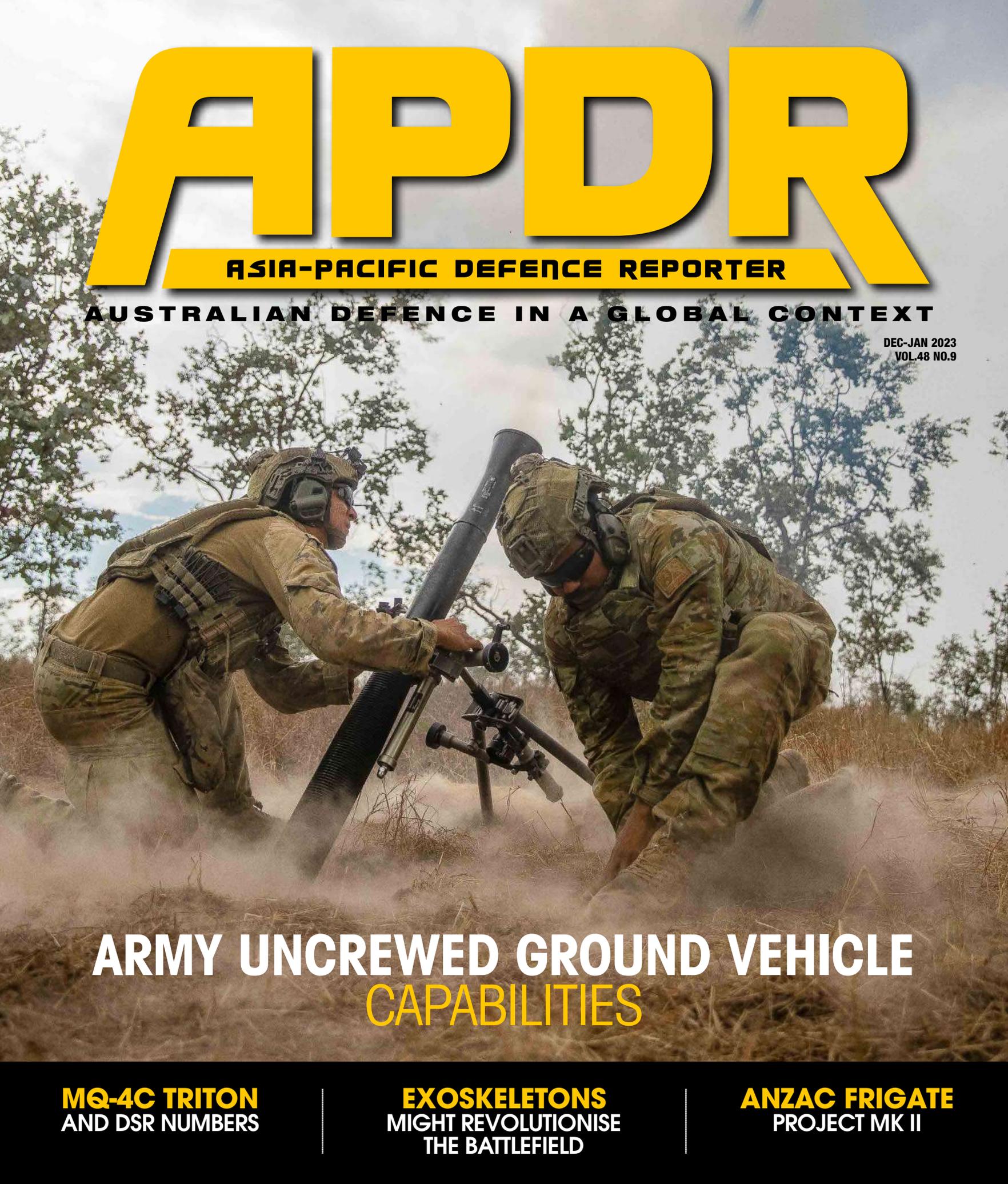


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AUSTRALIAN DEFENCE IN A GLOBAL CONTEXT

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ARMY UNCREWED GROUND VEHICLE CAPABILITIES

MQ-4C TRITON
AND DSR NUMBERS

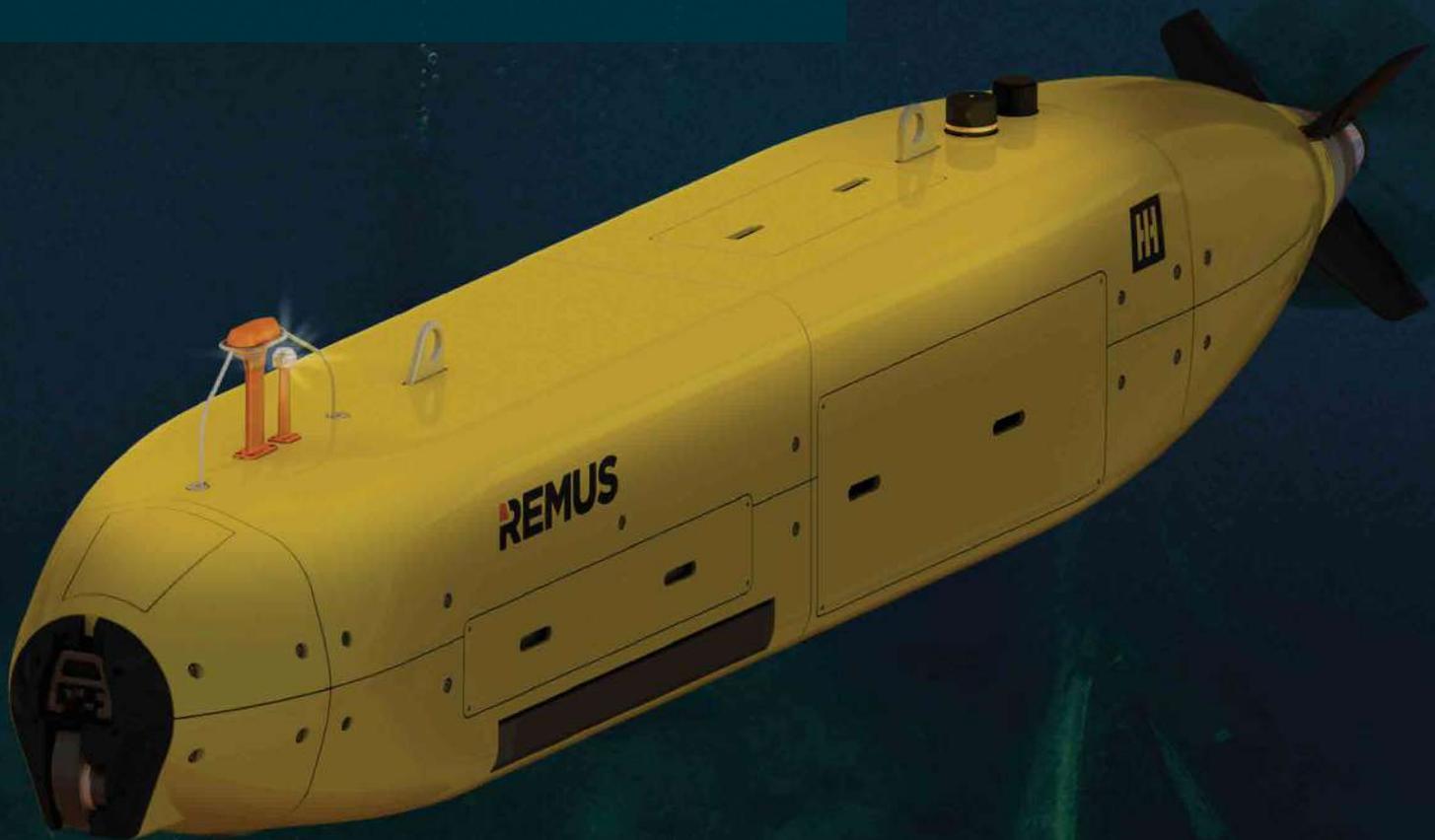
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MIGHT REVOLUTIONISE
THE BATTLEFIELD

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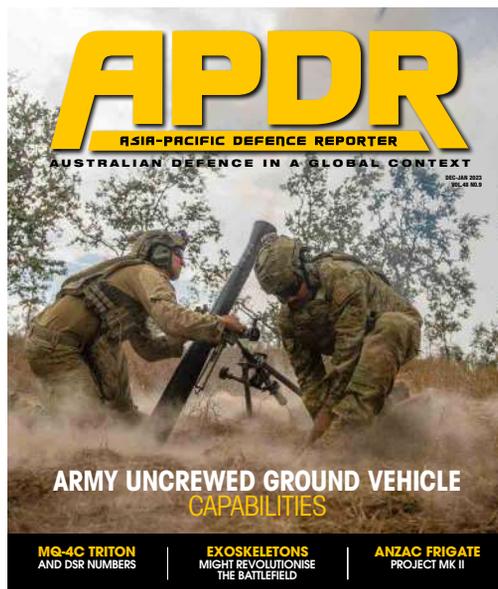
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Cover description: Australian Army soldiers from the 3rd Battalion, The Royal Australian Regiment fire the 81mm mortar during the Basic Mortar Course at Townsville Field Training Area on 26 October 2022. Credit: CoA / Gregory Scott

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From the Publisher

As 2022 draws to a close I sincerely thank the APDR editorial and commercial team for their efforts in bringing to our readers and advertisers the highest possible quality product in what has been a difficult year.

We appreciate your support and look forward to seeing more of you at the increasing number of industry events scheduled for 2023.

Merry Christmas and a happy and safe New Year ahead.

- MARILYN TANGYE BUTLER

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KYM BERGMANN, EDITOR
– CANBERRA

Looking back on the year it's hard to recall any significant conversation with a senior national security figure that did not include AUKUS, which in the minds of many seems to have morphed from a vague technology sharing agreement into something that will fix all of Australia's problems. Whether this view is shared in Washington and London is far less clear, but at home it seems to have become some sort of safe word to be spoken whenever questions are raised about major Defence issues.

The attraction of AUKUS as a universal panacea is easy to understand – a comforting return to the good old Anglosphere. No Defence personnel will ever again need to learn a second language or trouble themselves with knowledge of different cultures, instead bouncing safely between the US and the UK. The title of Allan Gyngell's study of Australian foreign policy – written prior to AUKUS – sums it up neatly: "A Fear of Abandonment", which once again is being played out for all to see.

This was very much on display at the Submarine Institute of Australia conference in early November, which already feels like a lifetime ago. Speaker after speaker waxed lyrical about how AUKUS would deliver to us the awesome capability of a fleet of nuclear-powered submarines. What no one addressed are the practical realities of how this will be achieved. To be fair, the way forward will apparently be detailed in March by the submarine task force – though there is no reason why matters such as Australia's industrial capacity, or rather the lack of it, should not be highlighted now.

Defence Minister Richard Marles gave a largely incoherent answer to a very reasonable

AUKUS DOMINATES ALL CONVERSATIONS DURING 2022

question about what practical steps Australian companies should be taking now to prepare for the construction of nuclear-powered submarines. Bizarrely, the head of the US Studies Centre asserted that the re-election of Donald Trump would strengthen AUKUS. This was the President who unilaterally scrapped the Iran nuclear deal; pulled out of the Paris climate accords; threatened to pull the plug on South Korea unless they paid more cash; held up arms shipments to Ukraine as a piece of attempted political blackmail; and is credibly reported as wanting to withdraw from NATO. Not to mention attempting to buy Greenland, which wasn't even for sale.

However, the very short presentation that actually made the least sense was from the Chief of Navy, who in front of a slide showing our sea lanes of communication and undersea cables, asserted that Australia did not need to be invaded to be defeated. This apparently is sufficient justification for the \$100 billion investment needed for the new submarine fleet. The problem is that it's completely wrong.

Australia is a net exporter of both food and energy. If we were blockaded it would certainly be enormously disruptive, but life would go on. Not being able to import flatscreen televisions or being able to go for a skiing holiday to Japan will be major inconveniences – but these are hardly things that would cause a nation to surrender.

Rationing would be introduced, a new locally made shirt would cost \$100 rather than \$25 for the imported equivalent – but life would go on. One of the understated aspects of Australia moving to renewable energy is that it adds greatly to self-sufficiency – especially with the increasing availability of electric and hydrogen powered cars, trucks and buses. Even in the unlikely event that all undersea cables could be cut simultaneously there are still these things called satellites.

If this view of Australia's strategic vulnerability is mainstream thinking in Defence then we are in worse trouble than previously believed. Someone needs to come up with a better argument about the need for eight Virginia class submarines than protecting our

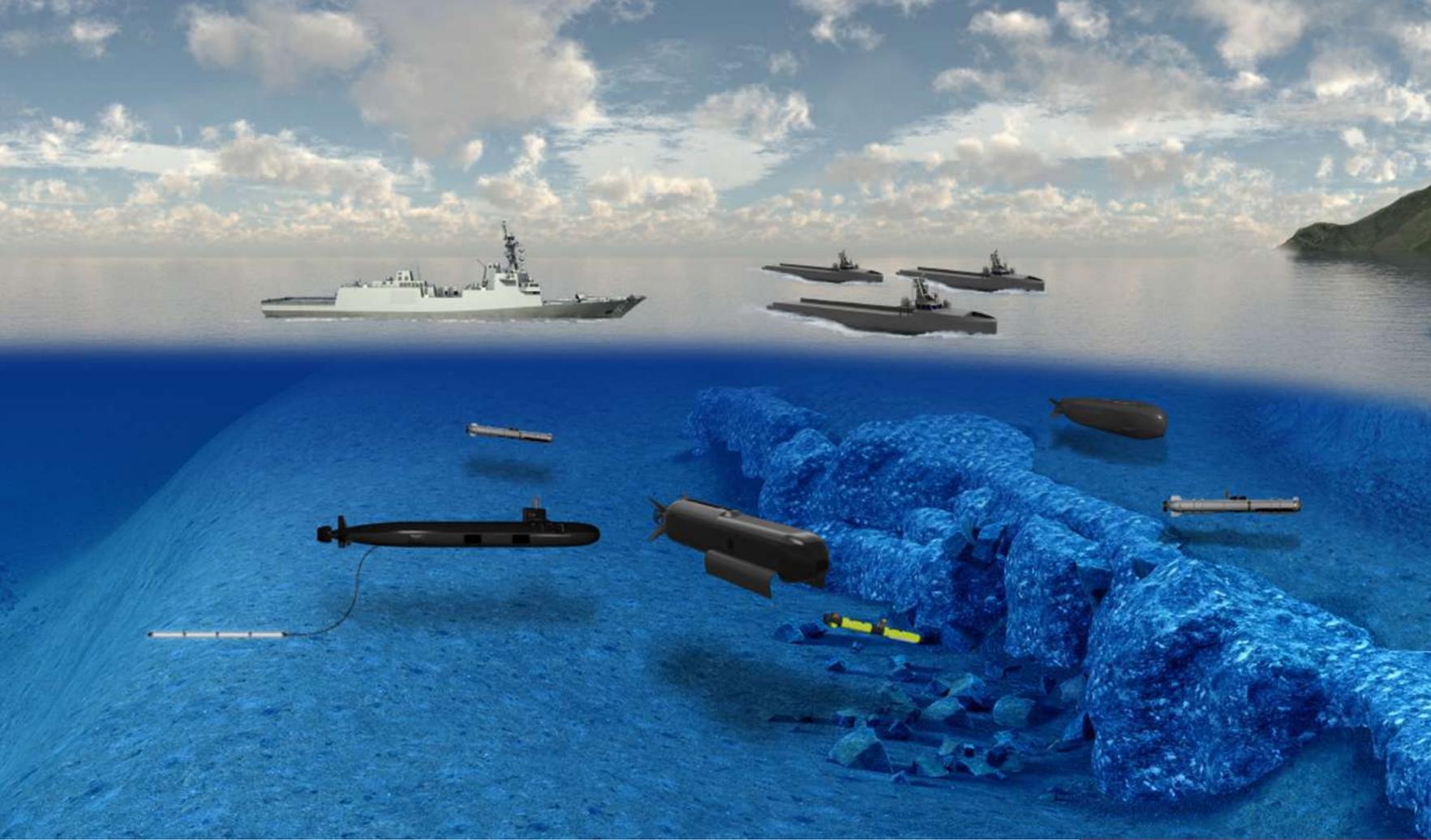
sea lines of communication. If another reason is to deter aggression there are plenty of ways of doing that – including building our own nuclear bomb – which would be faster and cheaper than continuing down the path that we are currently on.

If a nation decides that it wants to build up sufficient resources to produce an advanced piece of military hardware such as a fighter jet, main battle tank or an indigenous submarine the process takes about 30 years. This is because companies need to develop the necessary skills, initiate transfers of technology, have access to a large and skilled workforce and have the support of academia. Just ask South Korea – they have done exactly this since the late 1980s and they now have a huge base that can produce almost anything. If they wanted to, they could certainly build a nuclear-powered submarine because they have all the key ingredients in place – including a commercial nuclear industry.

Australia, not so much. One of the ironies is that we had a clear and relatively simple path to achieving the AUKUS goal – namely the cancelled Attack class program. We were in the process of converting a French nuclear powered Barracuda submarine into a conventional one – with a US combat system and weapons – and we could have gone back the other way.

The only missing ingredient was the need for a commercial uranium enrichment facility – something that has always been in Australia's economic best interest – so that the submarines could have been refuelled locally every ten years. Any government truly interested in Australia's security and independence would have done just that instead of hoping that mummy – in the form of the US and the UK – will make it all better for us and make the hurting stop.

This all matters because as the year ends, we can see the ghastly result when deterrence doesn't work with Russia's brutal unprovoked invasion of Ukraine. But to conclude on a happier note as the festive season approaches: we wish all of our readers a Merry Christmas and a prosperous and safe New Year.



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A pair of Lear jets perform a simulated attack during Exercise Kakadu 2016.
Credit: CoA / Jayson Tufrey



QINETIQ COMPLETES ITS ACQUISITION OF AIR AFFAIRS AUSTRALIA

6 December 2022

QinetiQ Group plc, a leading science and engineering company, announced on 4 October 2022 an agreement to acquire Air Affairs Australia. The business will be a wholly owned subsidiary of QinetiQ Australia.

The acquisition of Air Affairs further establishes QinetiQ as a long-term, strategic partner to the Australian Defence Force and underpins QinetiQ's strategic position as market leader in threat representation, training, test and evaluation.

Steve Wadey, Group Chief Executive Officer of QinetiQ, said:

"I am delighted that we have completed the acquisition of Air Affairs. The acquisition further strengthens our long-term strategic partnership with the Australian Defence Force and underpins our market leading position in T&E and air threat representation globally. The acquisition is an excellent strategic and cultural fit that grows our revenues in Australia by 40%, and further reinforces the focus of our growth strategy on our six distinctive offerings in our three home countries, delivering mission critical solutions for

our customers."

Greg Barsby, Managing Director of QinetiQ Australia, said:

"For more than 25 years the Air Affairs Australia team have been delivering critical sovereign capability as a trusted partner to Defence. I'm excited to embark on this next chapter together, continuing to build important training, test and evaluation, and engineering capability in Australia."

Chris Sievers, Chief Executive Officer of Air Affairs Australia, said:

"It's the beginning of a new era for all of us at Air Affairs Australia as we join the QinetiQ family. We are looking forward to working together to deliver even greater value to our Defence and industry customers."

Air Affairs Australia is an Australian defence services company – a leader in air threat representation, T&E, unmanned targets and mission rehearsal. Air Affairs Australia provides targets and training services, and electronic warfare capabilities to the Australian Defence Force, as well as aerial surveillance and reconnaissance in support of government firefighting efforts. It owns and operates a fleet of special mission aircraft and maintains an advanced manufacturing and engineering facility providing design, manufacture and certification operations. Air Affairs Australia employs 180 people, headquartered in Nowra, New South Wales.

TEXTRON'S BELL V-280 VALOR CHOSEN AS NEW U.S. ARMY LONG-RANGE ASSAULT AIRCRAFT

5 December 2022 - PROVIDENCE, R.I.

Textron Inc announced today that Bell Textron Inc., a Textron company, has been awarded the development contract for the U.S. Army's Future Long-Range Assault Aircraft (FLRAA) program. The award is based on Bell's V-280 Valor tiltrotor that was developed and tested as part of the Joint Multi-Role Technology Demonstrator (JMR TD) program that began in 2013. The V-280 progressed through design, manufacturing, and more than three years of rigorous flight testing that provided extensive data validating the technical and operational advantages of the aircraft for the long-range assault mission.

"We are honored that the U.S. Army has selected the Bell V-280 Valor as its next-generation assault aircraft," said Scott C. Donnelly, Textron's chairman and chief executive officer. "We intend to honor that trust by building a truly remarkable and transformational weapon system to meet the Army's mission requirements. We are excited to play an important role in the future of Army Aviation."

"This is an exciting time for the U.S. Army, Bell, and Team Valor as we modernize the Army's aviation capabilities for decades to come," said Mitch Snyder, president and CEO of Bell. "Bell has a long history supporting Army Aviation and we are ready to equip Soldiers with the speed and range they need to compete and win using the most mature, reliable, and affordable high-performance long-range assault weapon system in the world."

This award builds on a decade of the V-280 Valor's progress through design, manufacturing, and thorough testing to demonstrate that this aircraft will deliver on the FLRAA program requirements. Bell and its industry partners have systematically validated the V-280 aircraft and their modular open systems approach in collaboration with the Army.

"For the past several years the Bell team demonstrated the exceptional operational capabilities, digital thread synergies, and platform affordability enhancements the V-280 provides," said Keith Flail, executive vice president, Advanced Vertical Lift Systems at Bell. "Bell stands ready with our world-class manufacturing facilities to apply our nearly seven decades of tiltrotor expertise to deliver a modern FLRAA fleet to the Army."

The initial contract refines the weapon system design, sustainment, digital enterprise, manufacturing, systems integration, flight-testing, and airworthiness qualification.



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Skylark I-LEX (Elbit image)



ELBIT SYSTEMS OF AUSTRALIA SELECTED TO SUPPLY UNMANNED AERIAL SYSTEMS TO THE AUSTRALIAN ARMY

Elbit Systems of Australia was selected to provide the Australian Army with the Skylark I LEX Unmanned Aerial Systems (UAS) equipped with Electro Optical and Automatic Dependent Surveillance – Broadcast (ADS-B) system.

With a certified ADS-B system, Elbit Systems of Australia will support the Australian Army achieve wider use cases outside of traditional Army UAS employment including integration into more classes of airspace. This will enable Australian Defence Force (ADF) support to civilian operations for disaster and humanitarian relief.

Designed for in-theater operation by maneuvering forces, the fully autonomous electric propelled Skylark I-LEX features mission-oriented, intuitive man-machine interface (MMI) and a 40 km Line Of Sight (LOS) communication range, which make it effective for a variety of missions including reconnaissance and force protection missions. UAS of the Skylark family, including the 18-hours endurance Skylark 3 Hybrid, have been selected to date by dozens of customers among Israel, Asia, Europe and Latin America.

Major General (ret'd) Paul McLachlan, Managing Director of Elbit Systems of Australia, said: "This is great news for Elbit Systems of Australia as we gain momentum by broadening our offering to the ADF, as well as growth of our uncrewed and autonomous system capability being developed and used in country."

RAYTHEON AUSTRALIA BOLSTERS SME CAPABILITY TO SUPPORT AUSTRALIA'S DEFENCE

23 November 2022

Through Raytheon Australia's Capability Plus program, experts across the company have dedicated more than 10,000 hours sharing knowledge and building capability with local small- and medium-sized enterprises (SMEs). This collaborative effort is focused on building sovereign capabilities for Australia's defence and creating opportunities for real work for SMEs by enhancing their capability to support defence programs.

Capability Plus is a dedicated SME capability enhancement program, launched in April 2021 with the aim of building and nurturing Australian SMEs through tailored activities that meet SME requirements and objectives, including training and mentoring activities.

This includes a focus on:

- Leadership development.
- Understanding of the ASDEFCON contracting framework.
- Engineering and program management.
- Quality and ISO certification.
- Marketing and communications.
- Cybersecurity support.
- Global trade compliance.
- Knowledge transfer (including access to Raytheon Australia's Global Supply Chain Program).

"Our unique Capability Plus program is focused on helping local SMEs tap into the depth and

breadth of expertise that we have heavily invested in developing here in Australia over the past two decades," said Michael Ward, managing director, Raytheon Australia. "Through the more than 10,000 hours that we have already invested in this tailor-made program in its first 18 months, we are proud to be building a foundation of sovereign defence knowledge and know-how across the broader defence ecosystem – aimed at supporting the Australian Defence Force as they realise the full operational capability of their assets. Our Capability Plus program has also generated meaningful and sustained current work for local industry," he said. "As a trusted capability partner to the ADF, we have actively engaged with our SME partners to collaborate on major defence programs, such as LAND 19 Phase 7B, JP 9347 and the Collins class submarines – delivering tangible business benefits for these companies."

In addition to providing training and mentoring, the Capability Plus program also offers SMEs the opportunity to work alongside Raytheon Australia at the company's state-of-the-art facilities. This approach has resulted in Capability Plus participant Daronmont basing a team of employees at Raytheon Australia's Centre for Joint Integration in Adelaide to work on the LAND19 Phase 7B program.

"Daronmont derives tremendous value through participation in Raytheon Australia's Capability Plus program," said Lee Stanley, Daronmont Technologies business development manager. "We have benefitted directly through access to Raytheon Australia business specialists for advice as well as professional development opportunities for engineers, program managers and emerging leaders in our business. In addition to these tangible Capability Plus outcomes, Daronmont has developed a closer, more transparent and strategic relationship with Raytheon Australia that is proving advantageous in a number of important Defence business opportunities we are teaming to pursue."

In 2023, Raytheon Australia will build on the 10,000 hours of investment that has been made in the Capability Plus program, by expanding this initiative to include even more SME participants and enhance the value to participants. These companies will leverage access to experts across Raytheon Australia and Capability Plus alumni aimed at generating business outcomes through mentoring, training, access to facilities and skills transfer.

Current Capability Plus participants include Daronmont, Calytrix, archTIS, Coherics, AOS, Frontline Manufacturing, HEO Robotics, JEDS, Redarc, Silentium Defence and Willyama.

PENSKE AUSTRALIA, RHEINMETALL DEFENCE AUSTRALIA SIGN DEAL FOR LAND 400 PHASE 2 BOXERS

27 November 2022

Penske Australia has signed a deed of agreement with Rheinmetall Defence Australia for the assembly of powerpacks for Boxer Combat Reconnaissance Vehicles. In a deal worth approximately \$40 million, more than 100 power packs for the Land 400 Phase 2 Boxer vehicles will comprise of Rolls-Royce Power Systems mtu 8V199 engines and Allison 480OSP transmissions. In addition to the assembly of the powerpacks, the agreement also includes the establishment of local assembly and testing capability, training, and the provision of compliance documentation.

Penske Australia's team of specialist technicians will conduct local assembly and acceptance testing with production to be conducted at Penske Australia's Wacol, QLD facility. "This important agreement builds upon our long-standing history in supporting the Australian Defence Force platforms, both land and sea," said Hamish Christie-Johnston, managing



An Australian Army Boxer Combat Reconnaissance Vehicle from the 2nd/14th Light Horse Regiment (Queensland Mounted Infantry) dismounts an Improved Ribbon Bridge from the 2nd Combat Engineer Regiment during a training activity, Gallipoli Barracks, Brisbane. Credit: CoA / Nicole Dorrett

director of Penske Australia. "It's also a welcome extension of our relationship with Rheinmetall Defence Australia as a key industry capability provider and a member of Rheinmetall's global supply chain. The combination of the highly reliable and powerful mtu engine and Allison transmission will deliver a robust

powerpack solution that will serve the Australian Defence Force well for decades to come."

Upon completion, Penske Australia will deliver the power packs for integration into the vehicles to Rheinmetall Defence Australia's Military Vehicle Centre of Excellence (MILVEHCOE) at Redbank, South-East Queensland.

Rheinmetall Managing Director, Gary Stewart, said: "Rheinmetall is delighted to sign this agreement with Penske Australia today to deliver the Australian Army's stated operational needs. "Rheinmetall, as the largest supplier of military vehicles to the Australian Defence Force, recognises that agreements like this one contribute to paving the way for Boxer to be deployed, enabling Australian soldiers to operate in high threat environments. With the Australian Army's recent declaration of the Boxer Combat Reconnaissance Vehicle initial operational capability, Penske joins the Rheinmetall Australia industry network for this critical capability. What we do matters to those who serve," Stewart said.

Penske Australia anticipates delivering the first powerpacks in late 2023, with the final delivery expected in early 2026.



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HANWHA HANDS OVER 24 K9PL HOWITZERS TO POLISH ARMED FORCES

6 December 2022

Hanwha Aerospace has successfully delivered a batch of 24 155mm/52-calibre K9 Self-Propelled Howitzers to the Polish Armed Forces, meeting the requirements of the Polish deterrence capability.

Upon arrival on December 5, the howitzers, called “K9PL,” were unloaded from a cargo ship at the Port of Gdynia where a reception ceremony was to take place.

The official ceremony was held on December 6 to celebrate the arrival of K9PLs, with the attendance of Polish Government leaders including President Andrzej Duda and Defence Minister Mariusz Blaszczak.

Among the South Korean participants were Minister Eom Dong-hwan of the Defense Acquisition Program Administration; Deputy Minister Yoo Dong-joon of the Ministry of National Defense; Son Jaeil, President and CEO of Hanwha Aerospace; and Executive Vice President Lee Boo-hwan of Hanwha Aerospace Europe Business.

“The handover of K9PLs is a key milestone in the development of partnership between Hanwha Aerospace and the Government of Poland,” said Lee Boo-hwan, head of Hanwha Aerospace’s European business. “Meeting the requirements of the Polish Armed Forces is our top priority, and we’re proud of having produced and delivered the best-quality equipment to Poland on time.”

The K9PL delivery took only about three months after an executive contract was signed in late August. Under the executive contract, Hanwha will deliver hundreds of K9PLs by 2026. Plans are also in place to manufacture hundreds of more K9PLs in Poland from 2026 in cooperation with Polska Grupa Zbrojeniowa (PGZ), the largest defence group in Poland, under a broader framework agreement signed in July.

“There is no doubt Hanwha Aerospace is the most reliable partner for Poland to contribute the Polish defence capability and industry growth,” said Son Jaeil, President and CEO of Hanwha

Aerospace. “Hanwha is committed to making Poland as a hub for the supply of K9 systems in Europe based on stronger partnership with the Government of Poland.”

With the expansion of countries operating K9 artillery systems, Hanwha launched the K9 User Community in April 2022 to share experience on the operation of the K9, including logistics support capability. K9 user countries include South Korea, Turkey, Poland, India, Finland, Norway, Estonia, Australia and Egypt.

The K9 Thunder is the world’s most popular tracked self-propelled gun with over 2,000 units are already in service around the globe. The howitzer can deliver

consistent, accurate, rapid effects at +40km range with high rates and volumes of fire. In particular, the K9 is optimized for “Shoot-and- Scoot” capability to fire multiple rounds and immediately move to a different location to avoid potential counter-fire.

In a recent milestone, the K9 and K10 Ammunition Resupply Vehicle were successfully tested by the US Army to prove their compatibility with various US munitions. The test was conducted at the Yuma Proving Ground in Arizona in mid-September 2022 to fire different types of US munitions including 155mm M795 projectiles and XM1113 Rocket Assistance Projectiles.

MITRE AUSTRALIA ANNOUNCES COLLABORATIONS WITH UNIVERSITIES TO ACCELERATE INNOVATION

1 December 2022

MITRE Australia, a not-for-profit operating in the public interest, opened a headquarters office and advanced systems engineering centre in the Brindabella Business Park in Canberra to support growing engagement with Australian government, business, and research institutions. Building on AUKUS and bi-lateral Australian–U.S. accords, MITRE Australia signed agreements with new collaboration partners to foster development of whole-of-nation solutions that strengthen the defence of Australia, as well as security and prosperity in the Indo-Pacific region.

The new agreements include the Australian National University, University of New South Wales (UNSW), University of Adelaide, and Flinders University. Building on the goals of the AUKUS agreement, these technology collaborations focus on enhancing cybersecurity, artificial intelligence, maritime autonomy, quantum, and other technology innovations to advance whole-of-nation solutions.

“These partnerships accelerate Australia’s sovereign capabilities in defence, cybersecurity, and space as well as strengthen Australia’s technology leadership and coalition partnerships,” said Keoki Jackson, senior vice president and general manager, MITRE National Security Sector. “Australia plays a critical role in the Pacific. We are committed to help accelerate the implementation of the AUKUS agreement and promote stability, security, and prosperity in the Indo-Pacific region.”

Julie Bowen, MITRE’s senior vice president for operations and outreach, and chief legal officer, added, “MITRE has more than 60 years of history bridging government, industry, and academia to foster transformational innovation. We’re bringing that experience to the Australian government and partners to accelerate game-changing, real-world results. These whole-of-nation collaborations will catalyse solutions to

some of the world’s most complex challenges.”

Vice Admiral Paul Maddison (ret’d), director of UNSW’s Defence Research Institute, said, “UNSW is thrilled to be partnering with MITRE and applauds the strategic vision behind the decision to incorporate in Australia. As a defence research and education intensive university with a decades-long formal relationship with the Department of Defence at the Australian Defence Force Academy, UNSW is committed to accelerating the defence concept to capability cycle, especially in the priority capability areas highlighted by the AUKUS agreement. By activating UNSW’s ground-breaking and world-class research expertise across MITRE’s deep systems engineering networks, I’m certain that great opportunities will be generated to collaborate at speed in service to the shared national security interests of Australia and the USA.”

Keith Nugent, deputy vice-chancellor, research & innovation, The Australian National University, said, “We welcome MITRE to Australia and look forward to working together to forge new engagements with the US as partners under the AUKUS agreement. Through the ANU-MITRE MOU, the Australian National University will work with MITRE to increase our engagement with defence industries to ensure our nation’s security.”

Simon Lucey, director of the University of Adelaide’s Australian Institute for Machine Learning, said, “Building Australia’s sovereign capability in artificial intelligence is vital for our future security and prosperity. This new partnership between MITRE and the University of Adelaide’s Australian Institute for Machine Learning will see our leading AI research help support greater regional stability for Australia and its global allies.”

Flinders University’s Defence Partnerships Director Tony Kyraciou, said: “This new Flinders University and MITRE agreement will enable further development of our research strengths in marine autonomy, cybersecurity, and other scientific fields to ensure its effective application in Australia’s national security with our trusted US partners. We look forward to working with MITRE in accelerating our ground-breaking research initiatives in priority areas highlighted by the AUKUS agreement and engaging with defence industries supporting areas of mutual interest.”

MITRE also has a Sponsoring and Collaboration Agreement with the Australian Defence Science and Technology Group (DSTG) to serve as the conduit between Australia and partners to facilitate interoperability and the integration of joint forces and weapon systems. In addition, MITRE is an active member of the Australian Cyber Collaboration Centre (AC3). In March 2022, MITRE established its first international applied research centre—The MITRE Centre for Information Integrity & Defence—within Lot Fourteen in Adelaide, South Australia.

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TRITON MQ-4C AT RISK...AGAIN?

As the ADF's Defence Strategic Update report nears, one of the key considerations for its architects will be to recommend whether or not Australia continues with its plan to buy up to seven Northrop Grumman MQ-4C Triton uncrewed maritime ISR systems under Project AIR 7000 Phase 1B.

The Triton program has been a very slow burn for Australia, going back to the late 1990s when the ADF expressed an interest in a maritime ISR development of the then-new RQ-4A Global Hawk program. Recognising the potential of Australia as not only a possible customer, but also its ideal geographical location that could bridge a gap in ISR coverage between the western Pacific and the Middle East, Northrop Grumman and the US DoD eagerly welcomed and nurtured that interest.

The MQ-4C Triton was selected in April 2008 to fulfil the US Navy's Broad Area Maritime Surveillance (BAMS) requirement, ahead of an offering by Boeing based on an optionally-crewed Gulfstream G550, and the General Atomics MQ-9 Mariner. Based on the RQ-4B Global Hawk, the Triton features a stiffened wing, de-icing for the wing and intake leading edges, lightning protection, and optical, radar, and electronic sensors optimised for the maritime environment.

The US Navy has a program of record requirement for 68 Tritons, to be based at five operating locations worldwide: Sigonella in Italy, Bahrain or the UAE in the Persian Gulf, Guam in the western Pacific, Pt Mugu in California, and Jacksonville in Florida.

Initially it was planned that the RAAF would join with the US Navy as a development partner of the BAMS solution, but this option was shelved by the then Rudd-Labor government in 2009. In March 2014, the then new Abbott-LNP government announced its intention to buy seven Tritons at a cost of US \$3 billion, with the plan being to base the air vehicles and ground control segments at RAAF Edinburgh near Adelaide.

This plan was ratified in the 2016 Defence White Paper, and the first of six Tritons was ordered in June 2018. Under the resurrected Triton Development, Production, and Sustainment Cooperative Program, Australia would be a partner on the activity, giving it a say in the system's development and, hopefully, some industrial

participation as part of the larger global fleet.

"This cooperative program aligns with (the US) DoD's objective to strengthen alliances that are crucial to our National Defense Strategy," the then Triton program manager, US Navy Capt Dan Mackin said in an August 2019 NAVAIR release. "We are working together with our Australian counterparts to jointly define new capabilities that benefit both countries."

An initial eight RAAF Cooperative Project

industry workforce to support the system at the remote location because of a lack of housing, it was reported in early 2022 that the first RAAF Triton may initially be based in Guam from 2024 alongside US Navy MQ-4Cs.

In the meantime, the US Navy has been operating two Triton air vehicles from Guam as part of its early operational capability (EOC) for nearly three years in support of the US 7th fleet and allied naval operations in the region. The US Navy has also deployed an 'expeditionary' forward operating base – essentially a ground control segment in a semi-trailer – to the region.

But the Triton program has often felt like it's been under almost constant threat, and not just because of Australia's glacial-pace buy profile. The US Navy too has had to slow its acquisition of air vehicles due to having to negotiate away some capabilities in favour of others as part of the convoluted US budget process. The FY2021 President's Budget request (published in early-2020) initially saw funding for the program halted for two years, ostensibly to provide more

time to develop capabilities such as the Multi-INT signals intelligence system.

Fortunately, one US Navy air vehicle and Australia's first three Tritons were added to the FY2021 request, while two more US Navy air vehicles were added to the FY2022 request, thus avoiding a production pause which may have delayed the program by several more years. The FY2023 request sees three more US Navy Tritons added, while Northrop Grumman continues to work hard to get Australia to commit to more Tritons.

But with the ADF's current and near-future projects and force posture all being re-evaluated under the Defence Strategic Review, AIR 7000 Phase 1B may be seen as \$6 billion of 'low-hanging fruit' which may be cut or further-delayed in favour of the rapid acquisition of long-range strike weapons, air defence systems, submarines, or more air combat aircraft.



An MQ-4C on the runway at Marine Corps Air Station Iwakuni, Japan, July 13, 2022. (U.S. Marine Corps photo by Lance Cpl. Lance Kell)

Personnel (CPP) comprising engineering, research and development, flight test, and sensor operator personnel were deployed to the US Navy's NAS Patuxent River test facility to be embedded with the program teams, and RAAF personnel have been integrated as Triton Integrated Test Team (ITT) crew members.

To date, Australia has ordered three air vehicles in single aircraft lots, while the primary operating location will be RAAF Tindal near Katherine in the Northern Territory. The first Australia Triton was rolled out at Northrop Grumman's Plant 42 facility in Palmdale California in September 2022 and is scheduled to commence flight trials in 2023. RAAF air vehicle and sensor operator training is also scheduled to commence in 2023, and the first Australia aircraft is scheduled to enter service in 2024.

With the redevelopment of RAAF Tindal lagging initially due to COVID and difficulties in finding an



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MILITARY UNMANNED GROUND VEHICLES (UGV)

A clear global defence technology trend is for the ever increasing use of uncrewed and robotic systems in all domains. Australia is not immune and all three services have significant activities underway, including for ground combat. A Defence spokesperson told APDR that:

“The Australian Army is constantly looking for innovative emerging technology to provide novel solutions for its soldiers.”

“Uncrewed Ground Vehicles (UGV) have undergone trials with the Australian Army since 2018. Currently the deployed roles of UGV are limited to C-IED (bomb disposal robots) and surveillance roles. These types of robotic systems create stand-off between a hazard and a soldier and have proven successful.

“Army is exploring UGV for many other roles. These include load carriage UGV for infantry soldiers, legged robotic systems for reconnaissance roles, small packable robotic systems for cavalry, infantry and engineer roles, optionally crewed combat vehicles and fully autonomous cargo trucks in a leader-follower configuration.”

APDR has noted that the Army’s research is seeking to apply technologies in five areas: maximising soldier performance; improved decision making; leveraging human-machine teaming; troop protection; and efficiencies in logistics and maintenance.

OPTIONALLY CREWED UGVs

The M113-AS4 Armoured Personnel Carrier (APC) is an all-terrain vehicle designed to protect and transport its crew and up to ten Infantry personnel. This M113 variant came after several upgrades from the Vietnam-era M113-AS1. It incorporates armour resistant to small arms fire, ballistic plating for mine blast protection and spall curtains to maximise passenger survivability. Logistically, the vehicle is capable of rapid deployment by road, rail, sea or air. It is designed for highway, off-road and cross-country travel.

In November 2019, the M113-AS4 arrived as a new variant when Army received its first two unmanned armoured vehicles. These M113 APCs were fitted with autonomous technology developed and fitted by BAE Systems Australia in Adelaide. Their first task in Army’s hands was to provide a battlefield simulation demonstration to Chief of Army at the Majura Training Ground, just north of



An Australian Army M113AS4 Crew Commander positions his vehicle behind an autonomous M113 AS4 optionally crewed combat vehicle (OCCV) before a mounted assault demonstration at the Majura Training Area, Canberra. Credit: CoA / Tristan Kennedy

Canberra Airport.

With the technologies integrated into the new M113-AS4 prototype, these vehicles are now being used by the Army to better understand the opportunities for autonomy on the battlefield as part of its recently released Robotics and Autonomous Systems Strategy (see later). They are test vehicles for technology being developed at the Commonwealth’s Trusted Autonomous Systems Defence Cooperative Research Centre.

On 8 Aug 2020 BAE Systems announced that it was working with the Australian Army to install autonomous technologies into a further sixteen M113-AS4 APCs.

The new work would begin immediately and take the Australian Army’s fleet of optionally crewed M113s to 20. The new project followed the

conversion and trial of two optionally crewed M113 APCs in 2019 and another two earlier in 2020.

This fleet of vehicles is being used by the Army to conduct experiments to better understand the opportunities to employ autonomy on the battlefield.

At the time of this 2020 BAE Systems Australia media release, their Chief Technology Officer Brad Yelland said “This project highlights our continued commitment to leading the development of new technologies.

“The Defence Force of the future will rely on trusted autonomous systems to plan and coordinate operations, allow quick decision making and respond to unexpected or unplanned actions, and work to keep our service men and women out of harm’s way.”

Over a year later, by November 2021, Army’s

resident UGS fleet had increased to the full total of 20 optionally crewed M113-AS4s received from BAE Systems, increasing Army's flexibility for trials.

BAE SYSTEMS AUSTRALIA AND EPE FORM TECHNICAL PARTNERSHIP

Announcing the partnership at October's Land Forces 2022 Conference in Brisbane, the two organisations will collaborate on the development of autonomous technologies through BAE Systems' UGV program, which began earlier in 2022.

Focused on implementing BAE Systems' advanced vehicle management systems onto UGVs, the collaboration with EPE aims to develop soldier support systems for the Australian Army.

As Australian agents for the HDT Wheeled Offload Logistics Follower UGV platform, EPE was initially contracted to provide platform, integration and engineering support as well as test facilities, using the company's state-of-the-art UGV test and evaluation facilities in south-east Queensland.

Operating within a multi-domain autonomy architecture, the program focuses on the integration of UGV mission systems to enable prototyping that will develop certifiable mission systems.

NEW UGVs ON THE WAY

Malcolm Davis of the Australia Strategic Policy Institute has written that:

"The future of war is one of machines and humans working together as a team to operate faster than their opponent, delivering precision firepower at long range, when and where needed, inside the opponent's decision cycle.

"We are approaching future war in what Manuel DeLanda calls "the age of intelligent machines" in which fully autonomous systems can make choices and identify targets while operating within human constructed rules of engagement, to deliver rapid effects across multiple operational domains.

"In this future, lethal autonomous weapons systems supported by a range of autonomous platforms will operate in the air, on and under the sea, and on land."

Meanwhile Defence has awarded a \$A3.3 million contract to Brisbane-based Cyborg Dynamics Engineering to develop a lightweight, semi-autonomous UGV for Army called Warfighter.

According to the Defence department, Cyborg will integrate various Australian technologies into the modular, robotic platform to help improve the army's fire support capabilities and ensure better protection of soldiers.



Australian Army soldier Corporal Josh Green from B Squadron 3rd/4th Cavalry Regiment, School of Armour, commands a M113AS4 and two autonomous M113 AS4 optionally crewed combat vehicles (OCCV) during a demonstration at the Majura Training Area, Canberra. Credit: CoA / Tristan Kennedy

The UGV will also be equipped with artificial intelligence target recognition capability and advanced driving technologies so only one soldier needs to operate the vehicle.

The Warfighter is based on BIA5's tracked OzBot All Terrain Robot chassis enabling it to go virtually anywhere.

Autonomous ground vehicles are moving towards addressing limitations, by developing a UGV that can negotiate terrain and potentially able to be issued to lower-level units like companies and platoons.

This is where the highly dynamic quadruped robots such as those developed by American start up Boston Dynamics have a lot of potential. The company has released a number of videos of its robots in action, from negotiating complex terrain to opening doors while being overtly hindered by an armed person.

The capabilities of these robots lend to potential use by militaries as ground-based ISR platforms or pack mules in complex and even urban terrain that includes negotiating multi-storey buildings, making them potentially game-changing in terms of using autonomous systems in land warfare.

Ghost Robotics, has already displayed a similar quadruped robot in the United States armed with a 6.5mm sniper rifle. The company has also signed an agreement with Singapore's Defence Science and Technology Agency to identify cases

involving legged robots for security, defence, and humanitarian applications.

CURRENT AND FUTURE GLOBAL UGV MARKET

The global military UGV market is set to reach US \$732 million in 2032, growing at a compound annual growth rate of 4.4% between 2022 and 2032, according to data and analytics company GlobalData. They note that the growth in research and development towards incorporating advanced sensors, telecommunications, energy dense powerpacks and AI capabilities into UGVs to make them more effective in a wide variety of military applications is driving their adoption.

Evolution of urban warfare and the technological strides in military vehicle automation are also anticipated to contribute to their adoption in the next decade.

While most military UGVs in the current fleet are primarily used for explosive and mine disposal purposes, the market is projected to witness an increased adoption of UGVs for other applications, including combat, intelligence, surveillance, reconnaissance, and logistics.

The combat UGV segment is the largest segment and is poised to grow at a significant rate due to the increased emphasis on integration of unmanned systems as part of network centric warfare.



Army's new Tactical Uncrewed Aerial System, the Integrator, is ready to launch during 20th Regiment, Royal Australian Artillery's operator training course in Coominya, Qld, on 28 July 2022. Credit: Cody Tsaousis

The segment was valued at US \$222.9 million in 2022 and is anticipated to reach US \$362.6 million in 2032, growing at a compound annual growth rate of approximately 5% over the forecast period.

The development of swarm technologies for unmanned aerial vehicles has gained pace in recent years, and its integration with UGVs is being evaluated. UGV swarms can provide logistics support, perform ISR, and can also conduct combat operations in future with minimal soldier intervention, which is expected to immensely aid deployed forces.

ROAD TRAINS

Army has converted 4 trucks to be fully autonomous in a leader-follower configuration (1 lead and 4 HX40 follow vehicles) to explore the efficiency benefits that autonomy may bring. Army is collaborating with a number of state and territory road regulators, the Australian Road Research Board and Deakin University to progress trials of these convoys onto public roads so that they can understand the performance characteristics, edge cases and safety associated with the road environment. A video of the trials held at Monegeetta in 2021 can be found here: <https://www.youtube.com/watch?v=3Fq9CTVtpVI>

The journey to fully autonomous trucks on public roads is some way from being completed. However the ability to use autonomy on a deployment or training area is much closer. Trust is key to the deployment of autonomous systems enabling continuation of test and evaluation.

LOOKING UP AND AHEAD - LAND 129 PHASES 3 AND 4B2 ARMY UNMANNED AIRCRAFT

The Army's largest unmanned aircraft currently in operation is the AAI RQ-7B Shadow 200 Tactical UAS, now being replaced in LAND 129 Phase 3.

This project's preferred supplier was announced by Defence in March 2022 as Insitu Pacific Pty Ltd. The contract includes delivery and initial support of the Integrator UAS as well as associated Ground Systems and Prime Systems Integrator services, with the majority of manufacture and all assembly to be completed in Australia.

The Integrator is in service globally and is designed with open architecture, which supports modular and field-swappable payloads to deliver increased operational effects for Army across the wider multi-domain environment.

Under the contract, which began in 2022, deliveries are expected throughout 2023 and 2024.

LAND 129 Phase 4B, Small Uncrewed Aerial System (SUAS) will replace the in-service Wasp AE SUAS and provide organic surveillance and reconnaissance to commanders at the Combat Team level and below. LAND 129 Phase 4B will present for Government consideration in 2023.

It is intended to provide information to these commanders with enhanced situational awareness through improved reconnaissance and surveillance coverage. It will offer commanders near real-time video and still images with associated metadata by day and night. The SUAS reconnaissance capability has been likened to that of a flying pair of binoculars.

APDR knows that SYPAQ Systems (SYPAQ)

has submitted the CorvoX system as a sovereign Australian solution for Land 129 Phase 4B, which will deliver a man-portable small unmanned aerial system (SUAS) for Army.

CorvoX will provide Army commanders with the intelligence, surveillance and reconnaissance support needed to maintain 'over the hill, down the road and around the corner' situational awareness.

Designed, developed and demonstrated specifically to meet the unique requirements of Land 129 Phase 4B, CorvoX is an Australian innovation success that combines vertical take-off, hover and landing capabilities with fixed wing flight mode – all designed to reduce the physical and cognitive load on the operator.

IN CONCLUSION - ROBOTIC AND AUTONOMOUS SYSTEMS

Robotic and Autonomous Systems offer Army the potential to fundamentally change the way that Army trains, fights and organises itself. It is not simply a new piece of equipment but potentially unlocks new modes of operation and generates mass whilst protecting the force.

The Australian Army released its Robotic and Autonomous Systems Strategy V2.0 in August 2022, which was an update to its earlier version released on 2018. The strategy is intended to enable the army to 'gain an operational advantage' in the battlefield.

However, the strategy emphasises that its implementation relies on factors such as proven technologies, innovation and industrial capacity, international partnerships, as well as ethical considerations.

"The increased use of RAS capabilities will continue to evolve the way the army trains and fights – enabling increased tempo, decision making, and reducing risk," wrote Chief of Army Lieutenant General Simon Stuart in the strategy's foreword.

"In turn, this will afford commanders new opportunities in achieving competitive advantage in some of the most dangerous tasks in the future operating environment."

The strategy said RAS capability will enhance the army's situational awareness, survivability, and lethality through high-speed information analysis and distribution.

Highlighting potential future capabilities, the strategy said soldier performance could be improved through the development of systems such as a "modular autonomous platform" that would have uses including load carriage, close-fire support, or target acquisition.

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The Hanwha Redback is one of two contenders currently under consideration as part of the LAND 400 Phase 3 project.

HIMARS PRODUCTION BEING INCREASED TO MEET DEMAND

Lockheed Martin's High Mobility Artillery Rocket System (HIMARS) has been in the news for months because of its prominent role helping Ukraine inflict serious damage on invading Russian forces. For fear of further destabilising the situation, the U.S. is only supplying the version that can fire missiles over a distance of 80km rather than longer range variants that have the potential to strike deep into Russian territory.



U.S. Marine Corps High Mobility Artillery Rocket Systems with 3d Battalion, 12th Marines, 3d Marine Division, conduct a simulated fire mission during a HIMARS Rapid Infiltration event as a part of Exercise Talisman Sabre 2021 at RAAF Base Amberley, Queensland. (U.S. Marine Corps photo by Lance Cpl. Ujian Gosun)

The Australian Army intends purchasing HIMARS, with a notification to Congress of a possible sale published on May 26 this year. This is for 20 systems and a number of associated items of equipment, including Guided Multiple Launch Rocket System (GMLRS) missiles – regular and extended range – and also 10 large Army Tactical Missiles (ATACMS) that have a mass of 1,670kg and a range of 300km. The cost of the package is around \$500 million and – slightly surprisingly – Australia does not yet appear to have placed the order.

HIMARS is in such demand that on 1 December, Lockheed Martin received another US \$430 million contract to continue full rate production of the system. This will see the company continue to deliver 96 truck mounted launch systems and 10,000 GMLRS missiles per year. This is to meet the demands of the U.S. Army and international customers. The

order backlog at the moment is about four years, although since all sales are via the Foreign Military Sales system it is the U.S. government rather than Lockheed Martin that will decide the priorities for deliveries.

The production home of HIMARS is at the town of Camden in very rural southern Arkansas. The huge site used to be a major historic munitions manufacturing facility for the USN before being rented to Lockheed Martin, which also manufactures other missiles such as Patriot on site. The company assembles the 6 wheel, 5 tonne FMTV trucks from basic components, installs the launch system; attaches the armoured cabin from another supplier and fits the electronic fire control system in it – and in a separate building also manufactures the missiles it fires, the most prolific being the GMLRS.

The future of HIMARS seems guaranteed, and particularly with new, longer range munitions

it will play an important role in U.S. joint multi-domain operations, with GMLRS-Extended Range travelling 150km. Under development by Lockheed Martin is the Precision Strike Missile (PrSM) – cofunded by Australia – with an official range of 499km to fit within legal requirements. Already scenarios are being played out where – for example – targeting data from an F-35 sensor is fed into a command and control network, of which HIMARS is a part, which then launches several missiles almost simultaneously at widely dispersed targets over a very large area.

Because the system only takes seconds to get ready to fire, each vehicle is capable of quickly firing a salvo of six 227mm GMLRS rounds – or a single 640mm ATACMS – hydraulically folding the launcher back in place and driving away well before counter battery fire arrives. Another version of this scenario has HIMARS drive onto a C-130J, which then flies under the radar to a distant location, for the unit to rapidly unload, fire, and drive back onto the aircraft to go to yet another place.

The missiles are pre-packed into a carbon fibre pod – discarded after firing – which can be installed by a single person out of a crew of three in just a couple of minutes. This gives the ability of a single HIMARS unit to maintain a high rate of deadly accurate fire for as long as missiles are available.

The current generation GMLRS are fire and forget – once target coordinates have been entered and the missile is launched there is no further communication with it. Its course cannot be changed, so the best application is to use it against important fixed targets – headquarters buildings; communications nodes; bridges; ammunition dumps; airfields; fuel farms and tank parks. This is precisely what the Ukraine Army is doing, and it is why the combat power of Russian forces has been steadily degraded, leaving them weak and vulnerable.

High Mobility Rocket Artillery Systems of the United States Army and United States Marine Corps launch rockets during a firepower demonstration held at Shoalwater Bay Training Area in Queensland, during Talisman Sabre 2021. Credit: CoA / Max Bree



The missiles are highly accurate, using an inertial navigation system augmented with GPS meaning they land no more than 10 metres from the target and frequently score direct hits. With a 90kg warhead – either unitary or blast fragmentation - they can defeat all but the most hardened targets. For ones that are particularly tough, for example a stressed concrete bridge, it could be on the receiving end of multiple hits to render it inoperable. A HIMARS can fire a full salvo of six missiles in about 30 seconds.

At the moment there are 18 HIMARS users – though that number includes its heavier, tracked predecessor the M270 – and Lockheed Martin expects that number to increase to 23 in the near future.

With improvements in missile technology, HIMARS will be relevant for years to come. Even though GMLRS-ER is slightly bigger 6 of them will still fit in a standard pod. Most other characteristics are the same as for the original missile making it suitable for use against fixed targets, albeit at twice the range.

The real future is PrSM. It is a substantially

larger missile so HIMARS can only carry two of them. However, it has a number of features that will greatly improve its performance. Firstly, it will be possible to communicate with it during flight, making it suitable for use against moving targets with a steady flow of aim point updates. In addition to this it will also carry a seeker head that – for example – would make it suitable for fast moving naval targets that are considered “time critical”.

PrSM will also use a combined inertial / GPS navigation system and is expected to enter service in 2023 with the company having successfully completed a number of test firings. There is little information available about the size of the warhead, but it is designed to replace ATACMS, which can carry up to 560kg of explosive. Even if PrSM carries a high percentage of this amount – it is a slightly smaller missile – it will still mean a very bad day for anyone on the receiving end of it.

In 2021 the Australian Army decided to participate in the program, making a contribution of \$70 million to the overall \$907 million development and has signed a MOU with the US

military to cement the relationship. When asked what we are receiving for this investment Defence declined to answer – and similarly Lockheed Martin said any questions needed to be directed to the US government.

Given that Lockheed Martin is one of two strategic partners for the Guided Weapons and Explosive Ordnance Enterprise it might be the case that Australian industry is involved – something that APDR will continue to investigate.

When HIMARS plus PrSM is in the Army inventory, it will provide an unprecedented level of capability. Never before has the Army been able to even contemplate the engagement of targets at distances in excess of 500km – let alone naval adversaries. When combined with other missiles coming into service such as LRASM and NSM, Australian forces will have capabilities for multi-domain strike operations at extended ranges.

(Kym Bergmann travelled to the US as a guest of Lockheed Martin and would like to particularly thank Joanne Hon and Stacey Ward for their assistance)

ARE EXTRA-LARGE UNCREWED UNDERWATER VESSELS THE WAY OF THE FUTURE?

The quick answer seems to be: yes. Once humans are removed from the equation, submersibles retain all the advantages of extreme stealth and add greater endurance, far deeper diving depths – and they are orders of magnitude less expensive to build and support. The loss of one or more of them during hostilities would be of little consequence – unlike a crewed submarine, the sinking of which would be a national disaster.



Dr Shane Arnott, Chief Engineer Anduril Industries

In the Australian context, they could start their missions from a naval facility, commercial port, or be deployed and recovered from a surface ship. With the right navigation systems and artificial intelligence, they could find their way to and from areas of interest, remaining there undetected for extended periods of time, gathering data and periodically reporting back – just like something with people in it, but without the risk or the expense.

Some analysts argue that there will always be a role for crewed submarines, though their usefulness seems to be diminishing over time. The popular idea of using them as a mother ship doesn't always make a lot of sense because how does this concept add value compared with scenarios where the UUVs are being controlled from their home base and send data back directly to it, rather than via an expensive and vulnerable object in the form of a submarine? It seems to

make sense to eliminate the middleman.

While almost all the public focus has been on AUKUS and particularly the acquisition of nuclear-powered submarines, it seems the RAN is very wisely hedging its bets and has several parallel activities underway in the XL-UUV domain. The most high-profile of these is with U.S. tech company Anduril, although Canada's Cellula Robotics is working with local entity Trusted Autonomous Systems on something similar called SeaWolf.

It's worth noting that there is a great deal of international interest in the technology. The USN has a system currently in production called Orca – believed to be armed – that is a diesel electric uncrewed submarine; the Royal Navy has the MANTA XL-UUV; France is working on the same concept; and Sweden is looking at large numbers of UUVs of various sizes.

On the other side of the ledger, the Chinese Navy – the PLA(N) – has had a longstanding interest in uncrewed systems both for surface ships (including for anti-submarine warfare) and submersibles. In the near future the South China Sea might be so full of XL-UUVs that they will be at risk of colliding with each other.

The earliest date when Australia could acquire a nuclear submarine is 2040, by which time they will be highly vulnerable to detection and attack from swarms of hostile UUVs programmed to hunt them down. These will be backed up by packs of networked USVs with dipping sonar and lightweight torpedoes. Future crewed submarines will be at significant risk from lurking autonomous systems outside their home ports – let alone when they venture into contested waters – which makes one wonder why a country like Australia with a relatively modest budget is pursuing the nuclear option.

Anduril Industries have recently appointed Dr Shane Arnott as Chief Engineer, well known

to many readers because of his background at Boeing and his involvement in projects such as the RAAF's Ghost Bat jet powered uncrewed aerial system. He started with an update of what is happening locally on the initial activity to build three prototype submersibles:

"We are building a team of Australia's best talent to work on the most challenging projects facing the nation. We are rapidly hiring high-skilled personnel required for the XL-AUV (Extra Large Autonomous Underwater Vehicle) program and our other planned programs. We have a very strong team of talented engineers that are part of our foundational Anduril Australia team.

"We are sourcing talent from a range of industries, including the tech, defence and aerospace industry sectors. We are providing an 'engineer centric' environment for creativity and rapid progress.

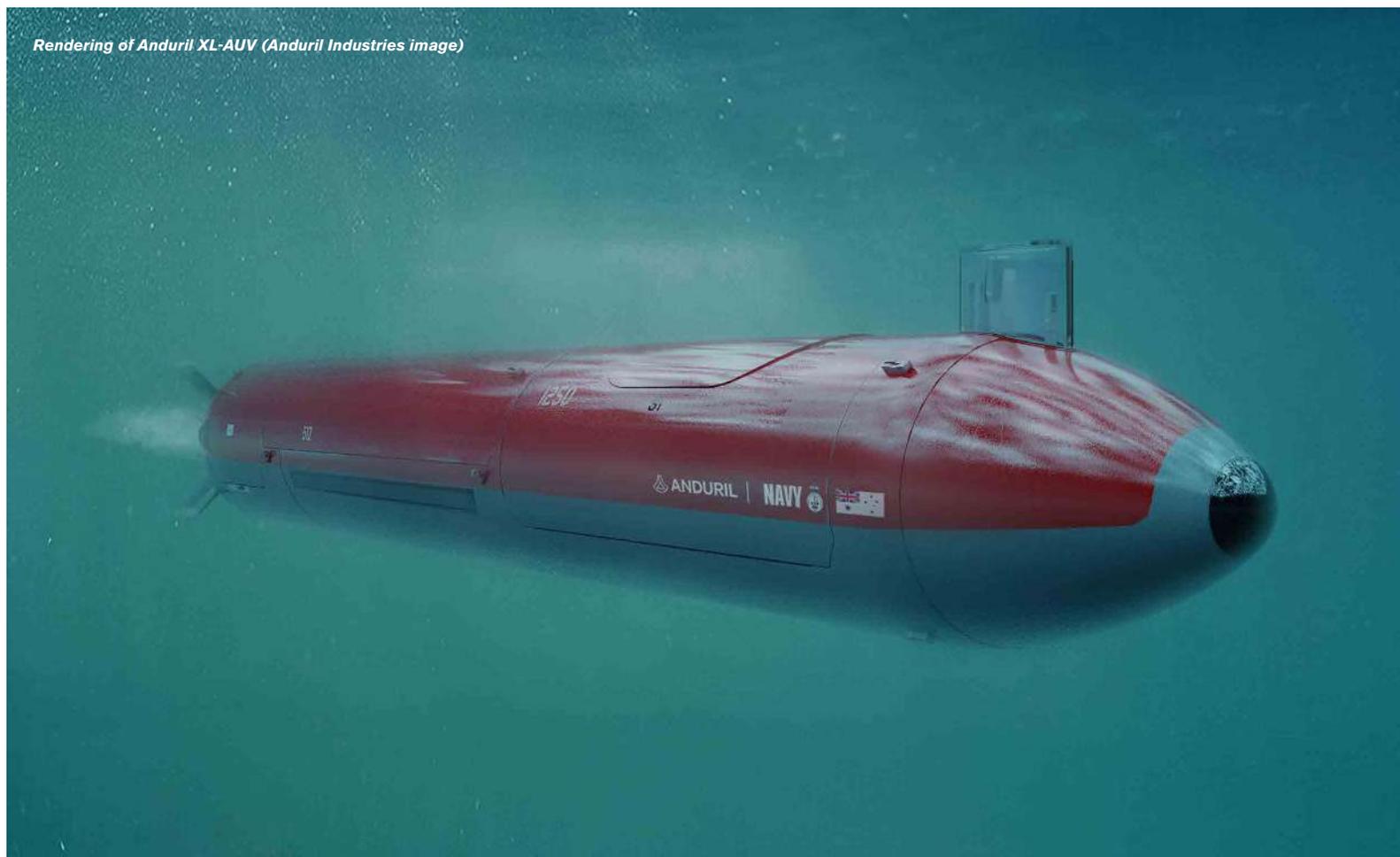
"Our engineers love working on ideas for Australia's defence – from concept through to prototype and production – at speed. Our software first approach means we are always iterating and improving. We believe in the 'show me, don't tell me' school of engineering development.

"We appreciate being able to bring the best tech to help defend Australia in this very tangible way."

He says that the company is very focused on developing the Australian supply chain and growing together. Though declining to name individual companies at this stage he believes there are significant opportunities for Australian industry as Anduril begins to manufacture at scale and with the potential for exports. He continued:

"Our product manufacturing team has met with 47 companies around Australia – materials providers and technology providers – to help us build an Australian-designed, developed, tested, evaluated and fielded, undersea capability."

Rendering of Anduril XL-AUV (Anduril Industries image)



On some of the detail, he explained the XL-AUV's energy system will be an evolution of the company's existing DIVE-LD's energy system to enable very long-range performance. The highly modular, 8 metre long LD uses a battery-powered

vision, machine learning and mesh networking to correlate real-time data from Anduril and third-party hardware into a single, unified picture:

"Our autonomous systems mean that you can have sophisticated sensor processing on the

be capable of carrying payloads according to the clients' requirements.

Regarding the possibility of UUVs being networked, he said:

"The XL-AUV will be integrated with Anduril's artificial intelligence-powered Lattice operating system. This enables sophisticated advances to existing subsurface systems through machine learning, smart sensor processing and advanced autonomy.

"There are various ways that the XL-AUV can communicate through the Lattice system with crewed and other uncrewed vessels. The XL-AUV will include ground-breaking collaborative autonomy capabilities enabled by Lattice. This level of sophistication is not seen in current autonomous undersea capabilities."

He says that the real advance on the XL-AUV will be both the payload flexibility and the autonomy to unlock new missions currently unexplored in the subsea domain – both for defence and commercial use. The first of the prototype submersibles is expected to arrive in Australia in the near future.

The earliest date when Australia could acquire a nuclear submarine is 2040, by which time they will be highly vulnerable to detection and attack from swarms of hostile UUVs programmed to hunt them down.

propulsion system.

Regarding data collection and dissemination, the XL-AUV will be integrated with Anduril's artificial intelligence-powered open architecture system called Lattice. Although a human is always in the loop, the XL-AUV spends large amounts of time below the waves and requires significant smarts to operate in that regime, while checking in as needed for approvals and updates.

Dr Arnott says that Lattice uses computer

vehicle so that it can conduct more complex actions. This enables significant advances to existing subsurface systems. Lattice also enables the XL-AUV to communicate to a wide range of systems through our joint all domain C2 interoperability architecture, providing wider situation awareness and command & control options for the warfighter."

Asked about possible payloads – including weapons – he would only say that the XL-AUV will



The Australian Army evaluates the MAPS Mule logistics UGV during Exercise Talisman Sabre 2019 (Sgt Jake Sims - Australian Army)

GUY MARTIN // JOHANNESBURG

UNMANNED GROUND VEHICLES GAINING TRACTION

Dozens of countries are developing military unmanned ground vehicles (UGVs), and with recent advances in robotics and autonomous systems, UGVs are being used for increasingly complex tasks such as base perimeter patrol and logistics, while also finding their way to the battlefield in places like Ukraine.

Military unmanned ground vehicles have been around since before WW II, but haven't been as widely adopted as unmanned aerial vehicles (UAVs) and unmanned naval surface vehicles, as it is significantly harder for UGVs to accurately map their surroundings and navigate difficult terrain. As a result, for decades battlefield robots have primarily been remotely controlled and used for combat engineering and explosive ordnance disposal (EOD), notably in Afghanistan and Iraq.

Full autonomy is getting closer to reality, driven by better artificial intelligence, computer vision,

improved sensors, wireless communications, hybrid power systems, GPS, and better batteries. While actuation/driveline technologies have been mature for some time, only recent improvements have been made in the sensors needed for UGV navigation (radar, ultrasonic, GPS, and lidar), with day/night cameras the most common and cost-effective.

These advances are enabling UGVs to carry out increasingly varied missions, such as intelligence, surveillance and reconnaissance (ISR), communications relay, jamming, combat support, search and rescue, medical evacuation, tunnel

mapping, mine clearance, firefighting etc. and countries like the United States, Estonia, Russia, China and Australia either putting robotic pack mules into service or testing them.

As targeting, recoil mitigation and remote weapons stations evolve, combat support is a growing niche. In early 2019, MBDA and Milrem displayed what they said was the world's first anti-tank UGV, fitted with MMP missiles and a machinegun. Since then, dozens of UGVs have appeared with anti-tank weapons. Although most combat UGVs are based on small existing platforms, and have no armour, several dedicated

large combat UGVs are under development, such as the Textron Systems Ripsaw M5 and Milrem Robotics' 12-ton Type-X Robotic Combat Vehicle, which can be fitted with 30 or 40mm cannons and other weapons.

Artificial intelligence is driving swarming capability for either outmatching the enemy or controlling numerous vehicles simultaneously. Swarms can act autonomously, following a single or multiple masters – if a master is disabled, another master can step in. Rheinmetall has fitted HX2 military trucks with autonomy kits, allowing them to operate in a leader-follower configuration, with only the first vehicle driven manually. In one test, a vehicle convoy operated for more than 75 minutes without intervention.

Rheinmetall's autonomy kit is one of a growing number that can turn manned vehicles into unmanned/optionally manned vehicles - Milrem, for example, offers its MIFK kit.

As they become more capable, UGVs are increasingly able to operate alongside and

integrate with other unmanned platforms (manned/unmanned teaming). Praesidium Global, for example, offers the 70 kg Scout, which can be carried inside an armoured vehicle while a parasitic option can be attached to a tank's rear in a purpose-built cocoon. Praesidium also envisages the Scout Pathfinder as the world's first air-droppable UGV that could be parachuted behind enemy lines while China has in tests delivered small UGVs by drone. General Dynamics Land Systems has showcased its TRX with 50 AeroVironment Switchblade loitering munitions.

CHALLENGES

For all their rapid advances, UGVs face numerous challenges, not least being the new doctrine and tactical support systems that are having to be developed around them, as well as the legal and ethical implications of weaponised robots.

A big hurdle is that UGVs require their own logistics chain, and add another layer of complexity, cost and maintenance to battlefield operations. They also have a limited range, especially if relying on battery power. To solve the deployment issue, Israel's Plasan has developed

Military unmanned ground vehicles have been around since before WW II, but haven't been as widely adopted as unmanned aerial vehicles (UAVs) and unmanned naval surface vehicles, as it is significantly harder for UGVs to accurately map their surroundings and navigate difficult terrain.



Estonian troops deployed TheMIS UGVs in Mali for logistics duties (Milrem Robotics)



Hanwha Defense's Arion-SMET can be equipped with a machinegun turret (Hanwha Defense)

In early 2019, MBDA and Milrem displayed what they said was the world's first anti-tank UGV, fitted with MMP missiles and a machinegun. Since then, dozens of UGVs have appeared with anti-tank weapons.

the All-Terrain Electric Mission Module (ATeMM), which functions as either a towable platform that provides extra tractive power to the control vehicle, or as an independent UGV (two to four ATeMMs can be connected to make a larger UGV).

Although robotic mules can relieve overburdened soldiers, troops are often concerned that big, noisy vehicles following them around will give their positions away, be vulnerable targets, and be unable to cross obstacles or operate at night/in poor visibility. Although wheeled vehicles are dominant due to their capability across rough terrain, quadrupedal UGVs offer greater mobility and can travel up stairs, with legged vehicles like those developed by Boston Dynamics proving to be extremely agile – an amphibious version of Ghost Robotics' Vision 60 'robot dog' can even swim, thanks to a water jet propulsion system. However, quadrupedal UGVs lack the payload of tracked or wheeled vehicles.

Aiding stealth, electric drive is often preferred over internal combustion due to almost soundless electric motors, but manufacturers are exploring other power plants with better endurance - French consortium Force W, for example, in mid-2022 unveiled its Weasel hydrogen-powered UGV demonstrator for the French military – hydrogen fuel cells can be rapidly refuelled, and are quiet.

Truly autonomous systems are proving hard to mature, and an operator is often needed to control a UGV, but this makes it susceptible to jamming. Inertial and other navigation systems can be used, or physical control cables, but the need to harden UGVs against hacking and hijacking is another important consideration for manufacturers.

INTO COMBAT

Militaries around the world are closely watching the conflict in Ukraine, where numerous UGVs have been deployed. Russia is using Uran-6 and Prohod-1 demining UGVs (the Uran-6 has also

been deployed to Syria and Nagorno-Karabakh). Other Russian UGVs may be deployed at a later stage – Russia has half a dozen combat, logistics, firefighting and EOD UGVs under development and hoped to introduce the Uran-9 and Nerekhta unmanned combat vehicles into service trials during 2022. The Uran-9 is armed with a 30mm cannon and coaxial machinegun, and is also able to carry Ataka anti-tank missiles. It was deployed to Syria in early 2019 but operational testing found limitations with communication links, operator orientation and target acquisition.

Ukrainian companies have developed multiple UGVs, including the anti-tank missile-armed Fantom. Temerland in June announced that its Gnom would be used by Ukrainian forces for reconnaissance and fire support, using a mast-mounted camera. It is armed with a 7.62mm machinegun but other versions can be used for logistics and engineering, or to deliver an anti-tank mine.

Milrem Robotics' THeMIS has made its way to Ukraine, with Kiev receiving the first vehicle, for equipment and wounded transportation, in August - prompting Russia to offer a RUB1 million reward for its capture. Ukraine is the first country to deploy the THeMIS in combat, although it was in 2019/2020 deployed by Estonian troops in Mali where it was used to transport supplies. Milrem has secured a dozen customers for THeMIS, including Thailand – in late 2021 Milrem delivered THeMIS Combat UGVs fitted with a remote weapon station for testing by the Royal Thai Army, where it's known as D-Iron.

ASIA-PACIFIC PROLIFERATION

Most large defence companies are working on UGVs, and many militaries in the Asia-Pacific are actively pursuing unmanned combat vehicles. Taiwan, for example, in 2015 revealed the tracked LRCCV with interchangeable modules for military and security applications, and Vietnam's Defence Technology Institute has developed the RBB-01 UGV with a submachinegun – a very small tracked UGV fitted with an assault rifle has also been observed undergoing testing.

AUSTRALIA

Australia has demonstrated great willingness to adopt UGVs, and already is a heavy user in the mining and resources sector. The 2016 Defence White Paper identified the need to expand the Australian Defence Force's (ADF's) UGV capacity, and in recent years the ADF has tested numerous different platforms, ranging from the handheld

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ThrowBot to the autonomous M113AS4 armoured personnel carrier, Jaeger-C from local company GaardTech and Vision 60 'robot dog'. During Exercise Talisman Sabre 2019, the Army trialed the MAPS Mule, a six-wheeled robotic vehicle made by Praesidium Global and able to transport a 500 kg useful load. The Australian Defence

drills with unmanned systems, including route clearance robots, and by April 2020 the People's Liberation Army (PLA) had deployed UGVs for reconnaissance operations. The extent to which they are being embedded in the PLA could be seen in a mid-2022 amphibious exercise that included multiple unmanned reconnaissance

Claw 2 6x6 thanks to a rear cargo area. The Sharp Claw 2 can be fitted with sensors and a 7.62mm machinegun.

It appears the PLA has also introduced the high mobility Sunward Intelligent Equipment Co Dragon Horse II 8x8 UGV into service to carry cargo (payload is up to 1 000 kg), with a video released in early 2022 showing it transporting artillery rounds.

Many different military UGVs are being developed in China, with some unusual designs being a quadrupedal UGV fitted with an automatic cannon, and the Marine Lizard amphibious autonomous vehicle, which reaches 80 km/h on water and deploys tracks for a 20 km/h land speed. One of the largest is the Norinco and China South Industries Group family based on the CS/VP16B Lynx 6x6 all-terrain vehicle. Unveiled in 2021, armed and unarmed variants were seen being operated remotely by PLA personnel.

INDIA

India's military has lagged behind rival China's in UGV development, but is looking to acquire them, especially for high altitude operations. A December 2021 event organised by the Indian Army evaluated three dozen UGVs for ISR and medical evacuation, amongst others. This included the Bharat Forge ECARS, available in 4x4 and 6x6 configuration. ECARS was subsequently seen in a joint Indian/Japanese exercise in 2022.

The Defence Research and Development Organisation (DRDO) has been slow to pursue UGVs, but has developed several somewhat rudimentary unmanned vehicles, notably an unmanned SUV, a remotely controlled BMP-1 IFV (Muntra), and the smaller MASS and MARS. More

Described as the first of its kind in Malaysia, the Kawbra is a military UGV that was unveiled in early 2022 by the Science and Technology Research Institute for Defence.



Milrem Robotics' Type-X heavy combat UGV can be fitted with different turrets (Milrem Robotics)

Force also uses EOD robots, and is developing the Muskitto route clearance UGV, based on the US HDT Hunter Wolf 6x6.

Elsewhere, Australian firms Cyborg Dynamics Engineering and BIA5 are using government funding to develop a new semi-autonomous UGV for the ADF, with a contract awarded in late 2021. This follows on previous efforts that resulted in the tracked Warfighter, based on BIA5's OzBot chassis. Payload is 330 kg, which can include a remote weapons station.

CHINA

China is driving military UGV use in the Asia-Pacific and has been evolving UGVs for some years. An August 2019 exercise, for example, saw Chinese armoured units conduct high-altitude

India's military has lagged behind rival China's in UGV development, but is looking to acquire them, especially for high altitude operations.

vehicles, unmanned anti-tank vehicles, self-propelled weapon stations and robot dogs.

Norinco is marketing UGVs on the international market, and already has several models in PLA service, including the 120 kg Sharp Claw 1, armed with a 7.62mm machinegun. It had entered service by early 2020 and was subsequently deployed to Tibet, along with Zhong Tian Zhi Kong Technology Holdings Company Mule-200 logistics UGVs. The Sharp Claw 1 can be carried and deployed by the much larger (1 tonne) Sharp

ambitious are its plans to develop a combat UGV based on the Arjun Mk 1A main battle tank, with a 120mm main gun as the primary weapon.

The DRDO is also developing three UGVs with Larsen & Toubro. Various private companies have military UGV projects on the go, including Torus Robotics, Combat Robotics, and Defence Master India – the latter in 2020 unveiled its 500 kg Sooran 4x4, fitted with a remotely operated machinegun turret.

INDONESIA

Indonesian companies have presented several UGVs over the last decade, such as the BDLtech War tracked vehicle, but most progress on military systems is being spearheaded by the Indonesian military. In 2018 the army's Politeknik Kodiklatad revealed a locally designed and manufactured UGV, fitted with a 5.56mm machinegun. The Indonesian Ministry of Defence's Research and Development Agency is developing a combat UGV (Sentry Gun) with PT Ansa Solusitama Indonesia. The electrically powered vehicle can carry up to 750 kg and be armed with a remotely operated machinegun.

MALAYSIA

Described as the first of its kind in Malaysia, the Kawbra is a military UGV that was unveiled in early 2022 by the Science and Technology Research Institute for Defence. In development since 2019, the 4x4 vehicle is electrically powered and has a four-hour endurance and 400 kg payload. It can be fitted with a remotely operated 7.62mm machinegun.

SINGAPORE

Singapore has dabbled with UGVs for years – as far back as 2011, the national Defence Science Organisation (DSO) unveiled the 40 kg Rush demonstrator. The DSO subsequently displayed the Harrier quadrupedal UGV and Foxhound 4x4 vehicle. The Foxhound is claimed to be able to operate over difficult terrain, autonomously, without maps or GPS.

ST Kinetics has taken a lead in military UGV exploration, for example in 2018 unveiling a 4x4 UGV equipped with a 7.62mm machinegun, based on the Roboteam Probot. It has also fitted weapons to the Israeli Amstaf from Automotive

mid-2019.

SOUTH KOREA

The Korean military is keenly interested in UGVs, and has evaluated several domestic models. In mid-2021 Hyundai Rotem delivered UGVs to the Army for a six-month test, with an initial contract for two vehicles based on 6x6 HR-Sherpa platforms. This 1.6-ton vehicle has a

was also evaluated by Korea's military.

The MPUGV subsequently evolved into the two-ton 6x6 Arion-SMET, which was in late 2022 selected for evaluation by the US military. The vehicle has a modularity-driven design to support various missions. A deep neural networking-based weapon station can detect and track enemy soldiers, and return incoming fire.

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Plasan ATeMM can incorporate various payloads such as a weapon station (Plasan)

Speeding up UGV development is the fact that most vehicle components are available commercially, and UGVs are more cost effective and quicker to build than crewed vehicles.

Robotic Industries, and Milrem's TheMIS, and used the Amstaf as the basis for its 250 kg payload Jaeger 6x6 – it has also developed an 8x8 version of the Jaeger under a project that began in 2015. Its largest project to date is an unmanned version of its 29-tonne tracked Next Generation Armoured Fighting Vehicle (NGAFV), equipped with a 30mm cannon and unveiled in

400 kg payload and is able to carry a 5.56mm machinegun, but other configurations include for logistics, medical evacuation and security.

Later in 2021, the Republic of Korea Army announced that it had started testing Hanwha Defence's I-MPUGV prototype. The vehicle, which has a 500 kg payload capability, is a more advanced version of the earlier MPUGV, which

CONCLUSION

With the return of great power competition and interstate conflict, UGV development has accelerated and their use in real combat situations will help give direction to this rapidly emerging field. Speeding up UGV development is the fact that most vehicle components are available commercially, and UGVs are more cost effective and quicker to build than crewed vehicles. By the 2030s, it is likely that UGVs will be a key component of the modern military, providing extra firepower and assisting soldiers tackle dangerous or difficult tasks.

SWARMING ARMED DRONES ALREADY A MAJOR COMBAT THREAT

The Israeli Defence Forces (IDF) are going to implement the use of drone swarms for combat missions. This is happening at the same time as Iran and some of its proxies are using the same technique to attack some Gulf States and Israel. The use of swarming drones has long been a concern for planners – and now it is becoming reality.

The IDF's decision has been made and now the command of the ground forces is evaluating the operational options with some Israeli companies. Until recently, this seemed like a scene from a science fiction movie. Not anymore.

The reason: a combination of new developments in drone technology, the proliferation of them - and operational needs.

Not many armed forces can afford to purchase big UAVs that can carry multiple sensors and payloads to satisfy the needs of different ground and air forces simultaneously.

Meanwhile, drone swarm technology is advancing fast, and while until recently there was doubt about the concept, that doubt seems to have disappeared. They are groups of different types of drones that work together to accomplish goals, communicating with each other and assisting other members of the swarm in tasks.

Israeli industry now wants to take advantage of technology that enables the operational cooperation of some drones. In the near future we can expect to see swarms of drones performing different types of missions even those considered complicated.

Another important change involves countermeasures. So far, the focus on anti-drone systems was on detecting and killing a single drone or UAV, but the threat has changed.

The cooperation between Russia and Iran in operating armed UAVs in Ukraine increases the threat of swarms that will be used to attack targets in Israel and some Gulf states. In some cases, Iranian armed UAVs transferred to Russia have been launched in swarms. In one case, 28 UAVs have been used to attack targets in Ukraine.

Israel is already adapting its multi-tiered air defence system to deal with this concerning new threat. In an article written for Maarachot, the official magazine of the IDF, Yair Ramati, former head of the Israeli missile defence directorate in the Ministry of Defence said that the battlefield in Ukraine proved to the Russians the importance



Deployable Drone Guard system (IAI photo)

Ramati writes that the Iranians supplied Russia with two types of "suicide" UAVs - Shahad4 131 and 136 - and one type for reconnaissance and attack, called Mohajer

of precise attacks at ranges of hundreds of kilometers:

"To fill this gap quickly, Russia turned to purchasing off-the-shelf products from abroad. The range of possible sources that did not require waiting for production available to the Russians was limited. According to the assessment they included the first and natural candidate - China, but it seems that China was not interested in putting its name to this type of conflict.

"The second was Turkey, which combines a business problem by being a NATO member and a supplier of anti-aircraft missiles to Ukraine, with a technical one by the lack of attack products of the type that Russia demanded. Therefore, probably

without a choice, Iran was selected."

Ramati writes that the Iranians supplied Russia with two types of "suicide" UAVs - Shahad4 131 and 136 - and one type for reconnaissance and attack, called Mohajer.

"As could be expected from a country that has almost no air force, Iran developed as a replacement many types of missiles and armed drones. These processes, the seeds of which were planted in the 80s and 90s of the last century, gradually began to mature. Step by step, Iran cultivated the necessary infrastructure, while relying on high-quality and educated personnel, initially with liquid ballistic missiles with assistance from North Korea, later - the full aeronautical

spectrum of combat systems."

Eden Kaduri, Liran Antebi and Dr. Meir Elran, researchers from the Israeli institute for national security studies (INSS) write that the Iranian UAV program is nevertheless the gravest potential threat to Israel. Iran has shown great boldness in UAV attacks against Middle East targets in recent years:

"At the same time, it aids proxies in various theatres and gives them knowledge for developing this arsenal. A variety of attacks in the Middle East are attributed to these organisations, among them the attacks against American bases in Syria and Iraq, the most famous of which took place in October 2021, causing damage to property; the attempted assassination of Iraqi Prime Minister Mustafa al-Kadhimi in November 2021; and attacks against ships owned or operated by Israel. Prominent in this context was the attack on the Mercer Street oil tanker in July 2021 which killed two crewmen. The August 15, 2022 UAV attack on the al-Tanf base in Syria is a continuation of the same Iranian-directed policy."

In conclusion, the researchers write that Israel must create a comprehensive strategy to address the growing threat posed by UAVs. Additionally, there must be effective solutions for severe situations that now seem improbable to occur yet present a major risk.

One instance is when terrorist organisations fly a small rotary drone against Israel from a neighboring country or from within Israeli territory. In terms of strategy, Israel must also keep creating cutting-edge technologies to address the threat presented by UAVs, expand its intelligence operations in this area, and step up its efforts to collaborate with other nations, including its defence exports in this sector.

The danger, which will only get worse in the future, affects more than simply Israel.

An Israeli senior expert in air defence who talked on condition of anonymity, said that the two Iranian manufacturers of armed and unarmed UAV – Qods and Hesa - received in recent months large sums of money for their products used by the Russians in Ukraine.

"This money will help the Iranian companies to develop and manufacture large numbers of advanced armed UAV that will be used in the hands of Iran's proxies around the world. This reality emphasises again the urgent need for close cooperation between Israel and Gulf countries, including Saudi Arabia. Such cooperation will be not sharing intelligence but about systems that can counter UAV attacks."

The expert added that air defence systems can cope with armed UAV swarms but added that the problem is detecting them as they fly very low.

The IAF made some changes in its early warning systems. Some are classified but one, deploying large, tethered balloons carrying long range radar systems is operational.

According to estimates so far Iran supplied 1,400 UAVs to Russia. Intelligence sources say that the Russians have ordered 2,400 more, mostly the armed versions.

The money goes to the two manufacturing companies controlled by the Iranian regime. Israeli sources said this will be invested in upgrading the armed UAVs with a focus on greater immunity to GPS interference and improved warheads.

The deals with Russia according to the Israeli

Israeli early warning systems. Countermeasures such as IAI's Drone Guard are already on the market.

Other Israeli companies such as DFend have started developing countermeasures that electronically captures the target. It can operate in either autonomous or manual mode, and it detects, locates, and identifies rogue drones and then neutralises the threat by allowing the operator to take full control over the drone and land it safely in a predefined zone.

Since the system does not rely on jammers or kinetic technology, EnforceAir avoids collateral damage, interference, disruption and disturbance. Continuity prevails as communications, commerce, transportation, and everyday life smoothly proceed.

The deals with Russia according to the Israeli defence sources will take the Iranian industry "some big steps forward"

defence sources will take the Iranian industry "some big steps" forward as one put it.

In August, according to the Iran International website operated from London by the Iranian opposition, Teheran exposed an underground military base on the second day of a countrywide drone war exercise – a possible vulnerability to foreign attack. In addition, an Iranian announcement about a joint UAV exercise with the participation of Russia, Belarus and Armenia - held in August at the Kashan Air Base - mentioned the Russian request to Iran for armed UAVs.

The Iranians are actively involved in operating their armed UAVs with the Russians in Ukraine. Some weeks ago, ten Iranians training Russian soldiers were reportedly killed in Ukrainian strikes, a Ukrainian official told KAN Israeli news channel.

Israeli defence sources said that the active involvement of Iranians in operating their UAVs in Ukraine will help Iran in developing more advanced versions.

The sources added that the Iranian armed UAVs pose a major threat not only to sensitive sites but also to ground forces.

"This threat is only starting to develop but armed forces must be ready for it as the armed UAVs will be a major part of any future military confrontation," one of the sources said.

According to Israeli defence sources, the fast-growing Iranian armed UAV capability causes concern in Gulf countries and some of them have already started negotiations for the purchase of

In a recent demo D-Fend's technology was able to hack multiple drones at the same time. Last year, the Israeli company revealed that the technology has already successfully hacked more than 10 drones that were part of drone swarm.

The anti-drone effort in Israel was taken one step forward. Israeli scientists are developing systems that will be capable of locating a drone operator so that they can be neutralised. The new Israeli operational demand to not only intercept a drone but also to kill its operator has prompted some efforts in this direction.

Researchers at Ben Gurion University in Beer Sheva, are developing a unique system that according to them will be able of pinpoint the operator. The research is led by Dr. Gera Weiss and is conducted by lead researcher Eliyahu Mashhadi who said that a realistic simulation environment is used at this stage of the research to collect the path of the drone when flown from the launch point and along its flight path:

"We insert all the points along the flight path into a deep neural network that was configured to predict the exact launch point and the location of the drone operator."

The researcher explained that while testing the model with the flight simulator, a 78% accurate location was achieved.

While Israel is taking its UAV technology further, including swarm operations, at the same time it is building better capabilities to protect itself from that fast-developing threat.

ARIANESPACE INCREASES ENGAGEMENT WITH AUSTRALIAN INDUSTRY

Placing a military communications satellite weighing several tonnes in geostationary orbit 35,786km above the earth's surface is no mean feat. There are only a handful of producers of rockets of this scale – and those from China and Russia are completely off the agenda for reasons of national security. Of the remainder, the company that has been most active in Australia – by far – is Arianespace.

Vivian Quenet, Arianespace's Managing Director and Head of Sales for the Asia-Pacific region provided an update to APDR during a recent visit to Australia, explaining that further discussions have taken place with local companies about possible collaboration. On previous occasions he has been unable to go into detail for commercial-in-confidence reasons, but now elaborated, describing the broader picture and some interesting opportunities:

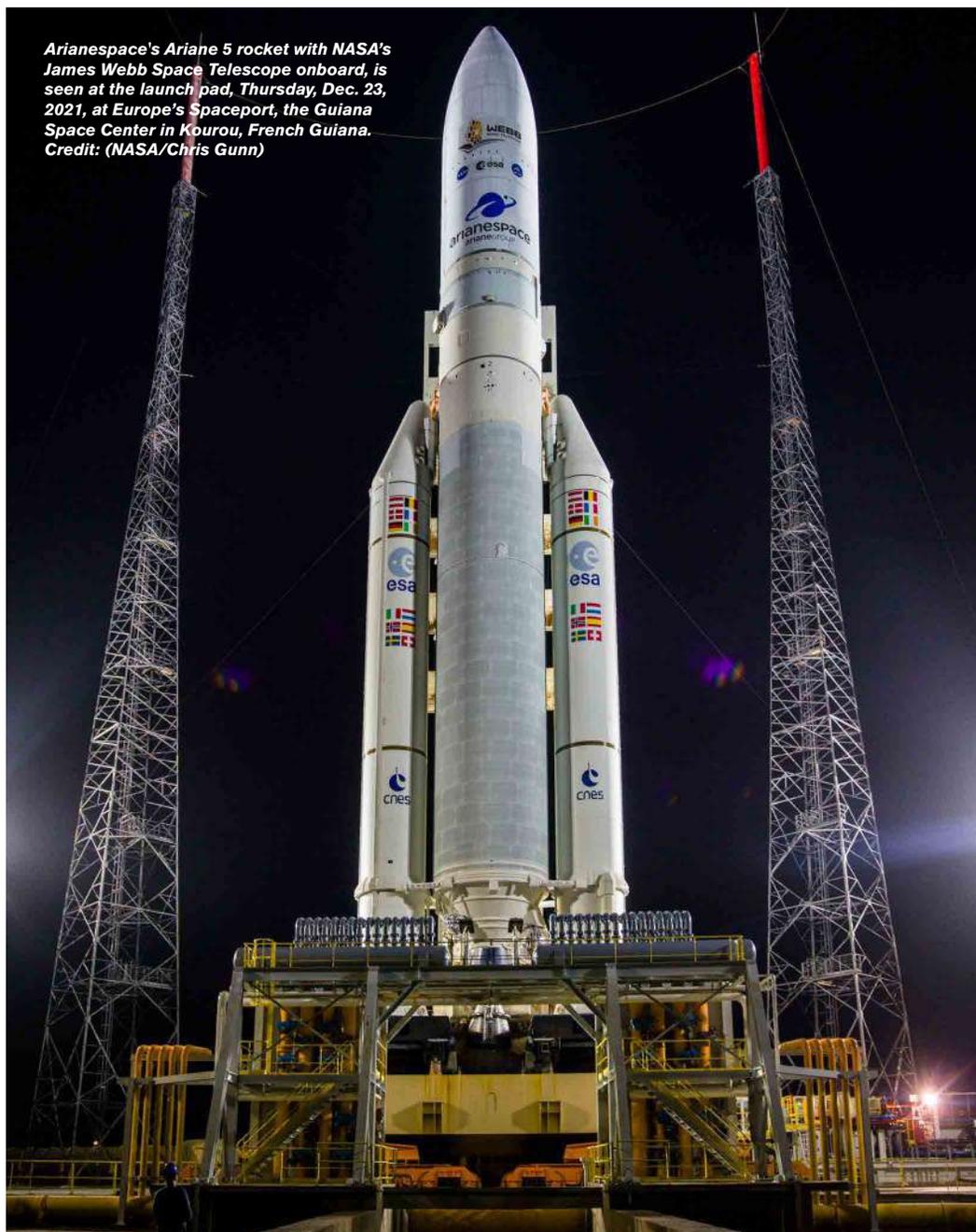
"Arianespace is owned by the Ariane Group – which is also very active in Australia. The company has three telescopes here that are used for space situational awareness – particularly the search for debris that can damage or even destroy satellites. They can also search for unfriendly satellites that might be trying to get close to one of your own in geostationary orbit.

"France has experienced that problem – and it is becoming more common. This is leading to the creation of "Bulldog" satellites which are designed to protect the main asset from unwelcome attention.

"Another initiative is the development of a re-entry test capsule that could land at Woomera and which is designed to test re-entry speeds. At the moment ESA's re-entry capability is limited to about 8km per second, but there is an interest to raising that to 11km per second – which is about the speed of an object returning from further out in space, for example from the moon.

"Woomera is attractive for several reasons. Firstly, it is a large area – and we will need a minimum of 80 x 80km. Secondly, we don't want to land in water, which was an option but not preferred because of issues such as salt water damage. Thirdly, the terrain is suitable because it's not too rocky and there are no trees to speak of. Finally, because it is a Defence establishment there is a lot of telemetry available – radars and so forth – that will allow us to track and recover the capsule.

"Ariane Group will share all of the data from



Arianespace's Ariane 5 rocket with NASA's James Webb Space Telescope onboard, is seen at the launch pad, Thursday, Dec. 23, 2021, at Europe's Spaceport, the Guiana Space Center in Kourou, French Guiana. Credit: (NASA/Chris Gunn)

this mission with Australia – which will be very interesting. Also – even though it's not the main point – a lot of information will be gathered about high velocity re-entry, which has a lot of defence applications.

"We could potentially include an Australian payload within the capsule to conduct your own experiments, which might be a very cost-effective way since you would not be paying any of the project costs. We are also open to the possibility of involving local companies or perhaps universities in the activity."

The project was put on hold and has just restarted, with the aim of having a launch in the 2027-28 timeframe. The capsule will be launched on a new Ariane 6, with the addition of a "kick stage" booster – still being developed - that will push it to the required speed of 11km per second.

While not at all a military project, the connection with defence is that hypersonic missiles – both fielded and under development – travel at these sorts of speeds. Intercontinental ballistic missiles are also in the same broad category, so one assumes that this sort of data would be of great interest for the Defence Science & Technology Group (DSTG) as well as a number of other government agencies.

Ariane Group is also helping the development of Australian sovereign capabilities through a relationship with Gilmore Space Technologies with the development of some parts, like the divergent, which is placed in the rocket engine nozzle. The hardware was tested in June and was so successful that it has been subsequently used a second time. This is the first of several areas of collaboration.

All geostationary satellites operated by Australia – in the shape of Optus and the NBN – have been launched by Arianespace for a 100% market share. In addition, a further contract has been signed with Optus for the launch of a software-defined satellite – a first for both companies.

There are only two such satellite manufacturers in the world: Airbus and Thales-Alenia Space. Mr Quenet explained:

"These satellites are completely reconfigurable, so instead of having a piece of hardware that will fairly much determine what it can do over its life, now instead it carries software that allows changes to be made while it is in space. If you are an Australian satellite operator and are responding to a lot of demand in Sydney, but suddenly Adelaide also needs capability, you will be able to re-focus a lot of your beams directly in that area."

This is the future of communications satellite technology, especially when combined with software-defined networks. The consequence will be

far greater data speeds, flexibility – and the means for satellites to produce a multitude of spot beams, for example following a commercial airliner in flight leading to far better, and cheaper, connectivity.

The significance for Arianespace in being selected as the launch provider is that these satellites use electric propulsion, which saves weight. However, the drawback is that it takes the satellite longer to reach its final position than if it were using a more energetic chemical system to nudge it into place – which is an opportunity lost, commercially speaking, with a delay getting to market. Aside from that, the cost of operating a satellite during its orbit raising, also known as LEOP (Launch and Early Orbit Phase) will be reduced.

However, a strong selling point of Arianespace has always been the accuracy of their launches, with satellites being delivered as close as possible to their final orbit. An excellent recent example is the James Webb telescope, which has had its operational life doubled thanks to an optimised injection, which helped conserve the amount of fuel

manage their satellites in space.

"SMC's spacecraft are designed to provide future capability for in-orbit logistics services, including spacecraft inspection, servicing, maintenance and removal."

Arianespace is seeing an increasing need for OTV technology. There are a growing number of small geostationary satellites – small in this context being 300kg-400kg – and it would be helpful if they did not require any organic propulsion because that weight could be re-purposed.

The concept is for several of these small satellites and an OTV to be placed as close to their final position as possible by the Arianespace rocket and for the OTV to then act as a small orbiting tugboat to use its fuel to push them to their final orbit.

There are many other applications of OTV technology, such as refuelling satellites while they are in space. Another problem is what to do with satellites when they reach the end of their life, and a solution could be to push them into a slightly higher orbit where they are out of everyone's way.

"We could potentially include an Australian payload within the capsule to conduct your own experiments, which might be a very cost-effective way since you would not be paying any of the project costs."

it needed to use to get to the L2 Lagrange Point 1.5 million km from earth, where it is permanently located.

Another attractive feature is the lower Delta V (total change in velocity) at which Arianespace is able to inject geostationary satellites, meaning that they spend less time passing through the very hazardous Van Allen Belt. In turn, this means that they need less shielding – especially for the solar panels – and every gram of weight saved can be used for more productive purposes.

Arianespace has also signed a MoU with the Sydney-based Space Machines Company (SMC) on October 31. SMC is developing in-space logistic and transportation services, saying:

"Through its Optimus Orbital Transfer Vehicle (OTV), one of the largest commercial spacecrafts designed, manufactured, and assembled in Australia, SMC is building the future of in-space transportation and logistics.

"SMC's space capability also addresses the future challenge of inactive satellites and space debris, designing solutions to help customers

Arianespace has offered its services to all five JP9102 bidders, but it is not known how many of them have embraced the offer. Other launch options such as Falcon Heavy and Delta IV Heavy are possible, though they seem to have taken little interest in Australia's specific needs.

For a military satellite, high on the list of requirements is security – and here Arianespace has an advantage that to date has received little attention. All US launches take place from government owned facilities that come with their own security protocols, which are not varied for any particular customer. One size fits all.

On the other hand, Arianespace owns and runs its launch centre at Korou in French Guiana on the Atlantic coast of South America, just north of the equator. This means that the company, in discussion with customers, can put in place the most rigorous security arrangements imaginable for not only the launch but getting the satellites there to begin with. In doing so, the company can draw on the considerable resources of the French government, which we will not detail here.

AUSTRALIAN CYBER WARFARE READINESS - PART 2

The first part of this article, in APDR's November edition, concentrated on new research and development capabilities being introduced by the Defence Science and Technology Group (DSTG), as well as covering the international cyber capabilities of Leonardo which can be made available to support the ADF.

Now in Part 2 we take a closer look at developments in Australia which have been, and continue to be, developed by Defence to train members of the ADF for both defensive and offensive cyber warfare.

DEFENCE'S CYBER SECURITY STRATEGY

An announcement of this Strategy was made on 31 August 2022 by the Assistant Minister for Defence and Assistant Minister for Veterans' Affairs, the Hon Matt Thistlethwaite.

The following is a summary, taken from the full document, which explains the need for this Strategy and how it will drive Defence's efforts in this field.

Defence must continue to improve its cyber security if it is to defend against constant malicious cyber activity and succeed in future conflicts. This is necessary for the continued fulfilment of Defence's mission, and the continued delivery of critical functions upon which our national interests rely, and all Australians expect.

The Strategy will shape the Defence portfolio's cyber security for the next ten years. It establishes the guiding principles and strategic objectives to enhance Defence's cyber security capabilities in line with the shifting threat environment.

The Strategy also establishes four priority action areas that outline objectives to be achieved over the next three years. This will set the necessary foundations for Defence to be a cyber security exemplar now, and into the future, as cyber threats evolve.

This Strategy will ensure Defence can continue to transform, adapt and evolve securely. It will support Defence's ability to Shape, Deter and Respond: shaping its cyber security environment through uplift, standards setting and strengthened partnerships; informing its deterrence activities through improved visibility of adversaries' activity;



RAAF staff configure a communications cabinet for cyber research and development systems at 462 Squadron. Credit: Corporal Brenton Kwaterski, Defence

and refining its ability to respond by enhancing its cyber security posture and limiting adversaries' ability to conduct malicious cyber activity against Defence.

The nature of cyberspace means that every capability, every individual and every industry partner represents a target and opportunity for adversaries.

This Strategy recognises that the unprecedented threat environment Defence faces extends across its industry partners. The need for industry partners to establish and maintain strong cyber defences has never been more critical. This can only be achieved through a concerted effort across Defence's entire ecosystem, working

together to strengthen our collective cyber security and defend Australia.

PROJECT JP9131 DEFENSIVE CYBER OPERATIONS

In mid-2021 the formal Defence Project JP9131 Defensive Cyberspace Operations, as part of the 2020 Force Structure Plan to strengthen the ADF's deployed cyber resilience, was announced by then Minister for Defence Senator the Hon Linda Reynolds CSC.

This proposed to strengthen the cyber defences of deployed ADF networks and combat platforms through its \$1.4 billion investment in Defence

cyber capabilities over the next 20 years.

“Cyber threats to Defence networks and missions systems have the potential to undermine the Australian Defence Force’s ability to operate,” Minister Reynolds said.

“This project ensures Defence can actively defend its deployed networks and combat platforms against the rapidly evolving cyber threats.

The Strategy also establishes four priority action areas that outline objectives to be achieved over the next three years. This will set the necessary foundations for Defence to be a cyber security exemplar now, and into the future, as cyber threats evolve.

As part of an initial investment of \$575 million, the project will deliver a comprehensive training program to support the growth of the ADF cyber workforce, including virtual cyber training environments and tools.

To maintain an edge over evolving threats, staged investment is also planned to develop the training, tools and infrastructure that is crucial to ensuring the capacity and relevance of the ADF’s defensive cyber operations capability.

“This Government is also funding the construction of a modern, purpose-built Joint Information Warfare Facility in the ACT which will offer critical Defence cyber training and simulation systems,” Minister Reynolds said.

As well as developing an Industry Engagement Plan to maximise Australian industry involvement, the project’s partnership with DSTG is expected to grow Australia’s sovereign cyber industry capability by linking industry to the Cyber Threat Response Lab.

The lab will provide direct opportunities for small and medium sized businesses to collaborate with Defence on innovative training and cyber tool solutions.

CYBERSIM

A major development was reported in mid-2021 by Flight Lieutenant Georgina MacDonald RAAF when she described in the Department’s Defence News how RAAF’s 462 Squadron has developed and is using a system for simulating advanced cyber threats

She wrote that 462 Squadron and the JP9131 team are enabling the warfighter in the cyber domain through the support of a simulated cyber environment known as the CyberSim.

The CyberSim was originally designed in-house by 462 Squadron to fulfil the need to train and upskill cyber specialists in a coordinated and controlled environment.

In that published media she quoted Commanding Officer 462 Squadron, Wing Commander Duncan Scott who said the work his squadron was doing alongside JP9131 was using innovation to move the capability into the future.

“No. 462 Squadron and JP9131 are enabling the war fighter in the cyber domain through the creation and support of a simulated cyber environment known as the Defence Cyber Range, which is an evolution of the Air Force CyberSim,” Wing Commander Scott said.

The capability provided by the CyberSim allows for the potential simulation of thousands of computers and their associated network traffic. Using such simulations, critical mission networks and their traffic can be replicated.

“This Simulated Key Terrain helps deliver two capabilities; a raise, train and sustain function needed to develop a cyber-workforce and the second being a cyber-range for cyber warfare operators to develop/perfect their tactics, techniques and procedures (TTPs) to address the evolving threats,” Wing Commander Scott said.

“The simulated environment is used by many of the sections within the squadron such as the Cyber Vulnerability Investigation Team who use the CyberSim to simulate full networks and conduct training for Vulnerability Assessments to prepare the team for what they may expect to see when assessing live Air Force systems. Practice within the CyberSim also allows the development of new processes and tools in a safe environment to ensure that Air Force systems are comprehensively assessed and secured.”

462 Squadron’s Cyber Protection Flight use the CyberSim to train in dynamic environments of both simulated mission systems and networks.

“These Cyber Warfare Analysts and Cyber Warfare Officers defend against emulated real-world threats generated by our Threat Emulation Operators who imitate the TTPs of known threat actors,” Wing Commander Scott said.

“The continued support and infrastructure upgrades from JP9131 will provide even greater depth of training and lead to increased realism of training environments to simulate the highly contested cyber terrain that the ADF is entrusted to defend from cyberspace threats.

“I’m incredibly proud of our team and the innovation they’re employing to move our capability forward and keep up with ever emerging threats.”

AUSTRALIAN SIGNALS DIRECTORATE (ASD)

ASD is a vital member of Australia’s national security community.

They state that they work across the full spectrum of operations required of contemporary signals intelligence and security agencies. This includes intelligence, cyber security and offensive cyber operations in support of the Australian Government and the ADF.

Often ASD personnel are attached as team members for specific tasks being undertaken by individual armed services cyber warfare groups.

IN CONCLUSION

The ADF, ASD and their industry partners are focused and working together to ensure that no major cyber attacks can be successfully launched against the government and the wider defence community.

By the same token, the ADF has trained personnel to both monitor what potential adversaries are planning and, if necessary, launch pre-emptive strikes.

Defence’s cyber warfare capabilities are developing rapidly to the point where readers can be reassured that there is now a greatly reduced likelihood of successful cyber attacks on government and the ADF and associated defence industry.

Unfortunately, the same cannot be said for the Australian business community.

On 22 September 2022, Optus announced that it had become the victim of a cyber-attack that resulted in the disclosure of information for over 10 million Optus customers, such as name, date of birth, email addresses, driver’s licences, Medicare card and passport numbers, may have been exposed.

Then on 26 October 2022 Medibank has confirmed the criminal entity behind cyber-attack on the company had access to the data of at least 4 million customers, some of which includes health claims.

GUY MARTIN // JOHANNESBURG

EXOSKELETONS SLOWLY REACHING THE BATTLEFIELD

Steady advances in technologies from robotics to power generation and artificial intelligence have made the concept of the military exoskeleton tantalisingly close to reality, but fully powered 'Iron Man' suits are still a way off and only small, but steady, steps are being made in getting exoskeletons onto the battlefield.



An exoskeleton is evaluated during China's Super Warrior competition in 2019 (China MoD)

Exoskeletons offer many appealing advantages to the modern military: greater soldier mobility, physical endurance, and protection. By far the biggest appeal is improving load carrying capacity: modern soldiers are being required to carry more equipment and therefore more weight, in spite of technological advances that are making equipment lighter and more efficient. High-tech equipment also requires power, and the average soldier can go into battle with up to 10 kg of batteries.

During the First World War, soldiers typically carried loads of around 30 kg, but by the Second World War, loads of 35-45 kg were becoming commonplace, and this has only gotten worse during the last three decades. In Afghanistan, for example, British soldiers were often carrying 50 kg, which started hampering their combat performance as the enemy was literally able to run rings around

them. One study concluded that a soldier can only optimally carry a third of his body weight, which gives a typical load of 20-25 kg – half of what many modern soldiers carry into battle.

One way of relieving a soldier's combat weight is using robotic mules or unmanned ground vehicles (UGVs). Another option is the exoskeleton, which can be either powered or unpowered, and full or partial body. Partial body and unpowered, or passive, exoskeletons are being brought to service most effectively, while fully powered exoskeletons are proving harder to mature.

Unpowered or passive exoskeletons merely provide support for the user, and as they rely on the

user's own muscles, they offer limited capability. Nevertheless, they are the easiest to manufacture and use, are generally comfortable as they make use of soft components, and are relatively light.

China's People's Liberation Army (PLA) is an early exoskeleton adopter. In 2020, border defence troops in Tibet were shown wearing lightweight non-powered exoskeletons designed to help them in harsh high-altitude environments. The PLA has been heavily involved in exploring exoskeleton technology, testing up to 50 exoskeleton prototypes from 25 developers in its 2019 Super Warrior competition and it seems that at least several designs are in frontline service.

Passive exoskeletons are entering increasingly widespread service around the world - for example, the US Army is testing the 1.5 kg Soldier Assistive Bionic Exosuit for Resupply (SABER), a soft harness which straps around the shoulders and legs to help lift heavy objects like artillery rounds. Developed by the US Army and Vanderbilt University, it completed field testing in May and is

High-tech equipment also requires power, and the average soldier can go into battle with up to 10 kg of batteries.

scheduled for field deployment in 2023. The US Air Force, meanwhile, is testing Roam Robotics' Forge System pneumatically powered exoskeleton to help aerial porters load and unload aircraft, and Russia's military has indicated it will test exoskeletons to assist crew handle artillery shells, with an eye on combat use in Ukraine.

MULTIPLE BENEFITS

Although alleviating the weight burden and increasing the load soldiers can carry are the main benefits of exoskeletons, there are many others as well, such as improved shooting accuracy. Russia's Rostec is aiming for a 20% improvement

in marksmanship accuracy with its exoskeletons while various other systems around the world, such as the US Army's Mobile Arm Exoskeleton for Firearm Aim Stabilization (MAXFAS), have shown improved shooting accuracy (although MAXFAS is a standalone item and not incorporated into a suit). Similarly, the Third Arm Weapon Interface System weapon stabilising device developed by the US Army Research Laboratory is more of an independent system than an exoskeleton, but could be integrated into one.

Improving a soldier's ability to withstand difficult environmental conditions is something else that exoskeletons can assist with. Singapore's ST Kinetics, for example, has developed the ARCTIC wearable, self-monitoring cooling system that utilises a solid-state cooling plate to reduce a soldier's core body temperature by up to 15% at an ambient temperature of 40 degrees Celsius, while the US military's failed TALOS suit incorporated a heating/cooling element.

Protection against chemical, nuclear, biological and radiological (CBRN) conditions can also be incorporated into exoskeletons, while sensors that monitor and record a soldier's health are other possibilities that already exist as standalone products - the TALOS suit intended to even incorporate wound treatment capabilities. Thermal cloaking and stealth are other elements that countries like Russia would like to add to their future soldier systems, as well as things like mine-resistant boots. Meanwhile, helmet-mounted

sighting systems and other related sensors are already entering service. Indeed, the military's ultimate vision of an exoskeleton would be a fully powered suit that would be able to carry significant weight, and provide speed, agility and protection as well as incorporate advanced sensors and support high-tech or heavy weapons.

THE RACE TO POWER

Exoskeleton-like devices have been around for over 100 years, but it was only in the 1960s that powered exoskeleton development began in earnest. For example, General Electric developed the Hardiman exoskeleton for the US military, powered by hydraulics and electric motors. However, it was heavy (nearly 700 kg), slow and difficult to control, and was essentially a failure.

For decades, successive exoskeletons offered little improvement, being heavy, clumsy and glitchy. Even by the 2000s, technology had not matured sufficiently. For example, Ekso Bionics and Lockheed Martin developed the Human Universal Load Carrier (HULC), an untethered, hydraulically powered rigid exoskeleton, which was tested by the US military. However, it hindered movement in some areas and actually increased muscle fatigue, and was shelved.

Another superficially promising exoskeleton was the Raytheon/Sarcos XOS 2, unveiled over a decade ago. This uses hydraulic power to allow the operator to lift 100 kg with no effort, but the power-hungry suit is tethered to an external power



A soldier tests an exoskeleton in 2017 at the US Army's Aberdeen Proving Ground as part of the Warrior Web Programme (US Army - Roby Carty)

source - an untethered version is more than a decade away.

One promising fully powered exoskeleton design is the Sarcos Robotics Guardian XO, which was in 2020 selected by the US Marine Corps to help Marines safely and efficiently lift, pull, push, transport and manipulate loads - Sarcos says 100 kg feels like 5 kg for the user. The suit uses force sensors to detect every motion that the operator makes, and then seamlessly moves its own limbs in parallel. Sarcos expects initial production of commercial Guardian XO units to commence by the end of 2022. The Guardian XO allows defence and industrial workers to lift and manipulate heavy objects up to 90 kg for a full shift or work day, due to its hot-swappable lithium-ion batteries.

SLOW BUT STEADY PROGRESS

Power is the main obstacle military exoskeletons are facing - electrically or hydraulically driven exoskeletons require significant amounts of energy, and various options are generally too heavy, too loud or do not have enough range at present to be really practical - even relatively recent powered efforts have not been completely successful. For example, a decade ago, the US military began developing the Tactical Assault Light Operator



Caracal CAR-816 (EDGE photo)



Lockheed Martin FORTIS knee stress reliever (Lockheed Martin)

China's People's Liberation Army (PLA) is an early exoskeleton adopter. In 2020, border defence troops in Tibet were shown wearing lightweight non-powered exoskeletons designed to help them in harsh high-altitude environments.

Suit (TALOS), designed to increase the amount of armour a special forces operator could carry. Initiated in 2013, the highly ambitious but heavy and complex TALOS was essentially a failure and five years later was replaced by the Hyper Enabled Operator project, which focussed on different technologies.

But now, the US Army believes technology has advanced enough for exoskeletons to become practical and expects a workable suit by 2040. Earlier this year, the US Army issued a request for information on the Powered and Unpowered Exoskeletons for Human Performance Augmentation During Manoeuvre or Logistics Support Activities project, which aims to identify companies able to develop exoskeleton technologies to improve soldier performance.

China, meanwhile, in early 2021, was revealed to

be using a new powered exoskeleton system to help PLA personnel carry heavy loads. Chinese media reported the exosuit allows a single soldier to carry a 52 kg crate with little effort – it apparently allows an extra 20 kg to be carried and can reduce the burden of a load by 50%. The year before, another powered exoskeleton was seen in use. Various powered and unpowered exoskeleton designs have been spotted in China over the last decade, and it has been reported that the Chinese Academy of Sciences, in partnership with the National University of Defence Technology, has even attempted to develop mind-controlled military exoskeletons.

NUMEROUS CHALLENGES

Aside from overcoming the power issue, one of the big challenges with exoskeletons is sensing, and letting the suit know when and how to move.

In early suits, there was major lag, making use challenging and often fatiguing. Another issue is actuation: it is very difficult to replicate the full range of body motion, and moving over rough ground or running has proven difficult to programme, although it has gotten significantly better as artificial intelligence and machine learning improves, and is not so much of a hurdle any more.

Another challenge is making a universal suit that easily adapts to each user's body – developing custom suits for each individual soldier is expensive and time-consuming. Cost is of course another issue, with exoskeletons costing tens or hundreds of thousands of dollars. Another hurdle is the fragility of the person inside the exoskeleton, who may not be able to withstand the shocks the suit can handle. Nevertheless, many of these challenges are being overcome, with great strides being made in sensing, motors/actuators, and batteries.

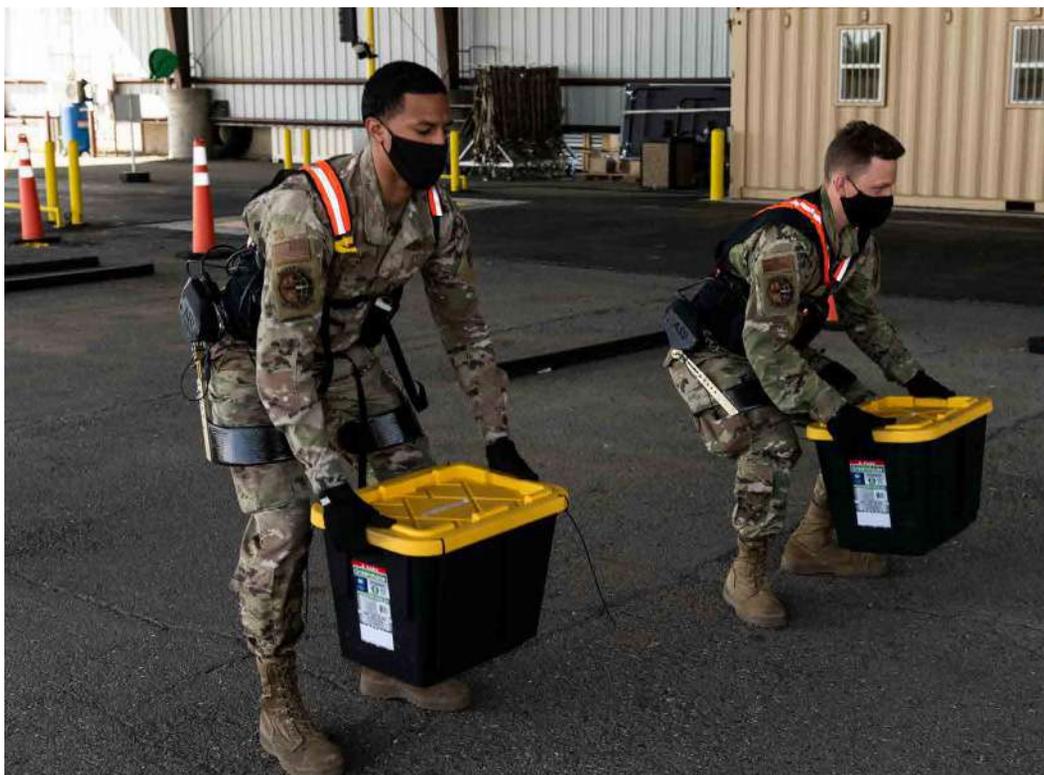
ASIA-PACIFIC PROLIFERATION

As the technologies needed for advanced military exoskeletons improve, countries around the world are taking small steps towards adopting these force multipliers. In the Asia-Pacific, China is making good progress, but its rival Taiwan has also been investigating exoskeleton technology, and the National Chung-Shan Institute of Science and Technology (NCIST) has been testing powered exosuits on soldiers. Its 10 kg lower body exoskeleton enables users to move at 6 km/h. A lithium-ion battery gives an endurance of six hours. Ultimately, the NCIST hopes to have a suit that can carry a maximum load of 100 kg. The four-year project to develop a powered exoskeleton began in 2020.

Japan is also actively working on exoskeleton technology, and three years ago the Japan Ground Self Defence Force (JGSDF) Acquisition Technology and Logistics Agency (ATLA) released footage of a prototype powered exoskeleton, which is able to assist the user with both walking and running – a difficult feat. A tablet is used to control the suit's parameters. Batteries give a walking endurance of two hours.

The Singapore Army has at least since 2020 been testing exoskeletons, including those based on the Canadian Mawashi Uprise passive unpowered load-bearing exoskeleton design. Uprise allows for a 50-80% load transfer to the ground and a high degree of mobility for users. ST Kinetics has also developed an unpowered Exosuit.

The Australian Defence Science and Technology



US Air Force airmen showcase the Aerial Porter Exoskeleton in May 2021 (USAF - Senior Airman Cameron Otte)

Group several years ago experimented with its Operational Exoskeleton (OX) passive, soft exosuit design, intended to decrease the strain on soldiers by using cables to redirect weight to the ground.

Elsewhere in the Asia-Pacific, South Korea's LIG Nex1 has for more than a decade been developing its LEXO (Lower Extremity eXOskeleton for Soldiers) exoskeleton; this can help users move objects weighing up to 55 kg. The company advertises three unpowered suit options as well as a powered LEXO 'robot' suit.

Many other countries around the world, from the Netherlands to Turkey, are following suit. Russia, for example, has tested its EO-1 passive exoskeleton in Syria (it is designed to ease load carrying capabilities of soldiers) while Rostec is working on a powered exoskeleton for the Sotnik soldier modernisation programme and expects a production powered exoskeleton in five years' time.

EMERGING TECHNOLOGY

At present, a lot of exoskeleton progress is being made in the industrial and medical sectors, with logistics and manufacturing pushing large powered suits for performing heavy lifting tasks, while the medical industry is using exoskeletons for injury rehabilitation and to replace wheelchairs – developments in these areas are directly

benefiting the defence sector, with Sarcos an example of this.

While a complete 'Iron Man' type exoskeleton is still far in the future, many individual elements are being perfected. For example, virtual and augmented reality displays are fairly commonplace and mature, as are improved communications and sensors for soldiers, while battery and electric motor technology continues to improve, and work is being done on hydrogen fuel cell and other alternative energy technology as well as utilising lightweight materials like carbon fibre and other composites.

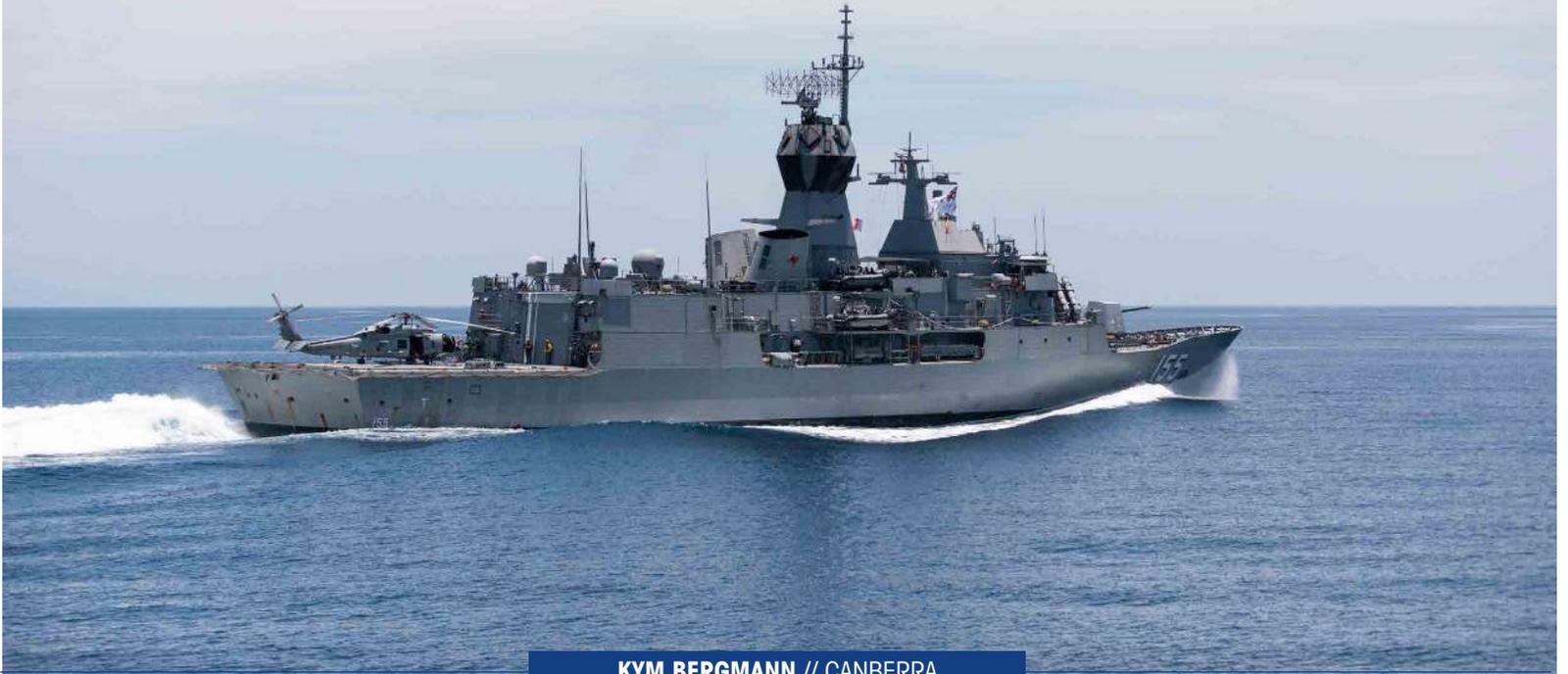
Flight is a possibility as well - development of practical jet packs is ongoing around the world. The UK's Gravity Industries, for example, has demonstrated its jet suit to the Royal Navy, and France's Franky Zapata demonstrated a Flyboard Air flying platform at the 2019 Bastille Day parade, but endurance is still very short and not yet practical for most military operations. Nevertheless, technology continues to advance, and it is clear that as it does so, exoskeletons will continue to improve and get ever closer to widespread adoption by militaries around the world.

As the technologies needed for advanced military exoskeletons improve, countries around the world are taking small steps towards adopting these force multipliers.



SABER exoskeletons being tested by the US Army (US Army - Larry McCormack)

*HMAS Ballarat sails through the Indonesian archipelagic sea lanes, during a deployment to East Asia.
Credit: Daniel Goodman*



KYM BERGMANN // CANBERRA

THE SOLUTION TO THE SURFACE COMBATANT SHORTFALL – NEW GENERATION ANZAC FRIGATES

Australia's most successful naval surface combatant project – by far – was the one that produced ten 3,500 tonne locally built ANZAC frigates. These were constructed on time and on budget – unheard of for other projects – and were commissioned between 1996 and 2006. Eight were for the RAN and two for the RNZN. Since then, they have remained the workhorses of both navies.

It is one of the abiding mysteries why such a successful template for project delivery was then ditched by Defence, who subsequently used different designers and primes for subsequent contracts, with far less successful results. The Hobart class Air Warfare Destroyers were at least four years late and \$1.4 billion over budget. The emerging Hunter class are behind schedule – though exactly by how much is a topic of dispute – and the eventual price tag for nine hulls is unclear, though it will certainly exceed \$40 billion.

Both the 9,000 tonne Hunter and 7,000 Hobart classes are much larger than the Anzacs and are

more complex, though following their Anti-Ship Missile Defence upgrades incorporating a CEA active phased array radar suite the latter are at the leading edge of capability. Also, the Anzacs achieved in excess of 80% Australian content – an almost unbelievable figure today and one which included a lot of the complex electronics. This was because the German designer Blohm+Voss – subsequently absorbed by its parent company thyssenkrupp Marine Systems (also known as tk MS) actually tweaked the parent design with the objective of maximising Australian and New Zealand content.

This came about for several reasons. In a fierce competition against a Dutch design, it was made clear by both the Australian and especially New Zealand governments, the Defence Department – and even the RAN – that local industry content was an essential requirement. To win, B+V and their Australian industry partner AMECON – basically the heavy engineering company Transfield, which morphed into Tenix – set about doing as much here as they could. In achieving this objective they were also helped by a large production run of 10 ships, with the further advantage that these were to a highly modular design well-suited to distributing



Ship's company onboard HMAS Anzac cheer ship to Royal Brunei Navy ship KDB Darulehsan during Indo-Pacific Endeavour 21. Credit: CoA / Leo Baumgartner

In a fierce competition against a Dutch design, it was made clear by both the Australian and especially New Zealand governments, the Defence Department – and even the RAN – that local industry content was an essential requirement.

work packages far and wide.

Not to pick overly on the Hunter class, when one reads the fine print, the first batch of three ships will use the existing UK supply chain, with only a gradual migration to Australia. A major effort was made to Australianise the Hobart class – not easy for a three-ship build – but even then only reached two thirds of the local content achieved on the Anzacs.

However, there is now an opportunity – albeit after a lengthy hiatus – to return to the successful formula of buying a new generation ANZAC from tk MS, with the prospect of rapid delivery of capable ships with large amounts of work done in Australia and potentially New Zealand if they also decide to come on board.

The original ANZAC design was part of the B+V / tk MS MEKO family of warships of which 68 are currently in service in 15 different navies, making them probably the most successful and adaptable warship in the western world. MEKO is one of those typically complex German acronyms that translates roughly as modular, flexible design and has been

trademarked by the company.

Using these principles, MEKOs have varied in size from 1,500 to 7,200 tonnes – the latter being the German navy's powerful F-125 frigates. In the animal kingdom, despite differing greatly in size, tigers are still very much recognised as being of the same species even though those clinging to survival in Siberia are twice as big as those clinging to survival

When ships of this configuration started appearing in the 1980s, they were early adopters of stealth characteristics such as radar deflecting shaping and the use of advanced coatings.

in Sumatra. The same can be said of MEKOs – their hull form is very similar, as is their general arrangement, leading to a somewhat inelegant but extremely robust and survivable ship. In other words, they all look roughly the same.

When ships of this configuration started

appearing in the 1980s, they were early adopters of stealth characteristics such as radar deflecting shaping and the use of advanced coatings. They are also all characterised by highly compartmentalised survival zones with separate pumps, fire fighting and electrical systems to allow them to continue to fight even after receiving heavy punishment. Because of the modular design they can also incorporate a large variety of weapons and sensors from almost all known suppliers. They typically also come with large design margins.

With the AWDs starting two-year mid-life upgrades in 2026 and the Hunter delivery schedule uncertain – though unlikely before 2032 – the RAN looks to be heading for a considerable surface ship capability gap. Despite many suggestions that the Arafura class OPVs be upgraded with a substantial mix of weapons, that seems unlikely to occur. It seems that once the RAN has classified them as patrol vessels they will remain in that non-combatant pigeon hole forever.

It is entirely possible that the Defence Strategic Review will seek to address this problem – and a solution might be a new batch of Anzac Block 2 frigates in the form of a MEKO 100 Light Frigate design from tk MS. This is similar to one currently being produced for Brazil. These are 107 metres long and about 3,400 tonnes, making them almost the same size as the legacy Anzacs.

Utilising the best of today's technology, such as Saab Australia's 9LV combat system, CEA radars and an underwater warfare suite from Thales Australia and Sonartech Atlas – to suggest but a few – and an embarked MH-60R, of which the RAN will shortly have more than they know what to do with, the RAN could have a rapid increase in surface ship capability. Offensive power would come from a Mk 41 VLS cell and qudpacked stealthy Naval Strike Missiles that have a range of 250km.

Another feature of the modular design is that construction can occur very quickly. This is because

fully outfitted hull blocks can be constructed in parallel in multiple locations and then brought to a final shipyard for rapidly assembly. In Germany, a MEKO frigate of this size takes 38 months to build. Final assembly is only a small fraction of that process. For the Anzac build, there were 12 hull

MEKO 100 for Brazil rendering (tk MS image)



BERNIE CLARK – A HUGE INFLUENCE ON THE ANZAC FRIGATE PROJECT

Kym Bergmann // Canberra

Bernard Chaffield Clark (OAM) – universally known as Bernie – passed away last year. He was the Managing Director of Blohm+Voss (Australia) and had an outsized role in winning the project, putting together an exceptionally strong Australian industry team and guiding the German parent company through the maze of the tendering process. He was instrumental in securing what at the time was the largest Defence contract the country had ever awarded.

Bernie led by example, always first in the office and usually the last to leave. His door remained open – literally – and he was keen to bounce his ideas off others and to leave no stone unturned in figuring out the best way of winning the contract. The word colourful is often overused, but not when it came to Bernie, who was interested in new ideas and different perspectives – and he had no time for crawlers and time wasters.

By some feat of alchemy, he persuaded Blohm+Voss and its corporate owner Thyssen Krupp to each invest in 49% of B+V (Australia), with him personally holding the 2% in the middle – probably a unique arrangement in the annals of defence contracting involving international companies. He was totally trusted

by the Germans and was instrumental in the decision to team with AMECON in 1988, a company that was initially made up of ASI, ICAL and Transfield. After a series of manoeuvres, Transfield ended up owning the lot – along with Williamstown Naval Dockyard and the contract to complete the final two FFGs, which had been sitting in pieces for years.

The Transfield team had some of Australia's best heavy engineers and a dynamic culture that came from the two founders – Franco Belgiorno and Carlo Salteri, rags to riches Italian immigrant engineers, who even in their 80s during the Anzac bid were still hugely influential figures. The people they had working on the bid were without peer and included Dr John White, Hans Ohff, Tony Shepherd and Carlo's sons Paul and Robert – two of the nicest and most decent people you will ever meet.

Germany Inc was still in shock over the 1987 decision to award the submarine contract to the Swedes and for the frigates B+V was absolutely determined to get this one right – and they did. Following Bernie's advice and led by the inspirational Dr Eckhart Rohkamm, they made sure that every decision was run through the filter of what the Australian government wanted – particularly in terms of local content. The B+V (Australia) office in Hamburg was a thriving operation, with Australian naval architects and designers led by Rob Dunbar constantly cycling through the place to get as much hands-on

and superstructure modules with the largest being 450 tonnes. These were fabricated and outfitted in a decentralised manner around Australia and New Zealand and were transported to Williamstown Naval Dockyard to be connected and launched.

With advances in ship automation, an Anzac Block 2 will require a crew of only 75 – half that of a current Anzac. The cost will be a product of the various subsystems – especially the electronics and combat system – but will be small compared with a major surface combatant.

There is general agreement that what the RAN needs for the coming decade – which analysts tell us will be one of the most challenging in history – are more hulls in the water. There isn't much time. A MEKO A-100 would plug the gap – and would be coming from a company that has already amply demonstrated its ability to deliver a solution designed for Australia's needs.

experience as possible – an investment made well in advance of the actual contract award.

It was an exciting time to be involved in a huge bid, with everyone motivated to work on the first fully Australian warship construction contract in almost thirty years. The government was enthusiastic – the Defence Minister was Kim Beazley – and the project had the full support of Cabinet, with Bob Hawke taking a personal interest in the outcome. Even the bureaucracy was supportive with Defence acquisition staff making a generally positive contribution, unlike today.

Bernie was in the thick of it with a constant punishing schedule of meetings and discussions, always looking for ways to make an already strong bid even better. Though born in New Zealand, he was a true Australian patriot and a champion of local industry. He was perfectly suited to the huge challenges of the day and his energy, commitment and focus was inspirational – as was his sense of humour and his genuine concern for the welfare of his staff.

The B+V AMECON team were awarded the contract in August 1989, with HMAS Anzac launched a breathtakingly fast four years later – in no small part due to the contribution of Bernie. After the success of the Anzac frigate contract he went on to help the winners of the Hydrographic Ship tender and then the Coastal Minehunters – a truly remarkable track record.

He is greatly missed.

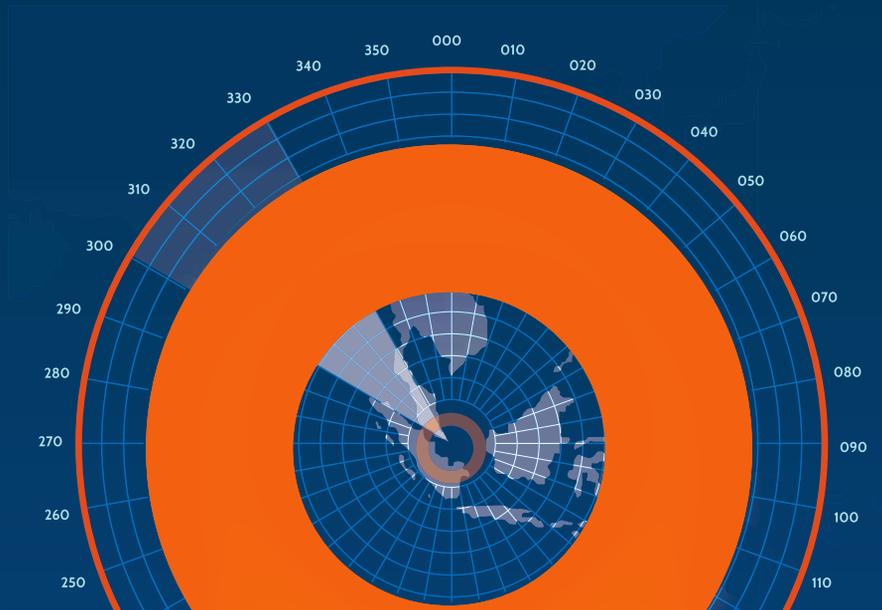


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No. 37 Squadron C-130J Hercules A97-448 and A97-467 on the RAAF Base Richmond flightline. Both aircraft have been fitted with Ka-Band Satellite Communications antennas.



ANDREW MCLAUGHLIN // SYDNEY

US APPROVES SALE OF NEW C-130JS TO AUSTRALIA

The US State Department has approved the sale of 24 Lockheed Martin C-130J-30 Hercules medium air mobility transport aircraft to Australia.

The approval was published in a Defense Security Cooperation Agency (DSCA) notification on 2 November, and came just a day after the Commonwealth revealed it had selected the C-130J for its Project AIR 7404 Phase 1 requirement.

The DSCA notification estimates the sale of the 24 aircraft will be US\$6.35bn (A\$10bn), which is an eye-watering amount considering the RAAF is already an established operator of the aircraft. Included in the sale appears to be a highly-spec'd list of capabilities, including 60 GPS/INS navigations systems, a comprehensive

self-defence package comprising AN/ALQ-251 Radio Frequency Countermeasure (RFCM) systems, AN/AAQ 24(V)N LAIRCM Infrared Missile Warning Sensors (MWS), AN/ALE-47 Countermeasures Dispensing Systems (CMDS), AN/ALR-56 Radar Warning Receivers (RWR), and AN/AAR 47 missile warning systems.

Also included is a sophisticated communications suite including Multifunctional Information Distribution System Joint Tactical Radio System (MIDS JTRS), KYV-5M communication security modules, AN/ARC-190 High Frequency (HF) radios, AN/ARC-210

radios, AN/ARN-153 tactical airborne navigation (TACAN) systems, AN/ARN-147 receivers, AN/ARN-149(V) automatic direction finders, AN/APX-119 Identification Friend or Foe (IFF) transponders, and AN/KIV-77 IFF cryptographic appliques.

The sale also includes integrated L3Harris MX-20HD electro optical/infrared targeting systems, a capability the RAAF has been experimenting with in recent years by fitting its current C-130Js with Litening AT EO/IR pods formerly carried by F/A-18A/B classic Hornets.

But even with all of these add-ons plus



Royal Australian Air Force C-130J Hercules aircraft from No. 37 Squadron conduct formation flying training in the lead up to the 75th Anniversary of the establishment of the Squadron. Photo SGT Christopher Dickson

the usual training, support, ground support equipment, and manuals etc, it is unlikely they add up to more than A\$400 million per aircraft, so it would not be unreasonable to wonder if additional enhancements may also be included but are either yet to be defined or have been intentionally omitted from the notification.

The 1 November announcement by Defence was short on detail, only saying the C-130J was chosen after other transport aircraft were considered, including the Airbus A400M, the Embraer C-390, and the Kawasaki C-2.

“Defence has approached a number of aircraft manufacturers and received information on all available medium air mobility options,” the release reads. “The relative merits of each aircraft type have been assessed against Australia’s capability requirements.

“Defence seeks a low risk, certified in all roles, proven, mature and affordable replacement aircraft that meets Australia’s air mobility needs,” it added. “Project principles have incorporated lessons learned from previous major Defence acquisitions as well as the in-service experience with the current C-130J fleet.

“Defence has identified that the new C-130J aircraft represents the only option that meets all of Australia’s capability requirements and assures Defence’s medium air mobility capability without introducing substantial cost, schedule and capability risk.”

Defence sources say the first 12 of the new aircraft are scheduled to be delivered in the

2027-28 timeframe which is likely to be towards the end of currently planned C-130J production. The same sources also indicated that previous plans for the possible acquisition of about six KC-130J tankers as part of the deal have been shelved.

Despite reports stating the new aircraft may



Royal Australian Air Force C-130J Hercules aircraft from No. 37 Squadron conduct formation flying training in the lead up to the 75th Anniversary of the establishment of the Squadron. Photo SGT Christopher Dickson

also replace the RAAF’s C-27J Spartan Battlefield Airlifter fleet, it appears these aircraft may now be retained following a 27 October release stating they will receive a \$70 million avionics upgrade. This may allow the aircraft to resume its planned Battlefield Airlifter role after being relegated to HADR and Pacific Partnership missions in 2021.

To be overseen by C-27J OEM Leonardo, the work will see the aircraft’s cryptographic radio upgraded, and is scheduled to be undertaken by capability steward Northrop Grumman and 35SQN personnel during planned maintenance periods from 2023 to 2026.

“Operated by No 35 Squadron, the C-27J Spartan fleet provides essential transportation and aerial delivery of passengers, troops and cargo, support to search and rescue missions, and aeromedical evacuation in our region,” Head of Aerospace Systems Division, AVM Leon Phillips said in a statement. “Upgrading the function of the C-27J platform will ensure ongoing availability of secure communications, including interoperability with key strategic partners and intelligence networks, and increased overall safety for our Australian Defence Force personnel.”

A final decision on the final number of C-130Js and their acquisition profile is expected to be made as part of the wide-ranging Defence Strategic Review which is due to report in early 2023.

RAAF BBJ (Defence photo)



BEN FELTON // CANBERRA

DEFENCE QUIETLY REPLACING VIP JETS

According to budget documents, the Royal Australian Air Force (RAAF) is preparing to replace its fleet of 737 Boeing Business Jet (BBJ) aircraft after almost 20 years of active service. The two 737 BBJs are operated by No. 34 Squadron, based at Defence Establishment Fairbairn in the ACT, which also flies three smaller Dassault Falcon 7Xs in support of special purpose flights.

The two BBJs were originally leased from Qantas Defence Services (QDS) back in 2002, however, with the purchase of QDS by Northrop Grumman Australia in 2013, Northrop Grumman took over the contract. In 2019, Northrop Grumman Australia was awarded a follow-on sole-source \$84 million contract to provide through-life support to the entirety of the Special Purpose Aircraft (SPA) fleet through to 2024, with options to extend support until 2037.

The BBJs operated by No.34 Squadron are a hybrid of the 737-700 and 737-800, crewed by up to six RAAF personnel. To facilitate the duties of government, they're also outfitted with secure communication systems and conference facilities.

Defence's intent to replace the 737 BBJ fleet with newer aircraft was first flagged in

an incoming government brief, released under Freedom of Information laws. The document lists the replacement with a new 737 platform as an 'approved enhancement' to the RAAFs air mobility fleet. However, unlike with other enhancements outlined in the document, it fails to disclose even a speculative price range.

It's also not clear if the BBJs are being replaced with newer 737-700 derived BBJs or a 737 MAX-based platform. The incoming government brief simply states that the aircraft will be replaced by a 'leased 737 BBJ platform'.

ADPR reached out to Defence to answer these questions and more, however, they ignored repeated inquiries over a series of weeks. ADPR also reached out to Northrop Grumman Australia, who did not respond to questions.

Absent an explanation from Defence, the Defence Portfolio Budget Statement (PBS) offers some clues as to why the BBJs are being replaced. According to the document, due to the introduction into service of new aircraft, the BBJs annual flight hours will grow to 1,600 hours across the forward estimates, up from 1,200 at present.

The BBJs have also been involved in several high-profile available issues, including in 2020 when one carrying then Prime Minister Scott Morrison broke down in Cairns, forcing a national cabinet meeting to be postponed. Taken together, this suggests that newer airframes are required to deliver the special purpose flight hours sought by government, and that simply refurbishing the aircraft is not a viable alternative.

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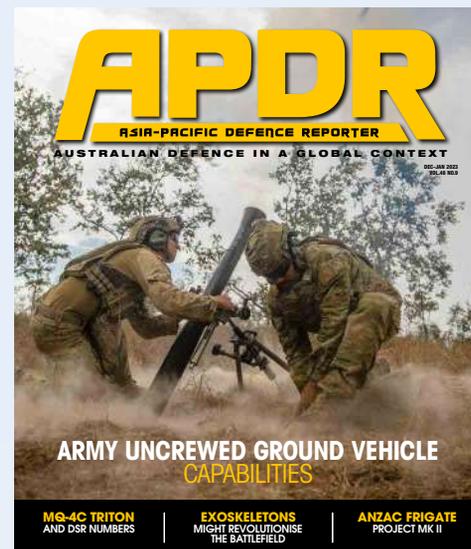
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NEWS FROM ACROSS THE TASMAN

FIRST RNZAF P-8A POSEIDON DUE TO ARRIVE BEFORE CHRISTMAS

An NZDF spokesperson confirmed to APDR that: "The first P-8A Poseidon will be arriving in NZ during December 2022. All four will be delivered by mid-2023."

The NZ Government announced in July 2018 that they had contracted to purchase four Boeing P-8A Poseidon maritime patrol aircraft. These will replace the six RNZAF P-3K2s, which have been upgraded several times since their introduction into the Air Force's service in the mid-1960s.

Roles planned for the new P-8A Poseidons include meeting commitments to South Pacific countries to monitor and respond to events in the region. The Poseidons will participate in international task groups, environmental monitoring, search and rescue, humanitarian assistance and disaster relief, as well as protection of the Southern Ocean.

The aircraft will also provide service to other New Zealand government departments including the Ministry for Primary Industries, New Zealand Customs Service, the National Emergency Management Agency, The Rescue Coordination Centre and the Ministry of Foreign Affairs and Trade.

They will operate from RNZAF Base Ohakea, which is located in New Zealand's lower North Island, approximately 130 km north of the nation's capital, Wellington.

In May 2022, a 500-tonne roof was lifted into place 33 metres above the ground at the base, a very visual sign of progress being made on the \$250 million infrastructure build to support the Poseidons. This has now been completed and is ready to receive its first aircraft.

CREW TRAINING

The NZDF spokesperson told APDR that: "The RNZAF has three qualified P-8A crews that completed their training in the US and will return to New Zealand shortly. Two additional RNZAF crews will soon travel to the US to train. The pilots will fly an NZDF P-8A for the first time in January 2023.

"The RNZAF crews are fully qualified to train additional RNZAF aircrew, and will supplement the training the crews received in the US. Pilots will be required to complete simulator training every three months."

The RAAF have assisted the RNZAF with the training of personnel. With the RAAF already operating the P-8A, the RNZAF has been keen, and grateful, to learn from their experiences. Maintenance personnel have undertaken training in Australia.

TAIL NUMBERS FOR THE NEW AIRCRAFT

APDR was very interested to see a video of the first RNZAF Poseidon emerging from the Boeing paint shop complete with its tail number, NZ4801 – 04. This led the author to enquire how these numbers are allocated.

The response was:

"All our aircraft have a unique serial number that follows New Zealand Defence Force convention. An important step in the construction of our new P-8A fleet was allocating the tail numbers, which will have the numbers NZ4801 – 04.

Broken down this means:

- NZ – the prefix for NZDF
- 4 – denotes the aircraft's role of maritime, our current P-3K2 fleet uses a 4 in the same way
- 8 – this denotes the aircraft type in this case 8 was available and made sense to use it given it is a P-8A fleet
- 01-04 – these final two numbers are the sequential tail numbers."

P-3K2 ORIONS RELEASE FROM ACTIVE SERVICE

P-3K2 Orion aircraft have given sterling service for nearly 60 years. As yet, no date has been set when the last one will be retired from RNZAF service, as they have all been maintained in excellent condition.

The NZDF will seek to retain one representative P-3K2 airframe for historical preservation and display at the Air Force Museum of New Zealand in Christchurch. The NZDF is in current negotiations for the sale of the remaining five P-3K2 airframes to a commercial US entity – noting any sale remains subject to final US and NZ government approvals.

BOEING TO PROVIDE SUSTAINMENT SERVICES FOR NEW ZEALAND'S P-8A FLEET

On 26 October this year Boeing announced that it had bolstered its regional sustainment capability

and expanded its footprint in New Zealand with the signing of a Head Agreement with the New Zealand Defence Force to support its fleet of P-8A Poseidon maritime patrol aircraft.

Executed by Boeing Defence Australia vice president and managing director, Scott Carpendale and the New Zealand Chief of Defence Force, Air Marshal Kevin Short, the first contract under the agreement is for sustainment services for an initial six-year period.

"The initial contract comprises engineering and supply chain services," said Carpendale. "Subject to performance, it will extend through the life of the fleet in rolling three-year extensions."

Rob Whight, Integrated Project Team Leader for the New Zealand Ministry of Defence added that Boeing Defence Australia brought proven sustainment capability for the P-8A Poseidon platform and opportunity for knowledge transfer to the New Zealand Defence Force.

"The partnership is key to the New Zealand Defence Force's sustainment strategy and they are looking forward to Boeing's contribution over the life of type," said Whight.

The contract comes on the back of Boeing Defence Australia's recent award for P-8A deeper maintenance for the Royal Australian Air Force, with Australia becoming only the second country outside of the United States to undertake the complex and specialised sustainment services.

To support the New Zealand contract, Boeing has established a new business entity, Boeing New Zealand Limited, which will employ a local team backed by the strength of Boeing Australia and our international P-8 program teams.

"Our long-term objective is to expand P-8A support in New Zealand in response to the emerging needs of our customer, while pursuing other campaigns and capitalising on synergies between Australian and New Zealand programs," said Carpendale.

"The Head Agreement acknowledges the importance of the relationship between the New Zealand Defence Force and Boeing in support of the platform, and provides a framework for future growth."

The initial sustainment contract commenced in October 2022 and runs to September 2028.

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