



MAKING INNOVATION PERMANENT

Technology has always been integral to Defence. In fact, history is littered with examples of how disruptive technologies have changed the course of a battle.

GABBY COSTIGAN | CANBERRA



FROM LEFT: Red Ochre is a quintessentially Australian substance, used in traditional indigenous ceremonies and a large part of our environment.

WHETHER it was the long-bow, the machine gun or the vertical take-off fighter aircraft, disruptive technologies time and time again have provided a strategic and battle-winning advantage.

Disruption in technology does not happen by accident. It requires investment and focus, and the time, space and resources to innovate. After all, it is innovation that is necessary to spiral technology in such a way that it can provide our armed forces with a capability edge and a strategic advantage.


BAE Systems Australia has been investing in advancing defence technology in Australia for over 65 years. Today we are focusing on our diverse and innovative work through Red Ochre Labs. Centred around a new facility in Melbourne, that acts as a hub for our leading engineers across the nation, Red Ochre Labs signals a renewed and strategic approach to research, innovate and develop disruptive technologies for the Australian Defence Force.

One of the enduring challenges we face is ensuring that we remain aware and responsive to the evolving needs of our customer, the ADF. We need to understand how they work, what their challenges are today, and how to combat the threats of tomorrow.

What I really like about Red Ochre Labs is that it will be a centre for collaboration with the ADF. It will also facilitate greater engagement with Australian industry and academia to ensure the ideas, ingenuity and expertise across the defence landscape can be harnessed.

As we look to the future, and contemplate a more challenging and ever changing defence and security environment in our region, I am excited about the approach we are taking to invest in technology right here in Australia.

There is no reason why Australia can't be the originator of defence innovation and technology. And there is no reason why we can't exploit the ideas we develop to create



“AT A NATIONAL SCALE, DEFENCE COMPANIES ARE NOT OFTEN THOUGHT OF BY THE GENERAL PUBLIC AS CENTRES FOR TECHNOLOGY DEVELOPMENT. BUT I HOPE THROUGH RED OCHRE LABS THAT WE CAN CHANGE THAT PERCEPTION HERE IN AUSTRALIA, AND CHANGE IT PERMANENTLY.”

SUPPLIED BY BAE SYSTEMS

new companies, and new industries that benefit not only the security of our nation, but our economy as well.

In this way I see innovation as providing an opportunity that also meets the challenges our nation faces today as a result of the COVID-19 Pandemic. Investing in innovation as we are through Red Ochre Labs can provide Australia's best scientists and engineers with interesting and rewarding work, something I know is integral to the career of any engineer, but particularly those engineers who work in defence.

If you can imagine the amalgam of people with expertise in rocket science, software hardware, mechatronic engineers, navigation and guidance experts, defence analysts, control systems engineers, material and additive manufacturing specialists – all under the same roof. That's Red Ochre Labs.

On a national scale, defence companies are not often thought of by the general public as centres for technology development. But I hope through Red Ochre Labs

that we can change that perception here in Australia, and change it permanently.

After all, Red Ochre has been a permanent feature of the Australian landscape for thousands of years. I believe that Red Ochre Labs can likewise become a permanent icon for Innovation in the Australian Defence industry.

Gabby Costigan is the CEO of BAE Systems Australia.

PARTNERED CONTENT

The following pages are a paid partnered effort between ADM and BAE Systems Australia to celebrate and showcase the R&D efforts of the company in the wake of the opening of their Red Ochre Labs.



BAE SYSTEMS CONSOLIDATES R&D UNDER RED OCHRE LABS

KATHERINE ZIESING | CANBERRA



ised,” Yelland said. “We went through a process essentially that said rather than working out how much we think we can afford to spend on technology, let’s work back from our strategy. What do we want to achieve? Where do we want to be in 20-30 years’ time as a business? How do we want to be supporting our Defence customer in 20-30 years’ time and what will they need over the next 20-30 years’? Work out where the technology gaps are, work out when you need to start investing in addressing those technology gaps and that then determines when and how much you need to spend.

“We can’t do everything, so

we’ve got to really be focused on which areas we invest in and we’ve identified five or six key areas that not only deliver technology that is going to be of benefit to our customer in the future, but technology that aligns with the capabilities that we’ve got and the opportunities that are coming in the short term through to the long term.”

Priorities being targeted include unmanned systems, autonomy and robotics, smart sats, data analytics, artificial intelligence (AI), advanced sensors including HF and EW, hypersonics, advanced weapons and countermeasures and sustainment technologies including prognostic health management. The company is looking to leverage opportunities where BAE Systems Australia has a natural advantage that will complement existing business both in Australia and internationally.

“You’ve got to be able to recover any investment that you make as a commercial company. Much as I’d love to, you can’t just invest in the things that are really, really cool to do. You have to invest in things that have a reason, a strategy behind them and therefore a route to market.”

FOR more than 65 years, BAE systems Australia has been expanding its capabilities across multiple defence domains. With work being pursued and executed across the entire defence business spectrum, the company has made the strategic move to consolidate its suite of Research and Development (R&D) efforts under a single banner, Red Ochre Labs.

“With the acceleration in technology in recent years, we decided to do two things,” Brad Yelland, BAE systems Australia’s Chief Technology Officer explained to ADM. “One was to change the way that we focus on technology and instead of breaking up a budget and spreading it around the business and having each individual line of business work out what they wanted to invest in, we decided to centralise everything and have it strategy led to increase its impact.

“The second part was if we now have a centralised technology area, an area where we do all the technology and early product development activities, then why don’t we give it a name?”

Akin to Lockheed Martin’s Skunk Works or Boeing’s Phantom Works, Red

Ochre Labs aims to capture the Australian R&D effort resident in BAE Systems. Picking the name of such a distinctively Australian business, Yelland wanted to evoke a sense of country to tie their increased efforts in with their Reconciliation Action Plan (RAP).

“Whenever you see a picture of a landscape with red earth, you pretty much know that it’s Australia. And when you have a look at a lot of the products that we work on like JORN, Nulka flight trials, like the UAV work we’ve done, the M113 work we’re doing now, photos show that red earth in the background. Red Ochre really says Australia.”

BAE Systems Australia spends roughly between \$10-\$15 million annually on advanced technology development and is looking to align its programs and partnerships with the capability decisions that Defence is making.

“We’ve really increased it fivefold in the last three years since we central-

ABOVE: Red Ochre Labs will also be supporting BAE Systems Australia’s largest programs like the Hunter class.



GETTY IMAGES

ABOVE AND BEYOND IN SPACE

EWEN LEVICK | SYDNEY

ADELAIDE is fast becoming Australia's space city. The recently-formed Australian Space Agency and its Mission Control Centre are located at the Lot Fourteen Precinct in the city centre; EW satellite start up DEWC Systems resides in the city's north; and launch provider Southern Launch, which recently flew the first Australian commercial space-capable rockets to the edge of space, is headquartered just near Rundle Mall.

Whilst BAE Systems Australia's presence in the city is perhaps most notable for its shipbuilding capability, it is in fact another major contributor to SA's growing space economy. Unrivalled engineering and advanced manufacturing capabilities allow the company to produce a wide

variety of space-related components, including electronics and optical systems, support for satellite ground stations, and advanced radio frequency components.

Now that capability is becoming increasingly important to Defence.

"Defence has dissected two key critical areas – space services and space control – in the space domain," Brenton Whittington, Principal Engineer ISR for BAE Systems Australia, said to ADM. "The recently released Force Structure Plan has clearly indicated the importance of space as a domain to the ADF, and Defence has also released a couple of requests for proposals (RFPs) and requests for tenders (RFTs) associated with the space domain."

ABOVE: If you ever needed a particular domain that's inspiring, space is it.

Defence and BAE Systems Australia, through Red Ochre Labs, consider the importance of space to lie in two critical areas. The first is space domain awareness, or 'traffic management'.

"The number of spacecraft debris, both natural and manmade, will significantly increase," Whittington said. "Access to space via commercial means will become commonplace. The number of small satellites filling Low Earth Orbit (LEO) to Mid-Earth Orbit (MEO) will ever increase the chance of collision. Awareness and understanding of the skies above will be of paramount importance."

An additional challenge in this area is earthbound supply lines; a global vulnerability that has recently been exposed by the pandemic.

"Whether we look to launch from an international partner, another nation some-



where or whether we look to launch from Australian soil, I think the pandemic has shown us which way we need to look," Whittington said. "Building the Australian ecosystem and industry to support those endeavours will be paramount."

The second critical area is bringing information back down from space, particularly Earth and deep space observation capabilities.

"This refers to the use of space and near space assets to collect, monitor, analyse and disseminate actions and activities," Whittington said. "This will enable us to understand environments faster and with more precision."

To advance Australia's capabilities in space domain awareness and observation, BAE Systems Australia is a partner in a number of cooperative research centres (CRCs), including the increasingly important SmartSat CRC.

"AN ADDITIONAL CHALLENGE IN THIS AREA IS EARTHBOUND SUPPLY LINES; A GLOBAL VULNERABILITY THAT HAS RECENTLY BEEN EXPOSED BY THE PANDEMIC. IN ADDITION, THE FORMATION OF RED OCHRE LABS BUILDS ON THE COMPANY'S ON-GOING EFFORTS TO GET KIDS EXCITED ABOUT SPACE AND STEM DISCIPLINES."

"The research and development that BAE Systems Australia is undertaking through its involvement with several universities and research bodies looks to the development of both ground based, near space and space based space technologies, with a keen interest in the development of secure and trusted AI frameworks to underpin more diverse aware and autonomous sensors," Whittington said. "So our partnerships and discussions with the growing Australian space industry community have been extensive and we recognise the need to develop current and the next-generation thinking and understanding."

Through the SmartSat CRC, the company is cooperating with Adelaide University, UNSW, Latrobe and Sydney University.

"Those four universities are predominantly engaged with us around AI cyber security and the enhancement of a lower swap, so size, weight and power," Whittington said. "So enhancing the processing ability in satellites as payloads."

The joint effort BAE Systems Australia is undertaking through the CRC is ultimately aimed at developing the next generation of space technologies and bringing them to market. It intends to capitalise on the 'Space 2.0' revolution, in which access to the last frontier moves from government to industry.

"The CRC is predominantly there to engage and attempt to foster an Australian ecosystem, to build an Australian ecosystem, not just for research and development but also for industries to come to commercially viable products," Whittington said. "It is about the application enhancement of current technologies, but it's really attempting to go to that next generation of satellites."

"it really will start to change the feel from space from being exclusively zoned for governments and military usage; we'll see commercial and industry playing a far bigger role in those lower orbits."

So how will the formation of Red Ochre Labs facilitate the company's presence in Australia's nascent space industry?

"Red Ochre Labs looks to enhance or deliver the next generation of technologies," Whittington said. "So it's looking at probably not what is clearly apparent or right in front of people's faces right now as technology to prosecute, but what will it look like for the next generation; the 'what ifs'."

"[For example] constellation and autonomous flights, and the development of AI in a multi-modal sensor capability. So near space and space based assets being able to determine courses of action based on their environment."

In addition, the formation of Red Ochre Labs builds on the company's on-going efforts to get kids excited about space and STEM disciplines.

"Even outside of Red Ochre Labs, I'm involved in a number of discussions with BAE Systems Australia to support a lot of STEM activities through high school developments, undergraduates, even Year 9 and 10 students coming out for vocational work," Whittington said. "They come out and learn, see what we're doing, have a look at some of the development activities."

"If you ever needed a particular domain that's inspiring, space is it."

SIMULATION



KATHERINE ZIESING | CANBERRA

In many respects BAE Systems Australia is known for its platform business. But the company also has form when it comes to products. One of the lesser known products that has achieved global export success (in use with 13 navies around the world) is the ship air defence model (SADM).

Beginning life in the early 1990s when simulation tools were still in their relative infancy, SADM was originally designed to showcase how to protect ships from missile attack.

The SADM simulates own-ship and task group protection using guns, missiles, active decoys, chaff and jammers, and includes detailed models of ship-board sensors and their interactions with ship combat systems.



JOURNEY GOES GLOBAL



LEFT: SADM uses feeds from ESSM, Nulka, radars and a number of ship systems to produce a coherent ship defence picture.

It also includes weather effects to model signal propagation and signature attenuation in rain and other conditions.

SADM today is a versatile operational analysis tool that simulates both task group and single ship operations against multiple aircraft and missile threats.

"The concept was so revolutionary when we began that it was hard to explain without some kind of visualisation," BAE Systems Chief Technology Officer Brad Yelland and one of the SADM 'fathers' explained to ADM.

"Using flight simulation information to build a set of 3D CAD drawings that could be combined and rendered to build the animation, the initial product was essentially a marketing tool.

"But we soon realised what it was we had in our hands – we could expand the capability to reflect different payloads, how different missiles would interact with the ships' systems."

"And, not long after we realised that what we were developing was an exemplar simulation of an air defence scenario for maritime.

"Then we started to think about all the different applications and realised that if we could get really good high fidelity models of radar seeker heads, the RF environment, ship motion together with building in the capabilities of other ship sensors and weapons, then what we would have is a pretty sophisticated naval air defence model that could be used for a number of different purposes.

"So we recruited experts to build that capability into SADM, using much more capability computer-based simulation and visualisation applications to produce a tool for three main purposes."

The tool is still used to inform developers as continued development and improvements to the capability are

made. Customers use it to develop requirements for air defence systems and combat systems. Finally, SADM is also a training tool.

The company is also working on a development plan that would see a fourth application in real time operational aid where in the ops room the sailors can actually use it, running faster than real time to work out the best approach to any given scenario therein.

A SADM users group consisting of all 13 navies that operate the system was initiated by the Canadian Navy

because it wanted a forum that could be used to communicate easily with other users of the model to talk about modifications, upgrades and additional capability they wanted, how to do certain things with the model. This forum still meets on a regular basis and it cost-shares modifications to the model. There are open modifications that are shared among the community.

"One country might pay for it but is happy to share it amongst all the other nations using it," Yelland said. "There are other enhancements that we do that are sensitive to one nation's particular needs that remain exclusive to that country's eyes only. It's used extensively in defence establishments such as the Naval Research Labs in the US, the Maritime Warfare Centre in Canada, DST Group in Australia and UK MoD. Many NATO nations use it too."

HUNTER CLASS R&D AND ENGAGEMENT FOCUS



BAE SYSTEMS AUSTRALIA

KATHERINE ZIESING | CANBERRA

AS part of the National Shipbuilding Plan, BAE Systems' Hunter class (based on the Global Combat Ship that both the UK and Canada have also chosen) design is on track to hit some key milestones this year. The first of five prototype blocks will begin construction in December in the new yard at Osborne. The new yard is complemented by the digital shipyard approach that the company has been finetuning for over 18 months in preparation for the work to begin.

The work is being done by ASC Shipbuilding, a subsidiary of BAE Systems Australia, for the life of the program.

"The main focus of the work that we're doing at the moment that overlaps with Red Ochre Labs is around data, data analytics, build for sustainment and sustainment technologies and how we leverage those technologies into the block builds early in the process," Sharon Wilson, Continuous Naval Shipbuilding Strategy Director at ASC Shipbuilding explained to ADM.

ABOVE: The design process for the Hunter class uses a range of Industry 4.0 tools

RIGHT: Visualisation tools are an important design and training tool for the Hunter class.

While the Hunter clearly has a reference ship design, the engineering team has been looking at a range of local solutions that can help Australianise the entire capability lifecycle of the class. With an Aegis combat system core and CEA radars, some of the major system aboard are already seeing the Australianisation process taking place. Red Ochre labs will contribute to Australianisation opportunities in the future with technologies such as high speed weapons, autonomous systems and directed energy weapons to name a few. It also means that BAE Systems and ASC Shipbuilding are looking to also make the most of Australian small to medium enterprises (SMEs) and their innovation where they can.

There are a few ways for companies looking to be involved to get engaged. Evangelos Lambrinos is the Innovation Manager, a key point of contact for industry, keeping up to date with the ICN portal, and the regular innovation challenges the company runs (again details posted on ICN for upcoming rounds).

"We're always interested in new technologies and new solutions," Wil-

son said. "The key thing is that it might not be yes straight away but it might be yes eventually. These things do take a bit of time, depending on what you're offering of course."

Red Ochre Labs also provide the Hunter team with 'Technology Watch' which is a regular newsletter update on the latest technologies available from industry and researchers – a valuable resource to the team.

For innovation challenges the company has teamed with Flinders University and moved in to the old Mitsubishi plant at the now Tonsley Innovation Precinct to create Pilot Line Zero, basically a mini shipyard, and part of a much bigger Line Zero Factory of the Future concept for advanced manufacturing. There are now more people working in the Tonsley facility than there was when it was a car plant.

"Line Zero is intended as a collaboration space where SMEs can come and showcase their technology," Wilson said. "For example, the smart logistics systems and people working with robots is something that we can demonstrate at Line Zero."

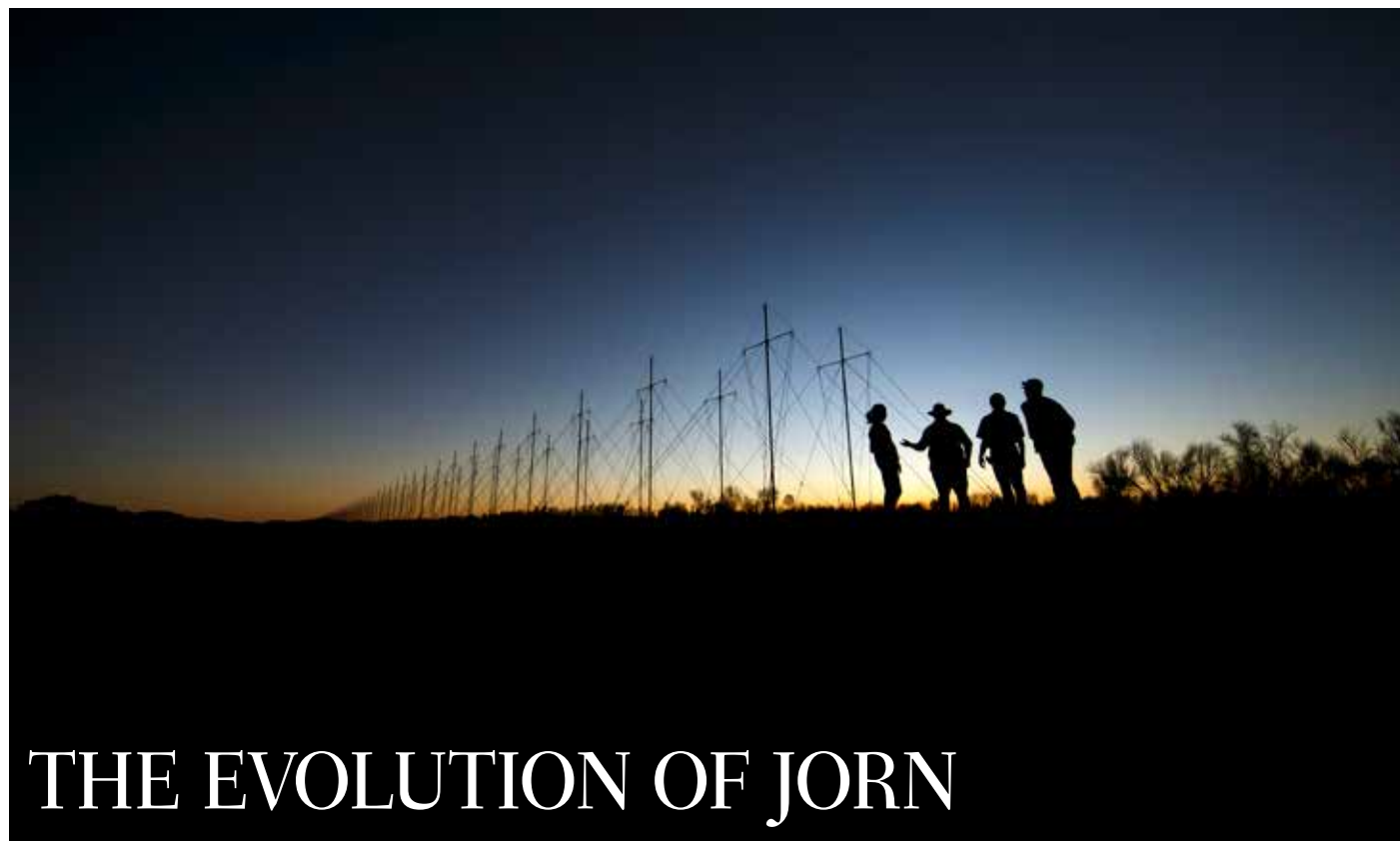
The whole idea behind Line Zero is that we can emulate the shipyard but without the security or access requirements. We can also engage with people in a more collaborative way that is more open so we can test and try different Industry 4.0 technologies as part of Line Zero.

In the same way, the building of the prototype blocks is not about proving that a ship can be built; it's more about testing and proving all the new systems behind the digital shipyard approach, according to Wilson.

"We need to make the technology people-centric. So it's not about the tools, it's about how our people work with the tools which will lead to success."



BAE SYSTEMS AUSTRALIA



DEFENCE

EWEN LEVICK | SYDNEY

THE story of High Frequency (HF) systems in BAE Systems Australia starts in the continent's red centre, for which Red Ochre Labs is named. The company has been involved in developing the globally-unique Jindalee Operational Radar Network, or JORN, for the past 35 years: a long-range, HF over-the-horizon radar that provides situational awareness of Australia's air and sea approaches.

"JORN is 100 per cent designed and developed in Australia," Richard Udall, BAE Systems Australia Project Director JORN Phase 6, said to ADM. "We've played a critical and central role in the development of JORN over the past 35 years, working closely with DST and also CASG to develop and enhance the capability."

JORN comprises three sites across Australia that together provide wide-area surveillance of ships and aircraft out to 3000 kilometres. It is operated by the RAAF out of Edinburgh, SA, and supported by 427

company engineers, project managers, technicians and supporting staff.

"It's controlled and operated across the road here at RAAF Edinburgh from the Battle Space Surveillance Centre," Udall said. "Each radar site basically comprises of a transmit and a receive site. The three locations are Longreach in Queensland, that's radar one; Laver-ton in WA, which is radar two; and then radar three at Alice Springs.

"In addition to that, there's also a pretty comprehensive network of ionospheric sounders and transponders over the northern parts of Australia."

Although the network is now in its fourth decade of service, it remains as cutting-edge as ever. Under Air 2025 Phase 6, BAE Systems Australia is opening the system architecture to extend its operational life out to 2042.

"The Phase 6 contract commenced in April 2018 and was designed to change and open up the system architecture, allowing next-gen technology insertions," Udall said. "For example, digital receivers and new next generation hardware which

will improve efficiency, reliability and operability for the end user."

The Phase 6 effort is supported by a large network of Australian suppliers and partners.

"We've got around 113 suppliers and local SMEs, including indigenous suppliers as well, who either directly support the existing system or are actually involved in the Phase 6 upgrade," Udall said. "We've also just launched the JORN Open Innovation Network (JOIN), partnering with DST, Defence and the University of Adelaide.

"This sees us partnering with academia to do some more student engagement, fund teaching programs and also become a research centre for developing new technologies."

According to Udall, the opening of Red Ochre Labs is an opportunity for further research and development into keeping JORN at the forefront of HF tech and Australian sovereign capability.

"We have the brains within the company and certainly within the JORN program," Udall said. "Having the ability to do some of that research and development piece as part of Red Ochre is going to keep us and JORN at the cutting edge."

ABOVE: JORN is a world leading HF capability developed and improved here in Australia.



DEVELOPING EXPORT POTENTIAL FROM THE JORN FOUNDATIONS

THE company is looking to leverage its experience into other markets.

"I think the key fundamental for us is how we can build on more than 40 years of conducting leading edge High Frequency (HF) research and development and specific to that, the work we're doing with Defence," Tom Tizard, BAE Systems ISR Campaign Lead said to ADM. "In line with Defence and Foreign Policy's ambition to become a top ten global defence exporter, we've been exporting HF systems technologies for more than a decade."

The HF export business has grown into a \$120 million program. Building on this strong base, it continues to fulfil customer requirements in both Australia and globally. From receive and transmit technologies to modular open systems architecture command and control and signal processing software solutions, the potential for further technology development is only limited by imagination.

"We're seeing customer requirements embrace more flexible, supportable and deployable aspects, so how we look at the same sorts of unique and innovative technologies but in more effective form factors and being able to deploy them to potentially remote locations," Tizard said. "And then secondly, also, how technology could

provide more multi-mission capabilities, and thus far more scalable and cost effective. That really comes through from the technology innovations the company's driving in collaboration with key industrial partners. This is providing some really exciting stimulus to our export business and the work we do outside of Australia."

Tizard is keen to highlight the collaboration with partners in Defence, CASG, industry and academia that underpins the world leading approach in what has become a sovereign capability.

"I think the good thing is the combination of strong domestic and export businesses is fundamental to driving that robust and long-term sustainable industry capability, which provides Australia with the ability to maintain its strategic advantage in the domain."

The ground-breaking nature of the work is also important to attracting and retaining a skilled workforce that has the opportunity to constantly work on new and innovative programs.

HF systems as a whole have been around for a long time; they've been through their ups and downs by way of operational popularity, especially given the rise in technologies such as SATCOMS and other forms of sur-

veillance. A recent renaissance and a focus on how technology advances can increase that capability, especially in a reliable, resilient and cost-effective way has seen the technology become more popular again.

"HF is a very dependable technology and so whether in the OTHR domain for another surveillance sensor as part of a wider battle space, a picture or indeed a reliable back-up communication system perhaps to SATCOMS in a satellite denied environment," Tizard said.

"The technology and the market has grown in line with the evolving customer requirements and the threats as well. As the threat environment has evolved, so too have customers' needs as a result, not just the Australian Defence Force, but other export customers have also sought to increase their own sovereign capabilities in areas like HF in order to respond to mission requirements. I think the future is really quite interesting in that respect, as technology drives innovation and as we get to embed that and prove it in projects like JORN, then the popularity of HF should continue to grow.

"Our ambitions in the export domain to date have been very much focused on the over-the-horizon radar segment with at least a decade of work in that domain. The future for us is moving into adjacent markets like to the HF communications domain.

"For that, our view there is that there could be a market potential in excess of \$10 billion globally. So working in collaboration with the Commonwealth and also Australian industry, we're looking to see how we could potentially leverage that investment in core HF technology to further build that sovereign capability base and related economic benefit in order to maintain a global strategic advantage. Very exciting times ahead in that respect," Tizard concluded.





BELOW: Work on the technology and platform will continue in the wake of the successful demonstration program.

LEFT: The work done by BAE Systems Australia and the Army on the M113 autonomous trial saw them win their Essington Lewis category of Support/Services this year as well the Prime contractor trophy.

KEEPING THE M113 RELEVANT AS UNMANNED PLATFORMS

EWEN LEVICK | SYDNEY

IN September 2019, BAE Systems Australia announced that it was working alongside the Australian Army to convert two M113 armoured personnel carriers into autonomous vehicles. The purpose was to help Army understand how autonomy will change the future of war.

"One of the really important pieces about the M113 program is it's actually not about the M113 at all; it's really about supporting Army to understand how autonomy can change the face of the land battle space," Natalie Waldie, Program Manager Technology Development, said to ADM. "The M113 was really a convenient vehicle that we proposed as an experimental platform to demonstrate autonomy."

Engineers and technicians at the company's Edinburgh Parks facility fitted out the two vehicles with a Vehicle Management System (VMS) containing the technologies for autonomous guidance, control and navigation of the M113. This VMS was a variant of the VMS that BAE Systems Australia has supplied to a range of other programs both in Australia and overseas, including the UK's Taranis and Mantis unmanned

aircraft demonstrators, and the multi-all-terrain vehicle (MATV) and Digger unmanned ground vehicle (UGV) demonstrators. The conversion took just six months.

"The reason we were able to do that really quickly was because we have this autonomous vehicle management system that BAE Systems Australia has developed over the last 20 years," Waldie said. "We've kitted these systems out to be able to follow a series of way points, and gradually over the next two years, we'll introduce higher levels of intelligence."

Now, the vehicles are available to all industry partners in the Trusted Autonomous Systems Defence Cooperative Research Centre (DCRC) on this land program to use as test and demonstration vehicles.

"We've partnered with Melbourne University and Adelaide University, as well as DSTG through the DCRC to develop that next generation of autonomy," Waldie said. "So in three years' time we will have an autonomous asset that can independently



manage a mission with multiple competing objectives, understand and interpret its environment, and cooperate to deliver an overall mission objective."

Ultimately, the goal is to achieve a network of autonomous vehicles that can deliver tactical effects ranging from casualty evacuation to electronic warfare.

"Autonomy doesn't achieve what it needs to unless you can effectively integrate it into your overall battle space CONOPS, and that's really what we're exploring with Army," Waldie said. "We'll work with Army as Red Ochre Labs to be their partner, to develop and mature the technology in an affordable, efficient and rapid way, ready for when Army to go to an acquisition program to acquire the capability that they know they need."



AUTONOMY – PAST, PRESENT, FUTURE



DEFENCE

EWEN LEVICK | SYDNEY

AUTONOMY: self-governing, freedom of action, independence of thought.

These are the definitions returned by a quick Google search. They're small phrases, but they contain enormous challenges. An autonomous platform is not just an unmanned platform flown by a pilot sitting in an office chair. An autonomous platform has no pilot at all. Autonomy means a machine that can make its own decisions; a machine that can answer the questions of how, when, and where to deliver tactical outcomes in any domain. It means learning, adapting, adjusting, responding. These verbs are easy for humans, but coding them into a software program requires industry-leading expertise.

BAE Systems Australia has a three-decade pedigree in autonomous technologies. Perhaps the most famous example this expertise is the Nulka active missile decoy, which is now Australia's largest regular defence export. The decoy is completely autonomous post-launch.

"Nulka is really where it started," Glenn Logan, Director of Technology & Product Development for BAE Systems Australia, said to ADM. "It formed the capability within BAE Systems Australia, and on the basis of that, autonomy became one of our key areas."

In the 1990s, the company was the lead Australian participant in the Raytheon-led collaboration to develop the Evolved Sea Sparrow Missile (ESSM), which protects warships against anti-ship cruise missiles. BAE Systems Australia developed the thrust vector controller, the aerodynamic control fins, the guidance section units and the algorithms that tied them all together.

Elsewhere, BAE Systems Australia has supplied flight control computing to the UK's Mantis program, and the company's Melbourne office was also involved in the UK's Taranis stealth unmanned combat aircraft technology demonstrator.

"We partnered with the UK in the early 2000s to develop a range of autonomy as-

sets through our Melbourne team – which is really the forerunner to Red Ochre Labs," Logan said. "In nine months we developed and delivered the whole autonomy solution – all the control systems, all of the data links, all of the RF comms, all of the ground station – and we all met up at Woomera, exactly 100 years to the day since the Wright brothers flew."

The autonomous technologies BAE System Australia supplied to those programs were recently integrated into two prototype autonomous M113 armoured personnel carriers, which were demonstrated to the Chief of Army in late 2019. More information on this program is available in the breakout box on page XX.

BAE Systems Australia has also leveraged experience built in the UK demonstrator programs to supply flight computers, navigation equipment, flight vehicle management and simulation capability to Boeing's Loyal Wingman since 2016, an autonomous fighter-like aircraft under development with the RAAF.

Now, BAE Systems Australia's Red Ochre Labs will bring all this expertise together under one roof.

"Red Ochre Labs allows us to bring all our people back out of those projects into a central place and re-establish that whole culture that we'd set up around autonomous systems," Logan said. "We have a long history, and now we're really looking to collaboratively work with Australian industry."



BAE SYSTEMS AUSTRALIA

ABOVE LEFT: The M113 unmanned conversion trial was a big win for both BAE Systems Australia and Army.

LEFT: BAE Systems Australia has a long history of unmanned flight platforms with Taranis being tested at Woomera.



OP-ED

A WORD FROM THE CHIEF DEFENCE SCIENTIST PROFESSOR TANYA MONRO

DST Group has gone through an evolution over recent times but continues to deliver on its core mission of providing world leading science and technology advice to the Department of Defence.

PROFESSOR TANYA MONRO | CHIEF DEFENCE SCIENTIST

THE 2020 Defence Strategic Update and 2020 Force Structure Plan, released on 1 July 2020, outline a new strategy for Defence and the capability investments to deliver it. Our strategic environment is now more complex, with Australian interests being more directly challenged than in the past – sharper prioritisation is required.

The new strategic policy framework for Defence has at its core three objectives: to shape Australia's strategic environment; deter actions against Australia's interests; and respond with credible military force, when required. Science and technology (S&T) plays a critical role across Defence capability. We must effectively shape and harness the national S&T enterprise in order to achieve a cohesive and agile innovation system that can deliver defence priorities.

The 2020 Defence Strategic Update asserts the need for emerging and disruptive technologies to be rapidly translated into weapons systems – such as sophisticated sensors, autonomous systems, cyber capabilities, and long-range and high-speed weapons. Defence, through the Defence Science and Technology Group, will play a stronger role in enabling, coordinating and focusing support to Defence from the national S&T enterprise including universities, other publicly funded research agencies and industry, as outlined in More, together: Defence Science and Technology Strategy 2030.

The 2020 Force Structure Plan delivers increased funding to innovation and capability acceleration programs to deliver on Australian industry's innovative solutions for Defence capability. The Government has committed to invest around \$3 billion across Defence innovation, science and technology over the next decade. It will enable the innovation programs to be driven by a more



ABOVE: Chief Defence Scientist Professor Tanya Monro.

comprehensive, coherent and agile innovation system that aims to strengthen the link between Defence's capability plans with industry policy initiatives, Defence's reform program, the More, together strategy, and clear resourcing plans. A more pro-active approach to the development of incremental and disruptive technologies will help bridge the 'valley of death' between technology development and acquisition.

New investments outlined in the 2020 Force Structure Plan demonstrate the potential for increased involvement of Australian industry, including investments in cyber, autonomous systems, artificial intelligence, radar, communications, and space-based capabilities and sensors. These investments offer the opportunity for Defence to work with industry to strengthen the Australian industrial base in these advanced technological areas.

Continued investment in the Next Generation Technologies Fund (NGTF) and the Defence Innovation Hub will underpin Defence's commitment to stability and growth in the innovation sector. The NGTF engages Australian industry, uni-

versities and research organisations to research emerging and future technologies with potential to deliver game-changing capabilities for Defence, and will make further investments worth approximately \$1.2 billion over the next decade. The Defence Innovation Hub funds Australian and New Zealand entities to develop innovative technologies with the potential to enhance Defence capabilities, with over \$800 million of further investment planned over the decade.

A new Capability Acceleration Fund will be introduced from the middle of this decade to ensure Defence's innovation system has the capacity to meet the demands of future technological development. Through this fund, the Government will invest over \$130 million to support the development of key disruptive technologies with industry, taking promising technologies through to acquisition.

Through the Australian Industry Capability Program, the Government will ensure Australian companies can participate in high-value, high-tech projects that will support the development of Australia's sovereign defence industrial base.

Building Australia's sovereign defence industrial base is a long-term body of work that requires coordinated effort. The 2020 Force Structure Plan expands the Government's investment to build a sovereign industrial base that is internationally competitive, innovative and high-tech to meet Australia's defence capability needs and national economic goals. This investment will deliver an Australian Defence Force (ADF) better suited to meet Australia's most pressing defence challenges, to deny or defeat threats as they arise and provide significant opportunity for Australian industry. It will ensure the ADF is better supplied, more resilient and able to sustain a technology edge into a more challenging future.



BAE SYSTEMS AUSTRALIA

ACADEMIA ALLIANCES THE WAY FORWARD

EWEN LEVICK | SYDNEY

THERE is a common thread looping through all these stories on BAE Systems Australia's formation of Red Ochre Labs: cooperation with Australian universities and academics. The company works alongside experts on a range of different projects and programs.

A prominent example is Professor Chris Manzie, head of the University of Melbourne's Department of Electrical and Electronic Engineering, whose team is

working alongside BAE Systems Australia on two programs: the 'co-design' of aerodynamic platforms; and path planning and verifiability within autonomous systems.

"We started working with BAE Systems Australia nearly a decade ago actually, starting in the supersonic space and looking at co-design of aerodynamic platforms," Prof Manzie said to ADM. "Think of the traditional design cycle. The engineering team goes through wind tunnel testing with a piece of hardware. It's then handed over to a control team in order to design and tune the control loops so that

the equipment can meet some desired specifications.

"But if the control team isn't able to get the particular hardware to meet those specifications, it gets sent through another hardware design iteration."

Professor Manzie's team is instead aiming to reduce the number of prototypes required, a process that could reduce the length of the design cycle for a range of platforms – including hypersonic weapons systems.

"What we were trying to do is use computational techniques and optimisation techniques to push the control design right up to the front and have fewer hardware prototypes and reduce the length of the design cycle itself," Prof Manzie explained. "We've continued to push that work into the hypersonic space and are now looking at hypersonic co-design problems in collaboration with the University of Queensland."

The second program Prof Manzie is involved in is developing aspects of autonomous systems in collaboration with DST Group and the University of Queensland.

"We're looking at two parts of the autonomous system. The first is multi-objective path planning, which involves working out a trajectory for a vehicle through potentially uncertain and risky environments in order to meet certain objectives," Prof Manzie said. "The other part of the program is verifiable autonomy. We want to ensure that when you put together the various components of an overall system, the combination of those components remains within the desired operating region of the controller."

For Prof Manzie, the formation of Red Ochre Labs will accelerate progress in these kinds of joint research projects.

"I think it's a fantastic initiative because it allows academia and BAE to co-locate, and often it's those synergistic discussions that accelerate progress significantly," Prof Manzie said. "It also ensures that we're all on the same page on where strands of the program are heading, so that we end up with a more cohesive overall program."

"I can't speak highly enough of the initiative."

ABOVE LEFT: Unmanned systems are a huge collaboration space for BAE Systems Australia and universities.



INTELLIGENCE IN SUSTAINMENT

EWEN LEVICK | SYDNEY

IT could be argued that the success of any military endeavour rests on the shoulders of sustainment. Keeping aircraft in the sky, ships out at sea, vehicles on the battlefield: it all depends on efficiently repairing and maintaining those platforms.

Through the formation of Red Ochre Labs, BAE Systems Australia is hoping to bring cutting-edge technologies to bear on the future of sustainment. The possibilities are immense and could see billions of dollars saved each year. The company refers to this as 'intelligent sustainment'; in effect, putting top-quality data in the hands of those who need it.

"At Red Ochre Labs we have our eyes on the horizon of game-changing tech, and we're implementing those that drive efficiencies to help us to do sustainment better," Karen Trezise, Principal Technologist for Sustainment within Red Ochre Labs at BAE Systems Australia, said to ADM. "We're also looking at that forward view to ensure that we're best placed to support the next generation of systems, in which autonomy and automation will be prevalent."

The company sees sustainment moving away from a reactive and physical approach to more of a predictive one, in

which advanced analytics and AI are used to drive effective decision making.

"It's going to be more monitoring, less of the physical work," Trezise said. "We're going to have technology to augment our maintainers and our operators; we're going to have more data fused platforms."

A key focus of these efforts is on mitigating the cost of corrosion, which for the RAAF alone can run to \$200 million a year. Up to 10 per cent of aircraft fleets can be grounded at a time.

The corrosion prognostic health management technology developed by BAE Systems Australia has been integrated into the world's largest defence program, the F-35 Joint Strike Fighter.

This is the first fleet of aircraft in the world with sensors installed on every production aircraft during manufacture. The technology will give each nation a sovereign ability to manage their assets to intelligently combat corrosion.

"Corrosion maintenance has generally been either completely reactive, so we fix it when we see it's broken," Trezise said. "Otherwise, we maintain based on a pre-established time interval in the hope that we nip the corrosion degradation in the bud."

"That approach is very costly. It assumes a one-size-fits-all approach to preventative maintenance."

Instead, Trezise and her team are embedding next-gen sensors and building prognostic algorithms to better time inspections and repairs.

"If we get an indication from our sensors and from our prognostic algorithm that the corrosive environment is high, we can then bring forward the inspections to minimise that impact of corrosion," Trezise said. "Maintenance becomes more condition-based."

The real focus, however, is on expanding the definition of sustainment beyond the machine.

"If we can do that for those assets, why can't we sensor and monitor the performance of our people?" Trezise said. "It's our people that also give us the capability edge."

"We're applying human factors to infer some wisdom from facial and eye tracking signals to know of and predict operator fatigue, what operator workload is like, and to improve training based on expected skill level."

According to Trezise, Red Ochre Labs focuses this vision and allows for outreach to global partners and universities.

"It definitely gives us a focused vision," Trezise said. "It gives us that enterprise approach to technology development, where we can leverage the best technologies out there."



LEFT: Corrosion management is a major sustainment cost driver.



HYPERSONIC RESEARCH RAMPS UP

EWEN LEVICK | SYDNEY

IT'S hard to think of any next-generation defence technology more discussed than hypersonic flight. The possibility of vehicles travelling at over five times the speed of sound – that's Melbourne to Adelaide in six minutes – tends to be seen as the holy grail of defence industry R&D.

"About a decade ago we could clearly see the trend towards hypersonics as a real discriminator for the future," Jerome Vethecan, BAE System Australia's Principal Technologist, said. "And it's become evident that other nations also recognise [their] disruptive value."

The company responded by focusing two decades of experience in guided weapons technology directly on the quest for hypersonic flight.

"The Nulka decoy and the JORN over-the-horizon radar systems are excellent examples of indigenous-led effort in innovation and engineering that's given us some of our real frontline defence capabilities today," Vethecan said.

"For a long time people thought that if you want high end guided weapons, high speed weapons, technology programs, that you have to look overseas towards the US," Mat Jones, BAE's Senior BD Manager for Future Tech, added. "But we believe - and we've proved in a range of relevant programs - that we have the capability and the engineering prowess to do certain elements of these weapons programs here."

An example is Project HiFire, a series of hypersonic flight tests at the Woomera Range in SA. The project was a collaboration between BAE Systems Australia, DST Group, the University of Queensland, Boeing Phantom Works (US) and others.

"The whole aim of HiFire was to be able to achieve understanding of the technology front, to solve some of the scientific problems around hypersonic flight," Vethecan said. "It has been an incredible achievement for Australia. We have been able to bring our considerable missile systems background at BAE Systems to develop solutions for some really challenging problems."



LEFT: The HiFire program is a strong foundation to further build upon Australia's hypersonic research efforts

BAE Systems Australia is also using its expertise to research systems that can defend against hypersonics; an approach that, according to Jones, is yielding great results.

"It's almost impossible to design, develop and implement a system to defend against a weapon that you don't know much about," Jones said. "So we're finding that all our work on the weapon and the vehicle technologies has direct relevance to the work that we're also undertaking on [hypersonic] defence technology."

The formation of Red Ochre Labs could accelerate Australian efforts towards successful hypersonic weapons and their counter-measures.

"There's a significant engineering effort that needs to be put into the development of scramjets," Vethecan said. "There are [also] some of the more obvious technolo-

gy limitations - things like very high temperature materials, avionics and systems that can survive the really hostile thermal environment of hypersonic flight."

"These are all core aspects of the future capabilities resident within Red Ochre Labs," Jones said. "We're working closely with DST to bring these technologies together to form an effective and cohesive response to the emerging threat in our region." ■

PARTNERED CONTENT

These pages were a paid partnered effort between ADM and BAE Systems Australia to celebrate and showcase the R&D efforts of the company in the wake of the opening of their Red Ochre Labs.