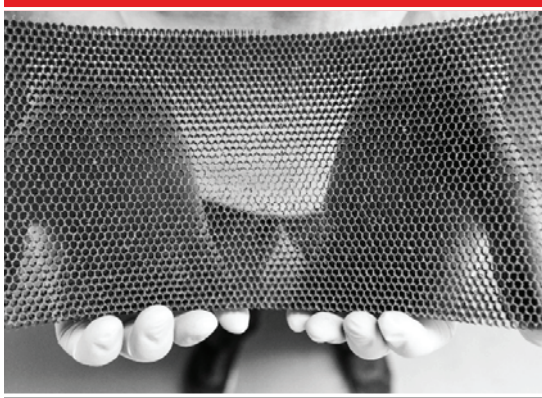
Desjardin's message to the space industry is that they "don't need to reinvent the wheel" when it comes to composite materials applications. They can leverage 50 years of experience and success at McConaghy, and save time and cost and get projects operational faster.

"We see ourselves as being here to assist," says Desjardins.

"We already have the capability, and have a proven track record.

"Much of that is on the water and under the water, but we are keen to get our products into space too."

McCONAGHY



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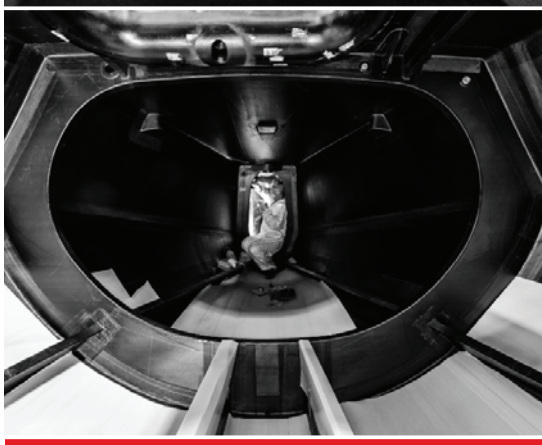

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