AIR FORCE

AIR AND SPACE POWER CONFERENCE

22-23 March 2022

Resilience and Innovation in Air and Space

PROCEEDINGS

AIR AND SPACE POWER CENTRE

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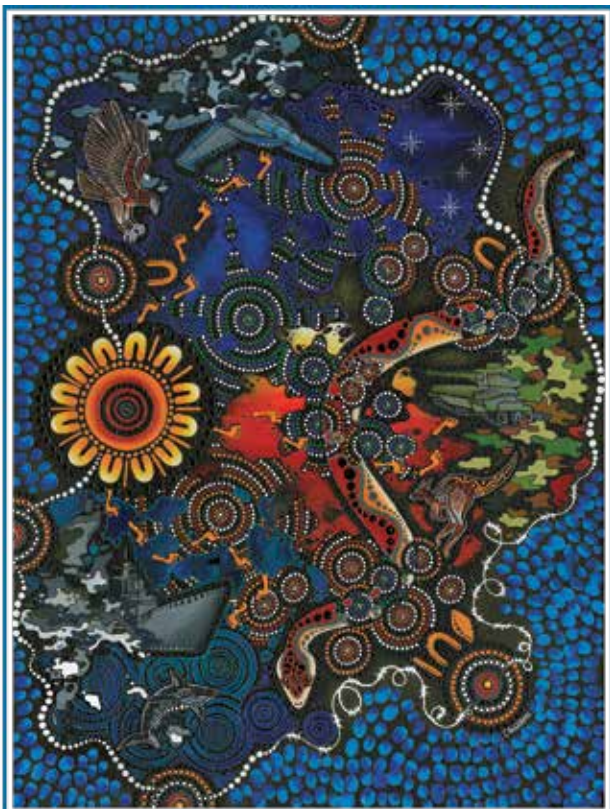
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Acknowledgment of Country

Defence acknowledges the traditional custodians of the lands, air and seas in which we live, work and train. We pay our respects to their elders, past, present and emerging. We also pay our respects to the Aboriginal and Torres Strait Islander men and women who have contributed to the defence of Australia in times of peace and war.

Cultural Disclaimer

Aboriginal and Torres Strait Islander people are advised this manual may contain images or content referring to deceased persons. It may also contain words or descriptions that may be deemed culturally insensitive. The term Australia's First Peoples is used throughout this manual to refer to Aboriginal and Torres Strait Islander peoples.

Opening Address – Resilience and innovation in air and space
Air and Space Power Manual launch
Closing Address

Air Marshal Mel Hupfeld, Chief of Air Force

The Royal Australian Air Force launches into its second century with a remit to lead the air and space domains in a dynamic strategic environment. Innovation and resilience will be critical to building and maintaining the air and space power needed to support Australia's Defence mission. Air Marshal Hupfeld will open the conference with an emphasis on some of the key challenges and opportunities facing Air Force as it navigates the future.

Regional strategic environment and the need for resilience and innovation in the sovereign agency of small and medium powers

Mr Bilahari Kausikan, Chairman, Middle East Institute, National University of Singapore

The Indo-Pacific is an environment of strategic competition, with technological and military drivers further accelerating change. Mr Kausikan will examine key issues affecting the regional and geostrategic environment, including risks to regional stability, the role of major powers, opportunities for small and middle powers to exercise sovereign agency, and the role of resilience and innovation.

Introduction to a national resilience and innovation framework

Air Vice Marshal John Blackburn (Retired)

Will introduce and moderate the panel discussion on Resilience and Innovation in Air and Space.

Towards National and Regional Resilience

Dr Carl Gibson, Executive Director Risk, Resilience, and Transformation at Executive Impact

Resilience has emerged as a critical factor in the way that Australia tackles natural disasters, pandemics and supply chain issues. Our complex strategic environment also demands national and regional resilience across an array of critical infrastructure and capabilities, such as information and communications technology, and energy supply. Delivering air and space power requires a resilient Defence workforce, infrastructure and enterprise. Dr Gibson will explore the evolving concept of resilience and new ways of thinking about national resilience, including the Margin of Manoeuvre concept.

The nexus between resilience and innovation in the fourth industrial revolution

Professor Tanya Monro, Chief Defence Scientist, Defence Science & Technology Group

The ADF will be increasingly self-reliant and able to operate independently in an increasingly contested strategic environment. This requires leading-edge national innovation, and a strong Australian defence industry base. Professor Monro will discuss the importance of technical innovation to the air and space environment, the impact of digital transformation, automation and 'the internet of things', and how technical innovation can enhance resilience and deliver military advantage.

Air command perspective on the future operating environment – trends and challenges

Air Vice-Marshal Joe Iervasi, Air Commander Australia

Defence's role is to shape Australia's strategic environment, deter actions against Australia's interests, and to respond with credible military force when required. Translating these strategic objectives into operational effects in and increasingly challenging environment requires creativity, flexibility and effort. AVM Iervasi will provide an operational perspective on the trends and challenges of the future operating environment, including 'exquisite' capability versus low-cost/high availability, multi-domain interoperability, and lessons learned from recent conflicts.

Regional perspective on the future operating environment – trends and challenges

Air Vice-Marshal Andrew Clark, Chief of Air Force, Royal New Zealand Air Force

New Zealand plays a significant role in supporting stability and security in the South West Pacific. The relatively small forces and communities of that region fce serious security issues, including climate change, internal disputes and foreign interference – all played out over vast geographic distances. Air Vice-Marshal Clark will discuss trends, challenges and opportunities in the future operating environment, and explore how innovation and resilience can deliver effective capability for a small force, focusing on the South West Pacific.

International perspective on the future operating environment – trends and challenges

Lieutenant General Jacob Luyt, Commander, Royal Netherlands Air Force

Global order, cooperation and security is under strain. While the Australian Defence Force's priority is Australia and its region, Australia will continue to play an important role as a regional and global leader, and actively engage to enhance global security. Lieutenant General Luyt will provide an international perspectives on the challenges and opportunities of the future operating environment, including innovation and resilience within NATO and lessons learned from recent events, with a particular focus on the ongoing conflict in Ukraine.

Industry perspective on the future operating environment – trends and challenges

Mr Hugh Webster, CTO Boeing Australia

Defence industry is an enabler and a true partner in the Defence mission. It is critical to providing the capability needed to deal with the strategic environment, and underpins the Australian Defence Force's aspiration to operate independently and assure self-reliance. Mr Webster will provide a Defence Industry perspective on the future operating environment, including the likely shape, size and character of Defence Industry, how emerging technologies might shape the operating environment, and how innovation can improve getting capability into service.

Keynote Address: Reflections on establishing the US Space Force

General John 'Jay' Raymond, Chief of Space Operations

Reflections on establishing US Space Force, the importance of space to all operations, and the innovative approaches required to achieve sustainable capability outcomes.

Vice Admiral Michael Noonan

Lieutenant General Rick Burr

Rear Admiral Ian Murray

Panel Discussion: Air and Space Power as Part of an Integrated Joint Force

Panel Members

Chief of Navy, Chief of Army, Chief of Air Force and Chief Joint Capabilities discuss what the new Air Power Manual and New Space Power Manual mean to their services and Australia's strategic focus.

Moderated by Mr Michael Shoebridge, Australian Strategic Policy Institute

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Opening Address – Resilience and innovation in air and space

Air Marshal Mel Hupfeld,
Chief of Air Force

This is Ngunnawal Country. Today, we meet on Ngunnawal Country. [Acknowledgement of Country given in Ngunnawal Language]

I acknowledge the Ngunnawal people, Traditional Custodians of the land on which we meet today. I pay my respects to their Elders past, present and emerging. I extend that respect to Aboriginal and Torres Strait Islander peoples who may be present and to the custodians of the land on which our many virtual participants are located. I thank them for the care they have taken of this land for many thousands of years and for teaching us all, as modern Australians, that if we take care of and protect this land, it will, in turn, care and provide for us and we will prosper.

I am very pleased to welcome many of our friends from around the world to meet with us here on Ngunnawal land for this conference, after a long period where such a meeting has been impossible due to the ongoing global COVID-19 pandemic.

I especially acknowledge the attendance of the Honourable Peter Dutton MP, Minister for Defence.

The Air and Space Chiefs from Bangladesh, Cambodia, Canada, Germany, Indonesia, Jordan, Maldives, Mongolia, Netherlands, New Zealand, Papua New Guinea, Philippines, Sri Lanka, United Kingdom, United Nations and from the United States.

Joining us digitally, the Air and Space Chiefs from Chile, Japan, Korea, Kuwait and Norway. Delegations representing Air and Space Chiefs from Bahrain, France, Italy, New Caledonia, Pakistan, Qatar, Saudi Arabia, Singapore and Thailand.

Senior Enlisted leaders from Canada, Maldives, New Zealand, Philippines, Sri Lanka, United Kingdom and the United States. Industry, academia and government leaders and the many young creative leaders in the audience joining us digitally.

I would like to acknowledge all who have been affected during this challenging time; I know the entire world has been directly impacted. I also acknowledge that there are global challenges beyond just the ongoing pandemic in our world as we gather here today.

Our thoughts are with all victims of war and that the purpose of this conference is to further the opportunity for stability and cooperation such that we will reduce the span and impact of future conflict.

It is a powerful signal of strength and solidarity that all of us here today have taken this opportunity to reconnect and reaffirm our close bonds that have proved strong enough to endure the pandemic and I believe to be strong enough to endure any crisis. I thank you all for your efforts to join with us here today.

I also acknowledge that there are so many more of our friends who wished to be here with us in person, but unfortunately, cannot be due to the ongoing challenges of the pandemic and other crises that demand focused attention.

There are very many with us here today virtually – I certainly expect a large percentage of the aviators to be tuned in; I know they have many competing priorities, but I can assure and reinforce to them that the commitment of this time to engage with our discussions over the next two days is worth their time and of tangible benefit to their much-valued service.

Many more will no doubt check in with proceedings when able over the coming days, weeks and months, as our conversations will be available to view and revisit online at any time in the future through our Air and Space Power Centre's website, which is open to all in our increasingly networked world.

The ability to enable such connection over distance and time zones has been one aspect that the COVID-19 pandemic

has certainly greatly enhanced; crises throughout history have always fostered great resilience, innovation and adaptation in society – another marker of our collective strength and, in part, the theme of this conference.

An Air and Space Power Conference of this magnitude, especially in these challenging times, could not go ahead without the extraordinary efforts of a great many dedicated individuals who can sometimes go unrecognised – so I will acknowledge them upfront. To the staff of the Air and Space Power Centre, our Air Force International Engagements staff, the Air Force Events team, the staff of the National Convention Centre and all those who have assisted in staging this conference – thank you for your collective efforts to bring us together for the next couple of days, both in person and virtually. Please join me in acknowledging these efforts.

I would also like to thank the principal sponsor of this conference, Boeing Defence Australia and our major sponsors, L3 Harris Integrated Mission Systems Australia, Lockheed Martin Australia and Rolls Royce Australia. Without your support, we could not have staged an event of this magnitude.

These efforts and the support of our sponsors have provided a compelling reason for many of our most significant stakeholders and partners to commit their valuable time to join us for this conference.

The impressive conference speakers will ignite and guide our thinking over the next two days. And that is what our gathering is all about – enhancing our thinking, both collectively and individually, about air and space power within the context of national and international objectives.

Before providing a brief overview of the program, I will first introduce the theme we have chosen for this conference. As signalled earlier, the theme is resilience and innovation in air and space. Now, this has raised some questions, which we hoped it would. Why focus on resilience? What even is it, and why is it relevant to air and space power?

One definition of resilience has come to describe the capacity of organisations or systems to endure and survive in the face of new threats and thus the ability of organisations and citizens to mobilise to adapt to new global and transcending threats.

And the term 'innovation' seems to pop up everywhere these days, almost as widely used as the term 'strategy' – so what is innovation, and why is it relevant to air and space power?

We may not provide all the answers to these questions for all of you as we progress through the program; in fact, we will raise more questions than we provide possible answers for, and well, that is the point! So long as we challenge you to think about these themes and the related questions, then the core purpose of this conference will have been met.

That being said, here is our opening premise for you to consider over the next couple of days, and, we trust, well beyond.

In an increasingly dynamic and uncertain world, it is imperative that we enhance our resilient ability to generate timely and relevant air and space power that can effectively contribute to national and combined efforts to shape the strategic environment, deter actions against our collective interests and respond with credible military force when required.

To achieve and sustain this, we must have resilient capabilities and support systems combined with an inclusive enterprise that embraces innovation in pursuit of meaningful military advantage.

Now, there is a lot packed into that – I ask you all to unpack it as we work through the program – engage with it, challenge it and enhance it.

Here is a simple analogy to help explain the focus of our theme. It is fair to say that discussions on air and space power tend to focus on 'leading-edge' capabilities, often embodied by the latest generation of combat platforms, along with the many complex and networked capabilities required for them to be effective in modern high-end warfare.

Let's call this the 'tip of the spear' – a commonly used metaphor in Australia and many other nations – we sometimes even like to focus more narrowly on the 'sharp edge' of that spear tip. I am not saying such a focus is not valid; it is an extremely important aspect and always will be, especially when you consider the human–technology relationship that lies at the very heart of air and space power – but more on that in my presentation this afternoon.

The theme of this conference is designed to force us to step back and examine not just the tip of the spear, but the whole spear, without which the tip has limited use.

We need to widen our view well beyond the spear to how the spear is used. Is it to be thrown to create an effect over some distance? Or is the spear held close in a defensive posture?

Stepping even further back, it is essential to realise the true value of the spear lies in the person wielding it – their skill, their knowledge and their partnerships. This is what makes the spear useful. And their effectiveness is the product of the quality of their training, experience and their wellbeing.

But we are not done yet – we now get to the core focus for this conference – none of this analogy works unless there is someone able to make a quality spear – supported by a wider community with the collective knowledge on gathering and supplying the required amount of quality materials.

This community must also provide all the things necessary to ensure that the wielder of the spear is well trained and

as strong and healthy as is needed to wield the spear to good effect at the exact time it is needed, for as long as it is needed.

That is resilience, and it is founded on a community with common values striving for a common purpose. When the environment in which that community lives is dynamic, where threats and opportunities continually change, that is when innovation within their practices is required to maintain relevance and, ideally, gain advantages.

I will now overview the program, provide some thoughts and pose some further questions with the intent of sparking your imagination and curiosity as our speakers expand our thinking over the next couple of days.

We are privileged and grateful to have Mr Bilahari Kausikan with us to provide the opening keynote address and set the strategic framework for the conference. As a former Permanent Secretary at the Ministry of Foreign Affairs, as well as ambassador to the UN and Russia for Singapore, and an influential commentator on regional and political issues, he is well placed to ensure our thinking is elevated and focused to where it needs to be in this era of great power rivalry in the Indo-Pacific – and I am sure he will challenge our thinking and provoke rich discussion.

When I reflect on our current strategic environment, an address by the Australian Prime Minister, the Honourable Scott Morrison, in November 2020 resonated strongly with me. In that speech, the Prime Minister noted that since the signing of the Treaty of Westphalia in 1648, our global community had been building a society around the idea of individual, sovereign nation-states and a common understanding of international law.

The relative peace the world has recently enjoyed is a result of this construct enabling sovereign nations, working in concert, to create deeper habits of cooperation on economic, security and global environmental issues while exhibiting a natural preference for rules-based solutions.

Australia has participated in this framework since World War Two, both because it is in our best interests to do so and the right thing to do. You can rely on us to continue to participate in and further these principles of international law, cooperation and peace.

We in Defence are committed to serving Australia's national interest by advancing our prosperity – which is by design tied to the prosperity of all who prosper within an open and stable rules-based global order, along with the independence of our sovereign decision-making and the security, safety and freedom of our people. This is certainly the case within our immediate region and across the broader Indo-Pacific.

These fundamental priorities are bound by a common thread – each seeks to respond to the opportunities and uncertainties of a dynamic and contested world. Our regional focus is more important than ever and is underpinned by

strengthened engagement both regionally and globally with like-minded nations, many of whom are represented at this conference, both physically and virtually, and I again thank you for your efforts to be here.

After morning tea, AVM (retired) John Blackburn will introduce and moderate a plenary with Dr Carl Gibson, a leading Australian thinker on national resilience, and the Chief Defence Scientist, Professor Tanya Monro. They will collectively explore what national and regional resilience is and the role of innovation in supporting and sustaining it.

After lunch, the Air Commander Australia, AVM Iervasi, the Chief of RNZAF, AVM Clarke, the Commander of the Royal Netherlands Air Force, LTGEN Luyt, and the Chief Technology Officer from Boeing Australia, Mr Hugh Webster, will explore the most significant trends and challenges for the future operating environment.

When reflecting on the future operating environment and throughout the conference, I offer the following questions for you to ponder:

- What is the enduring relevance of the premise of war being a 'clash of wills' (with military options being but one aspect)?

- Can we still afford to strive for a 'balanced force', or do we need a more focused posture?

- What is the right balance between relatively low numbers of exquisite platforms versus a far greater mass of replaceable capabilities?

- What are the impacts of emerging technologies on Defence acquisition, innovation and transition to service?

- What is the right shape, size and composition for the Defence industry?

I will be back on stage for the final session today to launch the 7th edition of the Australian Air Power Manual and our first Space Power Manual, both of which have been designed to explore how air and space contribute to joint effects as part of the military instrument of national power, for the purpose of supporting national objectives.

Some key themes I will expand on will be the centrality of people and their air- and space-mindedness to achieving optimal air and space power contributions to joint effects.

I will emphasise at this point that throughout this conference, I will not only be addressing you as the Chief of Air Force but also as both the Air Domain Lead and the Space Domain Lead for Defence. This is an important distinction that I will expand on this afternoon.

I will be joined by the Chiefs of the Royal Australian Navy, Australian Regular Army and the Australian Defence Force's (ADF) Joint Capabilities Group, who will provide their perspective on generating and integrating air and space

power and the central importance of the multi-domain approach within the ADF.

On day two, we are privileged to host General John W. 'Jay' Raymond, the US Chief of Space Operations, who will offer his reflections on establishing the US Space Force, the importance of space to all operations and the innovative approaches required to achieve sustainable capability outcomes.

This will be followed by a plenary with the inaugural Australian Commander Defence Space Command, AVM Roberts, the head of the Australian Space Agency, Enrico Palermo, the CEO of the Space Industry Association of Australia, Mr James Brown, and the CEO of Gilmour Space Technologies, Mr Adam Gilmour, discussing the key national resilience and innovation challenge that is the generation of sovereign space capabilities.

Between morning and afternoon breaks tomorrow, I am proud and excited to present what we are calling the 'Innovation Expo', designed for you to have an interactive experience, at your leisure and discretion, be that in person or virtually.

The expo showcases cutting-edge research and innovation from Defence, research institutions, academia, start-ups and industry to build awareness of some of the extraordinary developments occurring in our midst and to provide, very importantly, the opportunity for you to connect with others. These connections are key to us being best positioned to seize emerging opportunities to gain military advantage in an increasingly dynamic world.

We will reconvene here in the Royal Theatre for the concluding session tomorrow to focus on the crucial question of how we can actually turn good ideas and innovations into real capabilities and thereby consistently renew the resilience and relevance of air and space power. Our Head of Air Force Capability, AVM Denney, will be joined by Michael Shoebridge from the Australian Strategic Policy Institute to explore where we need to focus and evolve, organisationally and culturally, to truly leverage the advantages of agile, innovative and potentially disruptive capabilities.

The closing keynote will be delivered by Dr Brendan Nelson, a very well known and highly respected leader across many vocations, including serving as Australia's Defence Minister between 2006 and 2007, Director of the Australian War Memorial, and the current President of Boeing Australia. Brendan will be presenting his perspectives on what we both agree are the two most important aspects to realising resilient outcomes through creativity and innovation – regardless of the enterprise in question – and they are people and leadership.

I conclude by reiterating that this is not purely an Air Force event – we must recognise that to provide optimal contributions in support of national objectives, air and space power must be applied in concert with all other aspects of military power. We must recognise that military power is part of a whole-of-nation endeavour, which can only attain and maintain the pinnacle of resilience and relevance in our dynamic world through meaningful partnerships with industry, academia and like-minded partners regionally and globally.

Thank you.

Conference Opening Address

Minister Dutton
Minister for Defence

Good morning, ladies and gentlemen.

I would like to thank the Royal Australian Air Force and the Department of Defence for hosting this event – especially the Chief of the Royal Australian Air Force, Air Marshal Mel Hupfeld.

In particular, I would like to welcome the many distinguished guests in attendance today, including the more than 150 international delegates.

There are too many to name individually, but among this eminent cohort are Air and Space Force Chiefs or their representatives from countries around the globe. On behalf of the Australian Government, thank you for taking the time and making the effort to travel to Australia.

Your attendance speaks to the deep and abiding defence relationships that have been forged between your countries and Australia – between your air forces and the Royal Australian Air Force.

All of us are watching the terrible conflict unfolding in Ukraine at the hands of a despot hell-bent on reinstating Russia's imperial reach and spheres of influence.

Here, in the Indo-Pacific, many nations have been subjected to different forms of Chinese Government coercion over a sustained period. And we are witnessing China's rapid militarisation – the largest of its kind in peacetime and modern times – a build-up unaccompanied by transparency or strategic reassurance for concerned nations in the region and beyond.

The times in which we live reinforce the enduring importance of hard power – both in defence of a nation and to deter aggression – and the absolute necessity of like-minded nations working even more closely together to preserve the peace and stability that has and will continue to push humanity forward.

As we know, technological developments continue to change the character of warfare, particularly in the air and space domains. We have seen the increasing use of remotely piloted and uncrewed platforms – which can be used on

their own, teamed with traditional manned capabilities for force multiplier effects or in a swarm capacity.

We are also seeing the growing importance of hypersonics and spaced-based satellite communications. Both Russia and China are already developing hypersonic missiles that can travel at more than 6,000 km per hour.

Together with like-minded partners and the United Nations, Australia has long championed the responsible and peaceful use of outer space in accordance with international norms.

But space is becoming more congested and is already contested – particularly as the boundaries between competition and conflict become increasingly blurred through grey-zone activities. Tellingly, more than 7,500 satellites orbit the Earth, with thousands more being launched every year.

While space is primarily a civil domain – to support navigation, communication networks, financial systems, scientific enterprises, weather forecasting and disaster response – it will undoubtedly become a domain that takes on greater military significance in this century: a domain that is now an operational theatre that provides space-based communication, intelligence and navigation to the Joint Force.

We know that some countries are developing capabilities to threaten or degrade space networks, to target satellites and to destroy space systems. Countries that see space as a territory for their taking, rather than one to be shared.

In November last year, as part of an anti-satellite missile test, Russia destroyed its own redundant Cosmos 1408, which left behind a cloud of more than 1,500 pieces of lethal debris that will take decades to clear.

For any nation, losing access to space would have significant civil and military consequences. Thus, all nations have an interest in assuring their access to space. It is a domain that must be used to deter aggression rather than become a new realm for conflict.

So, friends, to that end, it is my great pleasure today to officially announce the stand-up of Australia's Defence Space Command.

I want to congratulate the newly appointed head of that command, Air Vice-Marshal Cath Roberts. Australia's Defence Space Command will initially be modest compared to those similar, well-established functions that already exist among some of our allies. But make no mistake, we are forward-looking. It is a necessary endeavour with a view to protecting our national interests and our need for a Space Force in the future.

Defence Space Command comprises personnel from our three services, defence public servants and industry contractors. It works in close collaboration with the Australian Space Agency, industry partners and our research and scientific institutions.

Importantly, Defence Space Command is Australia's contribution towards the larger, collective effort of like-minded countries to ensure a safe, stable and secure space domain. By developing our sovereign space capabilities, we will not only become more self-reliant but also be a better ally and partner through the combined effects of our capabilities.

Australia's aim will be to invest in new military space capabilities to counter threats, to assure our continued access to space-based intelligence, surveillance and reconnaissance and to uphold the free use of space. Guiding the efforts and priorities of Australia's Defence Space Command is the Defence Space Strategy – which I am pleased to release today.

Importantly, Australia and the United States are strengthening our alliance to support our mutual objectives in the space domain.

The Australian Department of Defence and the US National Reconnaissance Office have committed to a broad range of cooperative satellite activities that will expand Australia's space knowledge and capabilities.

Our partnership will also contribute to the US National Reconnaissance Office's pursuit of a more capable, integrated and resilient space architecture to support global coverage in a wide range of intelligence mission requirements.

Noting the dual focus of this conference, I will now turn to discuss some Air Force activities, including those undertaken in conjunction with our allies and partners.

Many of the countries represented at this conference have offered significant support to Ukraine. Australia is providing financial aid and military assistance to help Ukrainians defend themselves against their Russian aggressors.

I want to acknowledge the efforts of the men and women of the ADF. Our Air Force has successfully delivered military assistance on three separate flights of C-17 Globemaster transport aircraft. It is becoming clear that in invading Ukraine, President Putin has miscalculated. He has underestimated the resolve of the people of Ukraine and the response of nations around the world. We must remain determined in what we can do to support liberty against the odious forces of tyranny.

In the Indo-Pacific, Australia is contributing to collective efforts to maintain stability and deter aggression in this region. That is why we participate in exercises like Cope North in Guam – held in early February – along with the US Air Force and Japan Air Self-Defense Force. Among our Air Force contingent, 11 F-35s were involved in the exercise – the first time our Joint Strike Fighters have participated in a trilateral exercise.

In the broad, such exercises are crucial for allies and partners to enhance combat interoperability and participate in high-end training. Indeed, prior to Exercise Cope North, Australia accepted four new F-35s in Guam. Our Air Force is now operating 48 of a planned 72 Joint Strike Fighters.

And I look forward to hearing reports from this conference that discuss this important platform – a fifth-generation, multirole aircraft that is already or fast becoming the preferred fighter for many of our partners. Its capabilities are a critical part of Australia's air combat system that also includes the E-8A Wedgetail, EA-18G Growler and F/A-18F Super Hornet.

Another platform that I am sure will be a topic of discussion is the P-8A Poseidon patrol aircraft. Australia has taken delivery of 12 of these aircraft. Last month, the Australian Government – in conjunction with the South Australian Government – announced plans to establish a new deep maintenance facility adjacent to RAAF Base Edinburgh.

We envisage this facility developing into a regional hub to service not only P-8A Poseidons but also other aircraft like the E-7A Wedgetail Early Warning and Control Aircraft. Our P-8A Poseidon aircraft already support international efforts – like Operation Argos, where we help enforce UN Security Council sanctions against North Korea in response to that nation's weapons program.

Upon finishing a deployment for Operation Argos, a RAAF P-8A Poseidon will fly to Japan to be part of a trilateral intelligence, surveillance and reconnaissance mission with the US Air Force and Japanese Air Self-Defense Force.

The deep maintenance facility we will develop at Edinburgh is an example of how Australia is developing its sovereign capabilities, which will help us step up our contributions to such regional maritime activities.

Of course, our century-old Air Force would not be what it is today without its partnership with industry. One of our most promising joint ventures is that between RAAF and Boeing on the Airpower Teaming System – formerly known as the Loyal Wingman, but named officially yesterday, as the Chief pointed out earlier, the MQ-28A Ghost Bat.

This uncrewed aircraft, with a range of more than 3,700 km, is the first combat aircraft to be designed in Australia in more than half a century. It can fly solo missions or be

teamed with crewed capabilities for force multiplier effects. The Ghost Bat has already completed successful flight missions. Compared to crewed capabilities, autonomous capabilities can be produced in quantity, relatively quickly and inexpensively, with their loss or damage also being more tolerable.

This is our vision for the Ghost Bat – a platform that we anticipate will be of interest to many.

Ladies and gentlemen, distinguished guests, friends – I wish you well for discussions as part of this Air and Space Power Conference. Whether you are here representing one of our military partners, industry, Australian businesses or our research and academic institutions, it is events like these that can help translate intent into action.

Thank you.

Keynote Address: Regional strategic environment and the need for resilience and innovation in the sovereign agency of small and medium powers

Mr Bilahari Kausikan,

Chairman, Middle East Institute, National University of Singapore

Thank you. Thank you very much for inviting me back to speak to you for the second time. It seemed rather incautious of you to do so, but thank you. My theme is *China's Strategic Dilemmas* and I'll get straight to it. The war in Ukraine has thus far lasted a month. It began on 22 February. Today is 22 March. It is clear Mr Putin miscalculated very badly, and it is clear Mr Xi Jinping followed him with no easy exit. We will never know exactly what Mr Putin told Mr Xi before their meeting at the Beijing Olympics on the 4th of February and declared the partnership had no limits. That Mr Putin waited until the Olympics ended before invading Ukraine argues for a degree of foreknowledge on China's part. But Beijing, nevertheless, seemed taken aback by the scale of Russia's attack, by the resoluteness of the Ukrainian resistance and the tough and united Western response to the invasion. Mr Putin may well have misled Mr Xi because he misled himself.

The key strategic issue for Beijing is its competition with the US. The war in Ukraine has sharpened the line between them. I think Beijing wanted to stabilise relations with Europe as far as possible in order to focus on dealing with the US. But China's refusal to criticise Russian aggression complicates relations with Europe and will continue to do so as long as Russia does not withdraw from Ukraine. China is putting on a brave face, but is in a serious dilemma. It is confronted with three mutually irreconcilable objectives.

First, China does not want to become collateral damage from sanctions directed at Russia. The Ukraine war has disrupted an already fragile global economy. China's growth was already slowing for a variety of reasons, and Beijing is grappling with complex internal economic issues. With the 20th Party Congress in the autumn, maintaining stability is China's watchword, and obviously, Ukraine is the antithesis of stability.

Secondly, China has always been neuralgic about preserving respect for sovereignty, territorial integrity and non-interference as key norms of international relations and the reasons for this can be summarised in three words: Tibet, Xinjiang, and Taiwan. The Russian invasion of Ukraine was a direct challenge to these norms.

Third, and most crucially, China wants to preserve its partnership with Russia. The Sino-Russia relationship was never as idyllic as Moscow and Beijing like to portray. But whatever difficulties China may face because of the invasion of Ukraine, China will not break with Russia. Beijing has no other partner anywhere in the world with Russia's strategic weight who shares China's distrust of the current global order. Which other country is prepared to go as far as Putin's Russia to work with China to create a less Western-orientated, multipolar order? And reclaiming what China believes its rightful place in such a world lies at the heart of Xi Jinping's *China Dream*.

Beijing has indicated that it is prepared to play a role in brokering a ceasefire or a settlement in Ukraine. A quick negotiated end to the fighting would be in China's interest. But are Beijing's calls for negotiation significant? Significant other than as a sign of China trying to adjust its position and limit the damage? Will China really use whatever leverage it may have impartially? Talks between Russia and Ukraine are difficult enough without another interlocutor who is not neutral.

Having failed to secure a swift victory, Putin must now secure a decisive victory. Putin's right to rule rests on the claim that he restored Russia's strength and the world's respect of Russia's strength. But the perception of Russia's strength and respect for its strength are among the casualties of

Putin's war in Ukraine. Now that he has been denied a quick victory and questions have been raised about the competence of Russia's military, Putin cannot afford to look weak or accept any compromise that leaves him vulnerable to looking weak. And only Mr Putin knows what *not looking weak* means in practice.

I am among those who think that the West mishandled relations with post-Soviet Russia during the 1990s. But that is now all moot. It is irrelevant. Not only does it not justify aggression, but that may no longer be the relevant issue. The botched Russian invasion has changed the stakes. What is now at hazard for Putin is his legitimacy. This is a much higher stake than NATO's further expansion or Ukraine's complicated relationship with Russia.

You all know that the President of Ukraine has made clear that the country will not seek NATO membership and is reportedly discussing neutralisation, but the ferocity of the Russian offensive continues unabated. What outcome in Ukraine would be acceptable to Putin, the West, and Ukraine? What does China mean when it says that Russia's legitimate security interests must be considered, and how far will China be prepared to push Putin to accept a compromise?

I do not know. And at present, I do not think anyone – China included – has clear answers to these questions either, or only events will bring clarity. But I doubt, very much doubt, that Beijing will be prepared to go so far as to fundamentally jeopardise its relations with Russia or to do anything that would undermine Putin's grip on power. Still, that said, despite their shared distrust of the current global order, China is far more integrated into it than Russia and has benefited more from it than Russia.

The *China Dream* is certainly revanchist and assertively so, but to call China *revisionist* or a *systematic competitor* is, to my mind, something of an overstatement. China has no strong incentive to kick over the table and seek radical revisions, at least not to the economic aspects of the existing order. Beijing may want to dominate the global system but not overthrow it.

Under its *Dual Circulation* approach announced in 2020, China aims to become more self-reliant in key technologies and depend more on domestic household consumption to drive growth. Sanctions against Russia will lead Beijing to try and accelerate its drive for self-reliance and internally driven growth. But all this is far easier said than done and will not show significant results for a long time, if ever.

As the name suggests, *Dual Circulation* has two aspects, and the other is over-reliance on overseas markets. China is Russia's most important economic partner, but the Russian economy is only about the size of the South Korean economy. The United States, Japan and the EU markets are far more important to China than Russia and will remain so for the foreseeable future. Being subject to sanctions of an unprecedented scope and with about half of its reserves

frozen, Russia has nowhere to go except China. Russia will almost certainly become even more dependent on China, but will this be a liability or an asset for Beijing?

The US and Europe are not going to cut China any slack in implementing sanctions against Russia. And China will certainly protect its own interests as, for example, in its decision to deny Russia spare parts. I doubt China is eager to throw good money after bad to support the rouble. Nevertheless, with the majority of China's one billion internet users still cheering Russia on in Ukraine, and despite the risks of non-compliance with Western sanctions, I also doubt that Beijing can entirely refuse to help Russia because to turn its back on Russia risks raising inconvenient questions among its own people about the Party's wisdom in placing *no limits* on China's relationship with Russia.

Such questions have already been asked by a few brave Chinese intellectuals. They certainly do not represent mainstream views and will be ruthlessly suppressed. But the implications for the Party and Mr Xi personally should such views seep into the beliefs of the wider public would be a serious concern. They must maintain some semblance of solidarity with Moscow, and for that to be credible, it must be tangible and not just words. On Russia, political and strategic considerations pull Beijing in different directions from economic considerations. And in a Party congress year, we should not assume economic considerations will prevail.

There is no easy way for China to reconcile its objectives. Beijing will have to walk a fine and precarious line, and that line has got even finer and more precarious now that the US has revealed that Russia asked China for military and economic assistance and warned that agreeing will have serious consequences for US – China relations. So, it is in a fix. But I think it is important to understand that China's Ukraine dilemmas come on the back of other foreign policy errors. The most prominent mistake was a premature abandonment of Deng Xioping's sage approach of *hiding strength and biding time*. China has become more assertive, if not downright aggressive, in pursuing its strategic interests in the East and South China Seas and in the Himalayas.

After the global financial crisis of 2008, Chinese leaders seem to have swallowed too much propaganda about their system being superior to that of the West in general and the US in particular, being in absolute terminal decline.

China's history and political culture have instilled in Chinese leaders the conviction that strong central authorities are central to good government. This perhaps leads them to underestimate the resolve and resilience of decentralised Western systems. Their underestimation of the West was no doubt reinforced by the chaotic Trump presidency and the bumbling response in the West to the COVID-19 pandemic.

Strength and ambitions, once revealed, cannot be easily concealed again. Trade and investment in glib talk about a *community of common destiny* cannot erase anxieties

about China. Nobody will ever shun China; it is an economic and geopolitical fact that cannot be ignored. But I am hard-pressed to think of any country, even some who are very dependent on China, that are without concerns about one aspect or another of the Chinese Government's behaviour.

The concerns are not all the same for every country and are not held with the same intensity by every country, but they exist and are reshaping the security architecture of the Indo-–Pacific. To some – I think a fairly large – extent, the Quad and AUKUS [the trilateral security pact between Australia, the United Kingdom and the United States announced on 15 September 2021] were as much a result of China's mistakes, as successes for US diplomacy.

Concern with the behaviour of the Chinese Government is driving some European countries to try to play some sort of security role in the Indo-Pacific. Russian aggression and Chinese reluctance to criticise Russian aggression have also catalysed some broader geopolitical trends that were largely tentative and inchoate before the invasion of Ukraine. It has revitalised the idea of 'the West', which after the Cold War was loosening and in some danger of entirely decomposing. Moreover, the idea of the West reconstituting itself is a robust idea.

Mr Putin has succeeded where successive post–Cold War US presidents have failed. He has convinced Europe to take its own defence seriously. Overnight, Germany doubled its defence budget and weaned itself from the taboo on arms transfers. Even the determinedly neutral Swiss joined sanctions. Of course, there are still unanswered questions about the EU's new found resolve, long-term energy security among them. But they are unlikely to defect Europe's new trajectory.

Equally importantly, Russian aggression and China's support for it, has dispelled a dangerous Western illusion about the nature of post-Cold War international relations. One of the most foolish statements I have ever heard from a Western leader was then Secretary of State John Kerry criticizing Russia's 2014 annexation of Crimea as 19th century behaviour in the 21st century.

There are many good reasons to criticise Russia's annexation of Crimea, but this particular criticism assumed – probably unconsciously – that your rival ought to share your values and if they did not do so, this was somehow unnatural. But why should they? If they shared your values, they would not be your rival in the first place. Fortunately, I have not heard any Western leader make such silly statements this time.

This is an important shift of intellectual framework because a similar cast of mind has bedeviled American and European relations with China. From 1972 to the end of the Cold War, US-China relations were primarily based on clinical geopolitical calculations. This was healthy because US-China cooperation was without illusions. But after the end of the Cold War, and in particular after China joined the WTO in 2001, the comforting but naive assumption that economic reform would inevitably lead to political reform increasingly began to contaminate Western approaches to China.

I do not think anyone was quite so deluded as to think that the Chinese system would become exactly like the West, but the expectation was that it would evolve in the same broad direction. The disillusionment after it became clear that this was not going to happen, played no small role in shifting US-China relations from a mode in which the primary theme was engagement to one where the primary theme is now rivalry and competition.

Assuming your rival shares your values or ought to share them, can only lead to unpleasant surprises. More generally, it would be prudent not to over-emphasize values in international relations. Framing strategic competition as between 'Democracy' and 'Authoritarianism' limits rather than expands support. Not everyone regards every aspect of Western-type democracy as universally attractive, nor is every aspect of Chinese authoritarianism universally abhorrent. Values are important but interests are even more important. They are certainly more stable.

China's misjudgments began towards the end of Hu Jintao's second term. Xi Jinping has doubled down on them. That these errors spanned the administrations of two very different leaders suggests that their root causes are systemic and not due to the folly or mistakes of any individual. It will not be easy for any Chinese leader, however powerful, to change course.

China is a communist country. Not any longer in its ideology, but certainly in its political structure. China is a Leninist state led by a Leninist-type vanguard party that legitimates its right to rule not by class-struggle, but by an ethno-nationalist historical narrative of humiliation, rejuvenation and the attainment of the China Dream. Positioning the China Dream as the rectification of China's humiliation at Western hands since the late 19th century, infuses the China Dream with strong elements of revanchism and entitlement. A prominent Chinese academic has even described China's rise as "granted by nature."

A Leninist vanguard party insists on control over every aspect of state and society; the Party's interests must always take priority over all other interests. This attitude is the root cause of the Chinese behaviours that many countries find concerning. Its effects are accentuated by the revanchism and sense of entitlement of the Party's legitimating narrative, as well as the traditional Chinese assumption of superiority that equates 'community' and 'order' with hierarchy with China at the apex. Little wonder that China's dreams are often nightmares to others.

An authoritarian state does have some advantages. It is better placed to set goals and pursue them relentlessly over the long-term. A Deng Xiaoping capable of taking a cold hard look at his life's work, decide it was at risk of failing, and radically change direction with minimal opposition, probably could not have succeeded in any Western democratic system.

But the ability to set and relentlessly pursue long-term goals is an advantage only if the goals are correct in the first place. Deng's decision to reform and open up was correct. Mao Zedong's Great Leap Forward and Cultural Revolution were enormous disasters, costing millions of lives. Indeed, it was the immensity of Mao's mistakes that enabled Deng to so radically change course.

Deng introduced the principle of collective leadership to ensure that the excesses of Maoist China would not be repeated. By discarding term limits and concentrating power around himself, Xi has reintroduced something akin to a neo-Maoist single point of failure into the Chinese system. There is good reason to wonder about the quality of information being fed upwards to decision makers.

China has insisted that the situations of Taiwan and Ukraine are not the same, and indeed they are different. Taiwan is a more important node in the global economy and more strategically important to the US and its allies in East Asia. I hope that the Chinese leadership carefully ponders why Putin so badly misjudged how easily Ukraine could be conquered and the international response to his attempt to do so.

China's strategic dilemmas are real. Still, we should not assume that they will necessarily make China change course. China has no good options. But precisely because it has no good options, Beijing might well conclude that American, and more generally, Western, hostility to its rise is so implacable, that it is a sunk cost and that no basic adjustment of policy is necessary because it will not make any difference to how the West regards China. International opprobrium of China's support for Russia's aggression is in any case, at best a secondary consideration. The primary consideration for China's leaders will be internal: can the Party admit to having made a mistake?

The coalescing of the West does not imply that a China that continues to tie itself to Russia will necessarily be isolated or can be 'contained' as the Soviet Union was contained. It has become common to describe US-China competition as 'a new Cold War'. This is an intellectually lazy trope that fundamentally misrepresents the nature of the competition.

The US and the Soviet Union led two different systems which were connected only at their margins. US-Soviet competition was over which system would prevail. The US and China are both vital components of one global system. Russia too is part of the same system, but a relatively minor part, except for energy. The US and China, and all other components of the global system, are connected by a web of supply-chains of a scope, of a density, and of a complexity, never before seen in history.

These supply-chains are what distinguish 21st century interdependence from earlier periods of interdependence. Disentangling them is no easy matter. Just as it is easier for China to talk about becoming more self-reliant than to do it, it is easier for the West to talk about diversifying supply-chains to become less dependent on China than to do it. The global web of supply-chains is unlikely to bifurcate across all sectors, although partial bifurcation has already occurred in some sectors and more bifurcation is likely in sectors that have national security implications. But complete across-the-board separation into two systems is highly improbable.

The US and China will continue to compete within this single global system. Competition *within* a single system is fundamentally different from competition *between* systems. Competition within a single system is about occupying a position that will enable you to benefit from interdependence, while mitigating your own vulnerabilities and exploiting your rival's vulnerabilities. It is about using interdependence as a tool of competition.

Competition within a system is *not* and cannot be about one system displacing another system. It cannot even be about any vital part of the system disrupting any other vital part of the system in any way that could fundamentally damage the entire system. In this kind of complex, non-binary competition, it is as impossible to 'contain' China as to contain yourself.

None of this means that the geopolitical and intellectual shifts catalyzed by the Russian invasion of Ukraine can be disregarded by China. Broad global geopolitical trends are moving in directions that Beijing will not find comforting. Ukraine has underscored the importance of regional balances and the vital role of US leadership in such regional balances.

Even if not every country was prepared to say so explicitly, anxieties about China had always made Asia more aware of this strategic reality than other regions. This strategic reality is now clear in Europe, and will eventually dawn on countries in the Middle East as well. No country may be without some reservations about the US, but nobody has any real strategic alternative because without the US, there is no regional balance to China or Russia or for that matter, Iran.

At the same time, the nature of US leadership is in the midst of a long-term redefinition. Russia is a dangerous adversary; China is a formidable competitor, but neither poses an existential threat to the US in the way the Soviet Union posed an existential threat. Competition within a single system cannot be existential because it takes place within a common framework; it is not about changing the framework. Whatever we may think of them, it would be absurd to harbor the same kinds of hopes or fears about the Chinese system or the Russian system as those who once hoped or feared that communism would replace capitalism. Without an existential threat, there is no reason why Americans should any longer bear any burden or pay any price to uphold international order.

This is the thread that links the Clinton administration through the Obama and Trump administrations to the Biden

administration. With the George W. Bush administration as an exception forced by 9/11, the chief priorities of all the other administrations were domestic. This is not the 'retreat' from the world or neo-isolationism that some have portrayed, but a recalibration of the terms of America's engagement with the world.

More than fifty years ago, as part of the process of disentangling itself from intervention in Vietnam, the 1969 Guam Doctrine heralded the US moving from direct intervention in Asia to being the off-shore balancer. The US has been remarkably consistent in the off-shore balancer role ever since. I believe a similar shift in the American strategic posture is underway in the Middle East as a response to mistakes in Iraq and Afghanistan. Sooner or later this change of posture will take place in Europe too, delayed but not diverted by the Russian invasion of Ukraine.

An off-shore balancer is not in retreat, but demands more of its allies, partners and friends in terms of sharing the burdens of upholding order. The Biden administration has engaged and consulted allies, partners and friends more than its predecessor. This is all to the good. But the US does not consult you merely for the pleasure of your company, but to ascertain what you are prepared to do with it to meet strategic and regional challenges. It is a more polite form of Trump's transactionalism.

As AUKUS has demonstrated, Biden is prepared to go to unprecedented lengths to provide tools to allies who are prepared to step up. The last time the US shared nuclear submarine propulsion technology with an ally was more than sixty years ago.

In Southeast Asia, ASEAN has not sufficiently internalized these new realities and the hard fact that while the US under Biden will still be polite to those not prepared to step up, it will not take them seriously either. That Thailand, a formal US ally, was bypassed twice in 2021 by Secretary of Defense Austin and Vice-President Harris ought to have been a salutary lesson for all ASEAN members.

ASEAN need not – indeed should not – do everything the US wants it to do anymore than it should do everything China wants. But unless ASEAN finds the strategic imagination and political will to define the parameters of what it is prepared to do and, equally important, what it is not prepared to do, with both the US and China, ASEAN will be marginalized. Just insisting on your 'centrality' does not make you 'central'. Nor are you really 'central' just because others politely call you 'central'. The US will place more emphasis on some of its bilateral relationships in Southeast Asia and it is already beginning to do so.

Finally, Ukraine has drawn attention to the nuclear dimension of regional balances. In a speech to the Munich Security Forum before the invasion of his country began, President Zelensky struck a tragically wistful note about Ukraine giving up the nuclear arsenal it inherited from the Soviet Union in

return for empty promises. He was right. Would Russia have invaded if Ukraine had a nuclear deterrent? It is too late for Ukraine, but the lesson would not have been lost on others.

In Japan, former Prime Minister Abe Shinzo has suggested that Japan should allow the US to station nuclear weapons on its territory as it does with some NATO members in Europe. Japan has in fact been quietly preparing for several decades – with American acquiescence if not complicity – for contingencies that may require it to acquire an independent nuclear deterrent. In South Korea polls show strong support for the reintroduction of American nuclear weapons on its territory and the desirability of South Korea acquiring an independent nuclear deterrent has been openly debated.

For Japan and South Korea the impetus was North Korea's development of nuclear and ICBM capabilities and China's modernization of its nuclear forces. As North Korea and China develop and improve their second-strike capabilities, questions will inevitably be asked about the credibility of America's extended deterrence, just as similar questions were asked in Europe many decades ago after the Soviet Union acquired nuclear weapons. Japan and South Korea will eventually reach the same conclusions as Britain and France, if they have not already done so.

I do not think Japan or South Korea are eager to become nuclear weapon states. Such a decision will be politically very painful and internally divisive. But however reluctantly, the inherent logic of their circumstances will inexorably lead them in that direction. The alternative is the loosening of their alliances with the US and eventual subordination to China. Such an outcome will entail so a fundamental a redefinition of Japanese and Korean national identities, that the nuclear option will be the less traumatic option.

I do not know how long it will take, but sooner or later, a six-way balance of mutually assured destruction between the US, China, Russia, the two Koreas and Japan will be established in East Asia. The process of getting from where we now are, to where I think we must eventually land, will be fraught with tensions and even danger. But the end result will be stabilizing for the region.

Independent nuclear deterrents will keep Japan and South Korea within the US alliance system. With India and Pakistan in the equation, a multipolar nuclear regional balance will freeze the existing configuration of the Indo-Pacific, preventing its domination by any single major power. A multipolar Indo-Pacific maximizes manoeuvre space for ASEAN and other small countries.

This is not the kind of multipolarity that China favours. Nuclear weapons are great equalizers. In so far as the China Dream is a dream of hierarchy with China at the apex, a multipolar nuclear balance will force Beijing to temper – *de facto* if not *de jure* – such ambitions. This will make for healthier relationships between China and its neighbours.

Introduction to a national resilience and innovation framework

Air Vice-Marshal John Blackburn (Retired)

Service Chiefs, distinguished guests, ladies and gentlemen and of course, aviators, we live in interesting times. During our session this morning, we will discuss resilience in both Australia's context and regionally and invasion. We have a few complex problems that we are dealing with today. Here we are, two years into this decade and it feels a lot more like 10. So, what are we seeing happening at the moment? The pandemic has exposed a global lack of resilience caused by a collective failure to assess and act on national risks and vulnerabilities, particularly in Western nations. We did not prepare. Go back to the start of the decade. Bushfires and then floods and what's been happening just now in Northern New South Wales and Queensland.

And here I am going to quote Air Chief Marshal Binskin, in his role as the Chair of the Bushfires and Floods Royal Commission. "Unprecedented is not an excuse to be unprepared. We need to be prepared for the future".

But wait, there's more. Now, we have the war in Ukraine, highlighting significant resilience issues and concerns and preparedness as well. If anyone thinks on the backend of COVID-19 things will get sorted, I have depressing news. Because the economic impacts of the pandemic have accelerated the problems in the global economy we are anticipating in the next decade where you think where debt has gone and the fragility of the global economy and add to that climate change, which is not linear, will accelerate – and now conflict.

The biggest risk we will face in this next decade is economic. A crisis has the risk of becoming a catastrophe, and we have to understand that and prepare for it. You cannot wait to react to some of these scenarios or risks that are approaching us.

So, what do we see in the news? Discussions about – again, another royal commission and their recommendation to boost resilience, we will put billions of dollars into International resilience. I love what the *Irish Times* have said: 'Resilience: Does anyone know what this actually means?' 'The Government hands down budget, focused on post-Covid resilience'. Look, dollars and budgets are critical,

but that's not going to build resilience by itself. It takes leadership it takes people. It takes so much more, it takes – in Australia – a bit of a cultural change. I did find something on Singapore, a Facebook site that I thought was quite interesting. When they were talking about this, there was a scam alert for a fake Resilience Budget Scam. Look at the date, March 2020. Who is more prepared than everybody else? The scammers. They moved in very quickly.

The other thing that happens in these sorts of crises is that everything is labelled resilience. I want to highlight the mining camp in the Northern Territory for foreign visitors. It is laid out for isolation, but someone with a sense of humour renamed it as the Natural Centre of Resilience. But one media outlet labelled it as the worst word or phrase for 2021. We have to be serious about resilience but do not overuse the term. On the positive side, there has been some fantastic work done in this country.

This is about the profiling of vulnerability; we cannot address resilience if we do not understand our risk and vulnerability and are honest about it.

In a 2018 study Profiling Australia's Vulnerability, co-led by Dr Mark Crosweller of CSIRO, they came up with a list of what makes us vulnerable. This is 2018. Have a look at what happened at the bushfires, what is happening in the floods, what is happening in the pandemic.

We understand our vulnerability is significant. But did we act on this and think about doing something? No, we did not. Other really good work is happening in the community today. The Australian Institute of Disaster Resilience is doing some fantastic work, networking across the country looking at it. In reaction to the bushfires, we now have the Australian Government agency – National Recovery and Resilience. One slight problem. All of this, including the terms of reference for the home affairs report, is about natural disasters.

Putin is not a natural disaster. He is an unnatural one. Therefore, we have to expand our thinking so that we do not just say natural disasters, bushfires and floods because

to my mind, that is not natural in any case. We have to look at the whole list of vulnerabilities we face as a nation. For the past two and a half years, I have been running a national resilience project, with about 250 people involved from all areas of society from healthcare, energy, industry, academia, sociologists and people looking at trust issues within society. We tried to answer three questions:

1. What is a resilient society?

2. Are we resilient enough?

3. Can we make ourselves more resilient?

I will come back with some more detail after our speakers this morning. We tried to look at the various parts of our society and ask, are we resilient? More importantly, how are these areas connected? We live in a complex world, and you cannot fix problems just by looking at individual pieces.

So, we produced reports on each of these issues, but the first thing was very obvious. It looks really nice when you have a jigsaw, but we do not work that way in Australia. There are overlaps between these areas; no coherent policies or strategies exist. With an industrial-age model, we have made it difficult to deal with some of these problems. We produced a report that integrated all the individual reports, and you can tell from the title of this what we think: 'Australia – A Complacent Nation. Our reactions are too little, too late, and too short-sighted'. We have to pay attention to where we are today.

The definition of resilience we started with for the project comes from the United Nations Office for Disaster Risk Reduction:

Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to transform and recovery from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structure and function.

Is a pretty good definition. It addresses many issues, it is not going back to business as usual, because that does not exist for any of us anymore. It was business as it was. As we work through the challenges we are facing, we are not going back. It is impossible. It is still not enough. Purely reacting to a crisis is not enough. We have to prepare and mobilise society ahead of time to stop a problem from becoming a crisis or a crisis from becoming a catastrophe.

The other point is that resilience is not just about us. During our project, we spent a fair bit of time talking with the New Zealand Government, industry and Defence. How do we think about resilience as a team? For example, we are working with New Zealand and looking at Pacific Island problems and challenges. How do we work together? We work with Indonesia. No point in looking after our resilience in isolation if our neighbours are not resilient – if our region is not resilient. That requires a rethink. I asked the New Zealand Government: what approach have you heard from the Australian Government on this? The answer was none. It is about preparedness and mobilisation. A language that is common within Defence but was almost absent in civil society prior to the pandemic. These are some pretty important things. I will come back and talk a little bit about what we found in these results and how RAAF Plan Jericho fundamentally influenced the study over the last two years.

Towards national and regional resilience

Dr Carl Gibson,

Executive Director Risk, Resilience and Transformation at Executive Impact

Resilience: a confused journey

Resilience has become an almost ubiquitous term across all sorts of organisations and across society in general. However, there is still a lack of understanding about what we actually mean by the term 'resilience'. The title of this presentation is a Biblical reference from 1 Corinthians: 'through a lens darkly', because that is how many of us look at resilience. When we look through this 'lens' we have a dim and obscure view, only seeing a small part of what resilience entails, and that view is different for different observers and for different contexts.

Getting agreement on what resilience means is highly problematic. National and international committees that develop standards are still arguing, after several decades, on meanings and definitions for resilience. Many experts in the field are unable to provide a single consistent framework, accepting multiple different resilience models, their validity depending on the context in which the models are being applied.

We can see this confusion in the myriad of different concepts being promoted in the many thousands of publications about resilience, and it is now playing out in real time in a wide variety of organisations. I recently examined a selection of job advertisements for resilience specialists, all present on a single internet recruitment site on the same day. These various employers, from both government and the private sectors, showed very different ideas about what resilience means, involving duties such as 'manage our risks', 'help to bounce back from challenges', 'deliver emergency services', 'develop privacy and security architecture', 'provide sustainability guidance', 'maintain the business continuity framework'. Resilience has even been interpreted as managing a quarantine facility for returning overseas travellers.

In the last few years, resilience has become *the* catchy label, used by politicians, advocacy groups, businesses, NGOs, and the public sector and applied to many different issues. It is not surprising that it is still difficult to get agreement on what we mean by the concept of resilience.

This paper will provide several different ideas, concepts, and constructs about resilience, to try and generate some different thinking and mental models so that we can look through our 'lens' a little more clearly when we consider resilience from a national and regional perspective. Applying this different appreciation of resilience then needs to be translated into a more specific meaning for defence, and for air and space power.

Part of the problem that we face is that resilience concept originated in domains very differently from where it is now being applied. Early concepts were developed in ecology (the ability of ecosystems to withstand disturbance without being changed), from engineering (to withstand forces without plastic deformation), and from psychology (adapting to and recovering from trauma). Since which time government, industry, NGOs, and communities have taken the term and modified the concept to suit their own context and needs. As the resilience concept has evolved over time, new ideas about resilience have surfaced and taken hold, others have been abandoned only to resurface and become accepted years later. However, unlike Darwinian evolution, the progression of resilience thinking has seen outdated ideas persist rather than being abandoned. This has been a significant contributor to the confusion because, rather than refining and rationalising these concepts, they have all being gathered up and then used selectively in support of particular arguments.
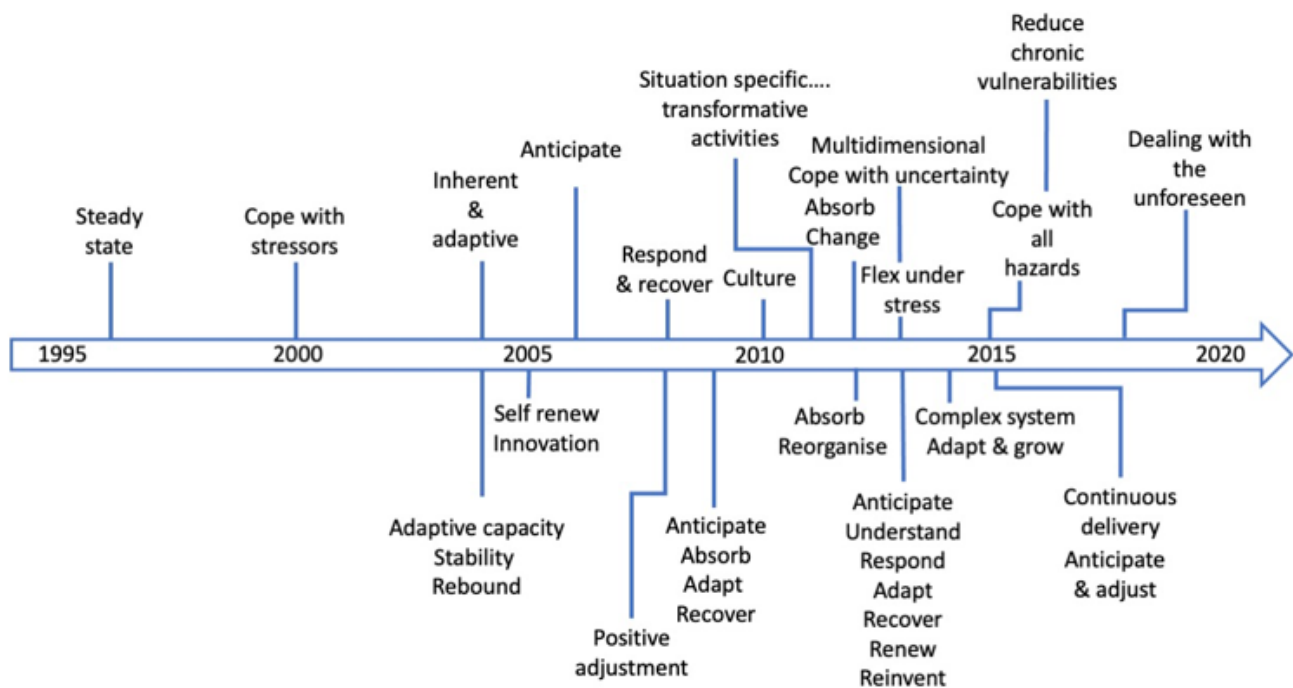
Figure 1: The evolution of resilience concepts[1]

Despite this confusion, there are a number of ideas that have evolved over the last three decades that do help to define resilience (**Figure 1**), of which perhaps the most foundational are that resilience is about a system's attributes for:

- Coping with unwanted stress (adverse forces).

- An ability to adapt in the face of such stress.

- Anticipating the potential future emergence of stressors.

- Understanding uncertainty, and uncovering and addressing vulnerabilities.

- Responding to the emergence or presence of stressors, before they can cause harm.

- Having a greater ability to absorb harmful effects and recovering from that harm should it occur.

- Agile and flexible response and recovery.

The basis of resilience: exploring resilience concepts

There are many different models of resilience, each representing different aspects of the evolution of and thinking about resilience (**Figure 2**).

Each of these types of models has multiple different sub models that have been developed, each of which tries to explain a very different aspect of resilience. There is no 'right' model, as the British statistician George Box once said,[3] *"all models are wrong, but some are useful"*. Accordingly, all of our models of resilience are 'wrong' (they do not tell the whole truth), but some can be very useful in helping to understand the challenges that we face and the approaches we can take to address these challenges.

Resilience is a complex concept, and this requires some complex models to try and explain the concept. Before getting into some of that complexity, it is worth considering a simple resilience model (**Figure 3**) in order to understand some of the core ideas about resilience. The starting point for understanding these concepts is recognising that resilience is an attribute of a system (any system: a team, part of an organisation, a whole organisation, an infrastructure network, a network of suppliers and customers, an industry domain, a government, a community, a society, etc.). As external stressors emerge and generate change, this causes the system to change. Where the system change
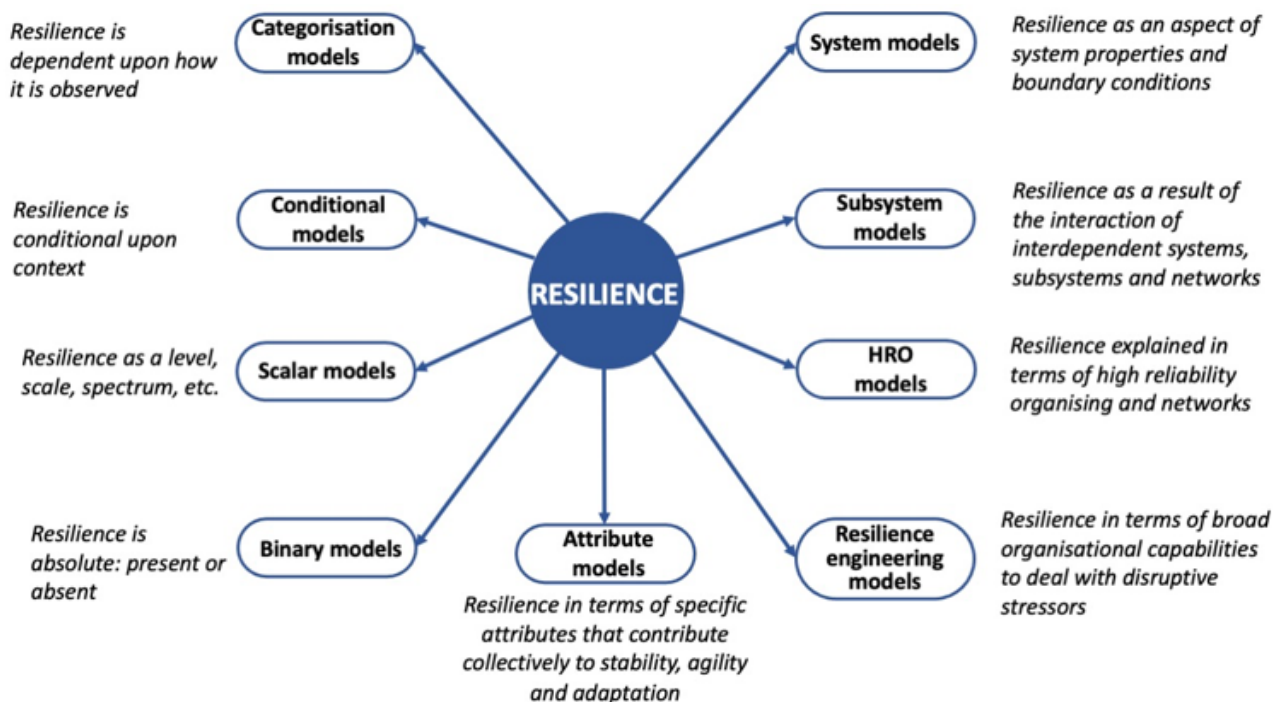
Figure 2: representative types of different resilience models[2]

2 Reproduced from Gibson (2019) with permission of the author.

3 Box G.E.P. (1979). *Robustness in the Strategy of Scientific Model Building.* In: Robustness in Statistics (Editors: R.L. Launer and G.N. Wilkinson) pp. 201–236, Academic Press.
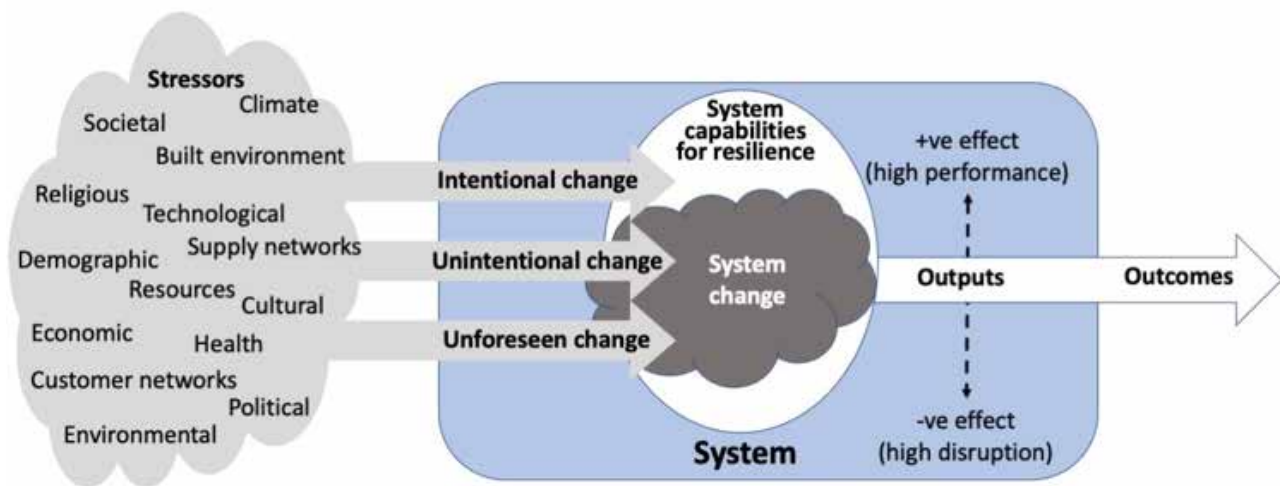
Figure 3: Foundational resilience model[4]

can be directed or coped with, then positive outputs are expected. We can say that the system has achieved a high resilience outcome. Conversely where negative outputs (disruption) occurs, then the system has a lower resilience outcome. Unfortunately, many models are entirely focused on the 'resilience' that is occurring within the blue system box (in **Figure 3**). Where the interest is on the capabilities that are *believed* to contribute to resilience, and the extent to which disruption (outputs) is prevented. There is much less attention paid to the resilience attributes that sit outside of that system box. For example, the extent to which resilience outcomes are achieved through interactions with other systems, and although we may claim that the system is resilient, to what is it resilient? Many 'resilience programs' are solely focused on building a resilience solution without first asking: *"if resilience is the solution…what is the problem?"*. What types of future scenarios could our organisation and society be exposed to and will need to be resilient against?

Problems with moving towards resilience

Our superficial understanding of uncertainty and complexity is a fundamental issue that is common across all types of organisations, sectors, and domains. It is a problem that has been hundreds of thousands of years in the making. Our brains, through evolution, have been 'engineered' and 'programmed' to think of uncertainty and complexity in certain ways. Humans have an innate preference for seeing our world in terms of simple linear sequences of cause-and-effect. When the first primitive hominids walked around their environment and saw a movement in the bushes, they could assign a cause (prey or predator), anticipate the need to act (kill or run away), and anticipate what the consequences would be (eat food or become food). This perception of the linear world persisted as these hominids evolved into Homo sapiens, and generally helped humans prosper in, what was up to modern times, a relatively simple linear environment.

4 From Gibson (2020), reproduced with the permission of the author.

For some parts of our prehistory and history this linear view has been supplemented by assigning a divine explanation (the will of the gods) for some of these cause-and-effect relationships. About four hundred years ago, this simple linear view of the workings of the world became more overt and formalised during the 17th and 18th centuries, with the Enlightenment in Western Europe. Under the influence of philosophers and scientists such as René Descartes and Sir Isaac Newton, the West started to abandon blaming gods and demons for much of the cause-and-effect that happened in the world, replacing it with the linear scientific/mechanistic ideas of the clockwork universe. For the last 400 years, this Cartesian-Newtonian thinking has firmly embedded the idea of a world of linear cause-and-effect relationships, and is still our dominant default mode of analysis and sensemaking. However, we live in a complex world, where such Cartesian-Newtonian thinking is increasingly invalid. At best, a lot of our world is filled with highly complicated relationships (where simple sequential linearity no longer holds true) characterised by multiple intersecting and interdependent cause-and-effect relationships (**Figure 4**). More likely, key aspects of our world are highly complex, where cause-and-effect relationships are difficult, even impossible to discern. New relationships are emergent from within the system, and are often unpredictable. Even with the benefit of hindsight, it can be difficult to uncover the interrelated causal pathways

that resulted in diminished or elevated resilience. Because we still think mainly in linear terms and because many of our analytical techniques are based on linear concepts, much of this complexity remains poorly understood. This is especially so with the complexity of the interconnected physical, procedural, logical, natural, and technological systems that we absolutely depend upon in the modern word. With increased complexity, comes increased vulnerability and susceptibility to disruption, especially since the presence of potential points of failure can remain opaque, until after that disruption occurs.

Assumptions about linearity

One of the other barriers to enabling resilience is our over reliance on untested, and often unrecognised assumptions, arising out of complexity and uncertainty. Much of our understanding of the world and many decisions on which we rely are dependent upon assumptions of unknown validity. This reliance on assumptions creates significant vulnerability, further weakening resilience.

Many of us with military backgrounds will be familiar with red teaming techniques, used to surface and challenge assumptions underpinning defence-related planning. In recent years, these red teaming techniques have started to be introduced into strategic thinking and planning in
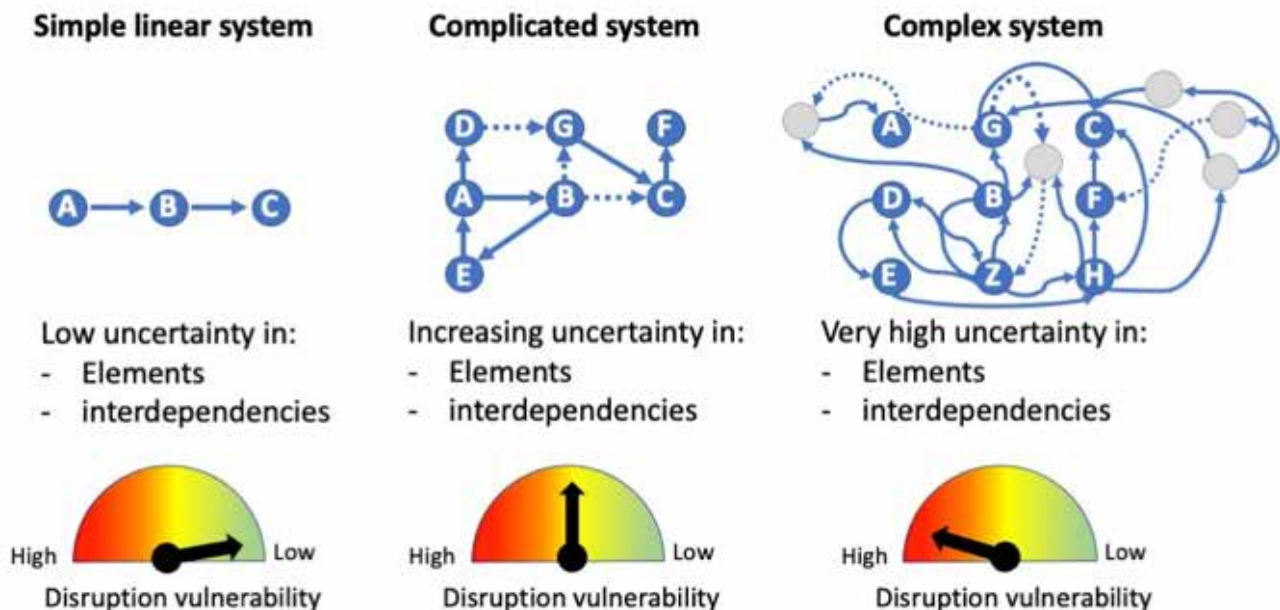

Figure 4: Linearity to complexity

5 Vaughan D. (2016). The Challenger Launch Decision. Risky Technology, Culture and Deviance at NASA. 2016 Edition, University of Chicago Press, Chicago and London.

non-military organisations. However, its adoption has been patchy in government, Not For Profit, and private sectors, and even in the military its use in more general critical thinking and decision-making is still restricted. Our assumption-laden decision-making thus becomes another source of vulnerability.

Assumptions about reversibility

Our decision-making processes can also become another source of vulnerability, especially because of a general lack of recognition that not all decisions can be made using the same process. We all make decisions, every day of our lives, and most of these routine decisions are 'reversible'. If we make an error in the decision, if things do not work out exactly as we would have wished, then it is fairly easy to reverse those decisions. We can step things back and change our decision usually with little harm arising or without suffering unacceptable costs. However, we too easily fall into the trap believing that all decisions are reversible and can be made using routine, familiar, and well-rehearsed processes. Unfortunately, an increasing number of decisions that we have to make about our complex world are irreversible decisions. These are decisions that are difficult if not impossible to reverse, without severe intolerable consequences. When faced with making irreversible decisions, we need to recognise that we are facing a different type of problem, one that requires a much more thoughtful and cautious approach, and the development of diverse perspectives. It is especially important that underpinning assumptions are identified and validated, preferably by someone independent of the decision and its outcomes.

Assumptions about the way things work

We all make assumptions about how the world around us works, especially about how our systems of work operate. What these assumptions rarely recognise is that almost everyone is a deviant. Diane Vaughan wrote a seminal book on the Challenger shuttle disaster[5], looking at how NASA operated and how it normalised such deviancy. We all introduce deviance into our work. When policies, doctrine, systems, procedures, processes, etc are designed and documented, it is assumed that these will be followed (work as designed) – the formal landscape (**Figure 5**).

However, users gradually introduce unapproved shortcuts to make things easier. Over time these practices diverge from the original design and become normalised into routine practice (work as performed). However, the assumption
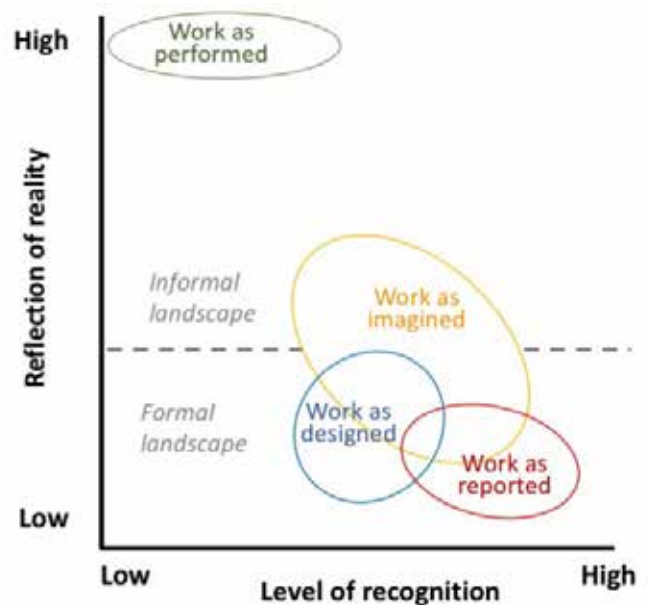
Figure 5: Normalisation of deviance

remains (particularly with management) that these practices still reflect the original design (work as imagined). There may even be a different version of the practice that is relayed to others (work as reported). Such deviancy introduces increased fragility into systems and lowers resilience, which may not become apparent until the system is placed under stress. In every major disaster where lessons are available, we see this normalisation of deviance occurring.

This brings us to a final problem for establishing resilience, we all too commonly pay insufficient attention to our vulnerabilities. Even when we are active in looking at vulnerabilities, we tend to focus only on inherent and acquired vulnerabilities. The sort of vulnerabilities that our audit teams might pick up because of poor design and implementation or because of gradual accumulation of errors over time. However, even less frequently considered are those vulnerabilities that can emerge when systems are placed under stress. We are far less aware of these emergent vulnerabilities, and far less attentive to their presence. We will revisit vulnerability later.

5 Vaughan D. (2016). *The Challenger Launch Decision. Risky Technology, Culture and Deviance at NASA*. 2016 Edition, University of Chicago Press, Chicago and London.

The basis of resilience

What does resilience look like? **Figure 6** provides a compositional model of resilience, illustrating some of the key components that are common, whether it is the resilience of community group, a large organisation, or whether we are considering national or regional resilience. There are two main takeaway messages from Figure 6. Firstly, resilience is comprised of three main components. When we are resilient, we are resilient to something, i.e. the purpose of resilience (the top set of boxes). Then there are a whole range of things that we do that directly build resilience (the middle set of boxes), and other things that we do that supports and enables what makes us resilient (the bottom set of boxes). Secondly, the Figure provides a consolidated view of how well society is performing across these various resilience factors (a personal and very subjective view). The red boxes in **Figure 6** represent where the factors are performing fairly well. Where there is no red box (either absent or only partially covering the element), that is an area undertaken poorly or ignored by many organisations. In some instances, the red box extends beyond the element, this indicates where activities are being undertaken that do not contribute significantly to resilience or in some instances may be introducing vulnerability. There is still a lot of work that needs to be done to get organisations to think properly about resilience. A starting point may be to encourage better approaches to lessons learned, so that as a society we can better understand what makes organisations and systems fragile and where to focus our efforts on building resilience.

When resilience fails

The COVID-19 pandemic provides a great classroom for understanding resilience and fragility. The Australian Government were very effective in closing down the country's borders very early in the outbreak, limiting community transmission to a small numbers of cases through late February, March, and April 2020. In late March, some border restrictions were eased, with incoming overseas travellers subject to two weeks quarantine in city hotels. Australia was down to virtually zero cases of community transmission by late May/June, and then something happened. A second wave that started in the State of Victoria. This sudden increase in community transmission was due to a catastrophic failure of Victoria's hotel quarantine system.

An Inquiry into the disaster was eventually held, examining 96 witnesses and over 350,000 pages of evidence. However, the Inquiry was criticised for failing to properly investigate the failings, and several Ministers and public servants would not answer some vital questions about key decisions, claiming a collective failure of memory. **Figure 7** summarises some of the key evidence and media revelations, and identifies causal relationships based on facts (solid lines), and relationships based upon plausible inferences, suppositions, and allegations (dotted lined). Catastrophic failure rarely has a single cause, and this causal relationship map shows that the path to failure is rarely a simple linear sequence.
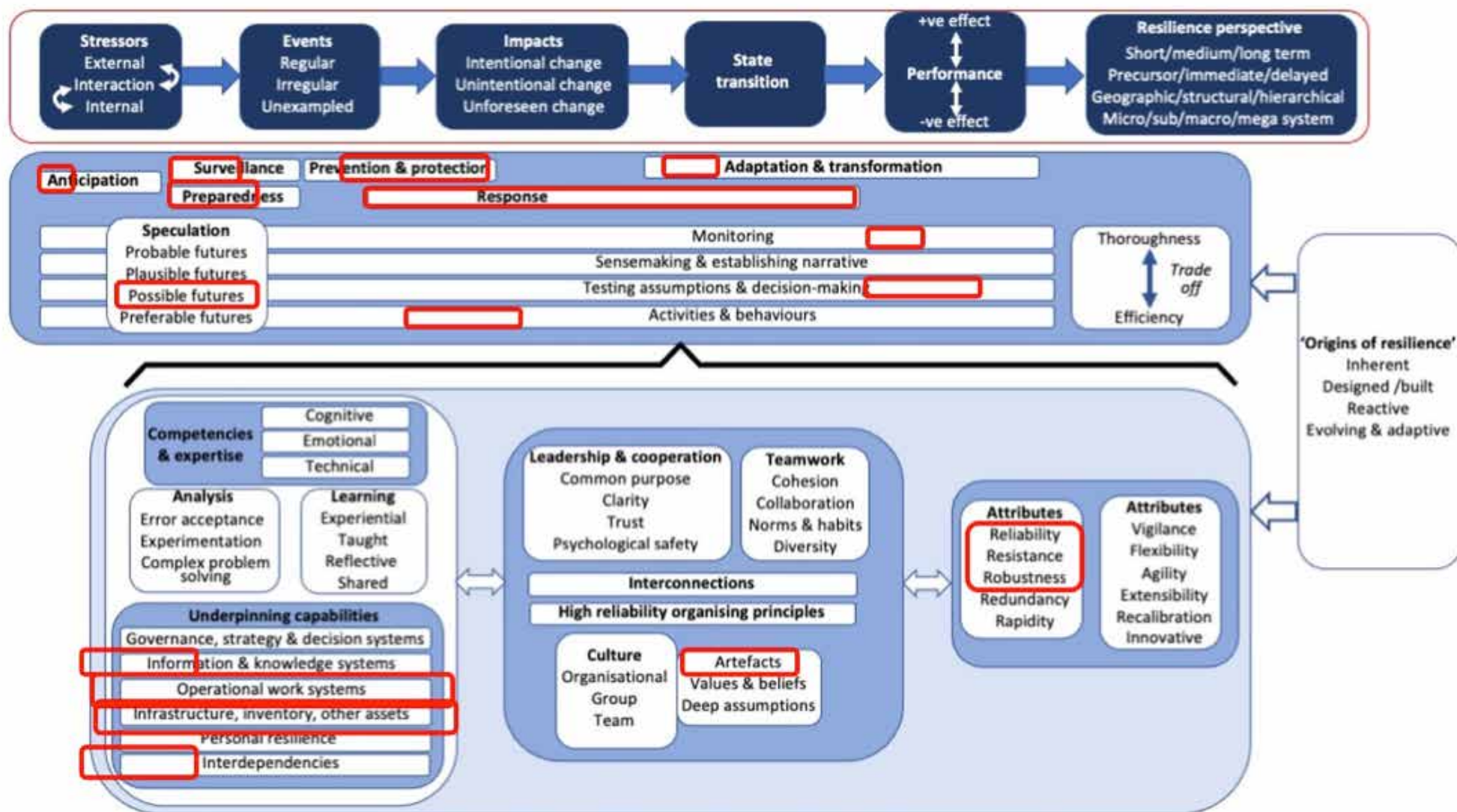
Figure 6: compositional resilience model
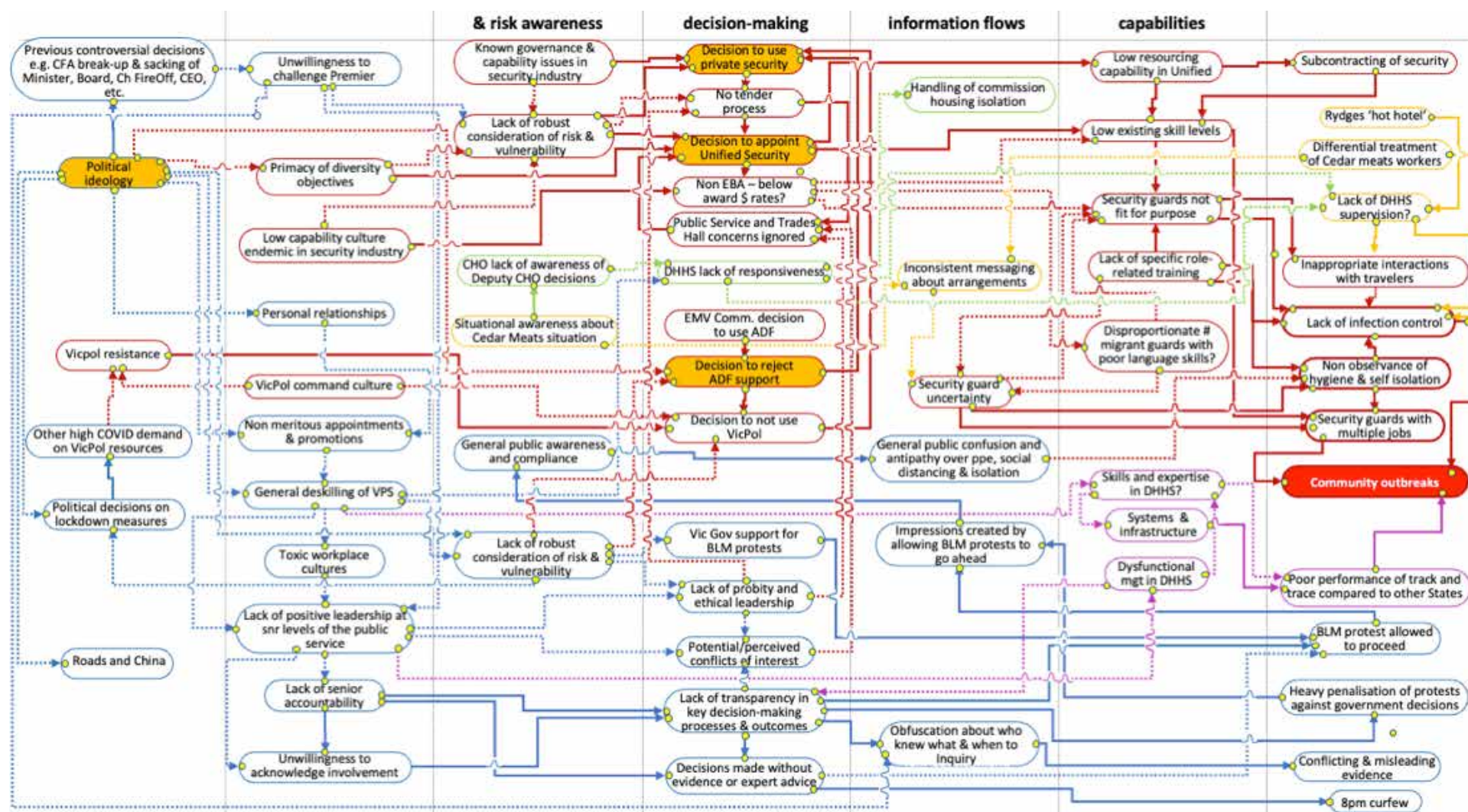
Figure 7: Victorian Hotel Quarantine Program Failure

This disaster was an outcome of severely degrade strategic and operation resilience within the Victorian Government that occurred as a result of failures of leadership, decisions, and actions in the weeks, months, and years before the pandemic emerged. The hotel quarantine disaster is not unique, and we see many of the same common causal factors in almost all catastrophic failures. These common pathways of failure can be summarised in a much simpler relationship model (**Figure 8**). This organic model is based upon a common factor analysis of hundreds of disaster case studies, and comprises fives domains were vulnerabilities and failures manifest:

- How decision-makers perceive risk and uncertainty, which influences the accuracy and timeliness of their situational awareness, and the expanse and quality of their sensemaking.

- How decisions are made, based upon that perception and sensemaking (especially the extent to which they utilise shared sensemaking).

- How decisions are enacted through building and mobilising capability.

- The effectiveness and sufficiency of knowledge flows that interlink these other factors.

- The way in which culture influences perception and sensemaking, especially what is attended to; influences both the generation of decision options and the process of exercising judgment about those options; influences how capabilities are developed and mobilised; and influences what information is made available, how it is shared, how it is interpreted, and how it is used.
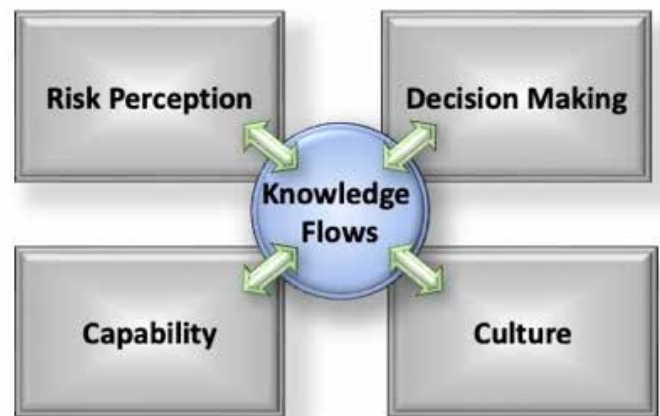
Figure 8: The organic model – pathology of failure

This organic model is relevant to and applied at every level, from subsystems, to systems, to meta-systems (**Figure 9**). When we have problems with resilience (issues within our 5 key factors) occurring at the socio-economic level, these problems cascade down through the organic models in the other systems and subsystems within our society. Similarly, failures in the organic model at lower levels of the metasystem can influence the emergence of failures at higher levels.
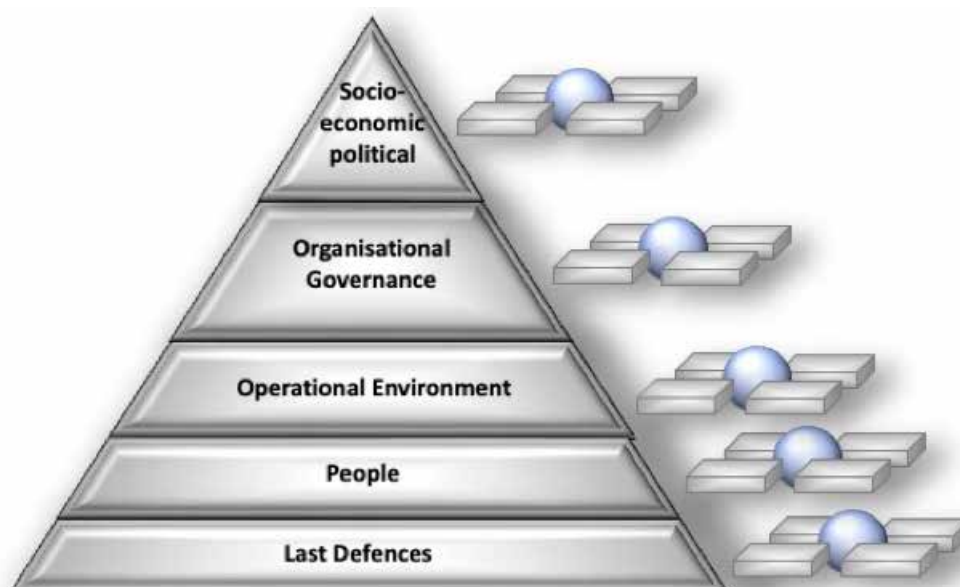
Figure 9: Societal positioning of the organic model

When resilience goes well

The pandemic provides us with many examples of organisations that not only survived but thrived. By way of example, one particular organisation, a global manufacturer, showed high resilience and high performance during the pandemic, both through its preparedness and through its ability to adapt as the situation changed. Many potential vulnerabilities (as described in the organic model) had been resolved and addressed well before the pandemic, and emerging vulnerabilities dealt with during the pandemic. Particularly, a range of non-routine capabilities were mobilised, adding to the company's resilience:

- Fluid leadership (also known as deference to expertise) is one of the key features of a high reliability organisation. As the strategic and operating environment changes, i.e., becomes more volatile and uncertain, leadership transitions to different people at different times, and decision-making authority is delegated down the hierarchy to those people in the best position to make the decisions quickly. By regularly deferring to expertise during the pandemic, the company ensured an agile response to a dynamic operating environment.

- The company, years prior to the pandemic, had recognised that they were dependent upon complex interrelated value networks, rather than simple linear supply chains. Accordingly, they developed special relationships with their suppliers and major customers, 'keeping them close' and tightly coupled with the organisation. The company established their primacy with their suppliers and closely monitored performance and reliability. They encouraged their suppliers to do likewise with their own dependencies.

- Criss leadership: the company took their best thinkers and established a dedicated leadership team (the 'A team') removing them from the day-to-day business in order to solely focus on the disruption that the pandemic was causing. The company also established a 'B team' to look after and continue the day-to-day operations. The 'A team' was not distracted by the minutiae of business-as-usual, and the 'B team' was not distracted by worrying about the pandemic. They also had a senior leader whose role was not to make decisions or direct activities, but instead to be a devil's advocate, to test the assumptions that everyone else was relying upon.

- Acceptance of error: Company leadership recognised that errors would be made, but they wanted their people to get out, to make decisions, and take risks. They accepted that when their people made mistakes, they wouldn't be blamed or punished. Instead, these mistakes would be used as learning opportunities across the company.

- Systems were put in place to continuously monitor the changing situation and key decision-makers received updates several times. This regularly updated situational awareness created an expanded decision-making and action 'space', and by removing a significant amount of uncertainty and associated stress also reduced emotional influences on the decision-making. This increased 'space' provided flexibility and introducing more reversibility into their decisions.

Towards a national resilience perspective

Vulnerability

The concepts discussed thus far can apply at all levels of society, influencing resilience in teams, organisations, governments, across industry sectors, and at a national level. To comprehensively review all of these models and concepts with a national resilience lens is outside the scope of this paper. However, we can start the conceptualisation of a national resilience construct by exploring just a few key factors, starting in the domain of national vulnerabilities (**Figure: 10**). Although this examination is considering Australia's current status, it would be surprising if most developed nations did not have similar issues.

It should also be noted that this is a model, it is not comprehensive and is used to highlight a selection of key national vulnerabilities (noting that similar vulnerabilities will be found at all societal levels)
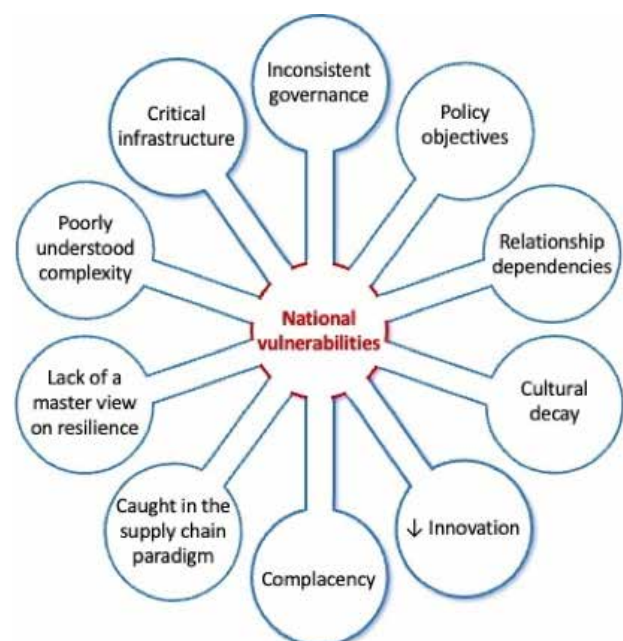
Figure 10: National vulnerability model

Policy and policy objectives

Policy drives the national agenda, but on many occasions, policy is not translated into meaningful action, policy objectives are not met, and desired outcomes are not realised. There is a recognised economic concept – the Tinbergen rule[6], which states that the number of policy objectives cannot exceed the number of policy instruments being used. In other words, if single policy instrument is used to address two or more policy problems, then it is likely that none of the problems will be resolved because of conflicts between objectives. We saw this occur multiple times during the pandemic, and Victoria's experience with its Hotel Quarantine Program is a case in point. CBD hotels with contracted private security were set up as quarantine facilities (the policy instrument), with the policy objectives of boosting indigenous employment (not achieved), reinvigorating the tourism sector by securing revenue flows (only partially achieved), and preventing further community transmission of COVID-19 (not achieved).

Cultural decay and inconsistent governance

Many western nations are experiencing cultural decay, degrading social structures, increasing political divisiveness, the polarisation of ideologies, and a decline in social cohesiveness. This has been accompanied by an increasing short-termism and a drive for immediate reward, rather than establishing long term sustainability and stability. We can see from the large number of corporate failures and misconduct scandals in recent years that there are continuing problems with the governance of organisations. Critical policies and procedures are being frequently ignored or abandoned in favour of expediency and ideological fulfilment. However, in the absence of adequate governance, critical decision-making and mobilisation can fail catastrophically, a situation clearly seen in a number of government-mediated disasters, such as the Commonwealth government's pink batts home insulation disaster, and the Victorian quarantine disaster. There is a growing distrust of and dissatisfaction with the established 'political class' and an increasing rejection of traditional news media. There are now multiple and conflicting societal narratives being expounded, to the exclusion of a compelling and unifying national narrative.

Relationship dependencies

The increasing integration across multiple societal systems and global supply networks has resulted in such complexity that few of us understand the nature of the interdependencies that we have an absolute reliance upon. It is only when a small part of these complex networks fails that we even start to realise how vulnerable these interdependencies have become.

Innovation

Australia has long been proud of its 'clever nation' image, but in recent years the country has been declining in its relative innovation status globally[7], slipping from the 19th most innovative nation in 2019 to 25th in 2021. Innovation is not just about technology, our national conversation about innovation also needs to consider the ways that we teach people to think. Whilst there are many factors contributing to our declining innovative power, perhaps one of the most significant vulnerabilities is how we teach skills beyond just the STEM subjects, such as critical thinking, design thinking, and complex problem solving as part of a comprehensive combination skills base. Our education models have changed little from over the last four hundred years. Whilst our higher education institutions have replaced blackboards with computers and online learning, the actual creatin and transfer of knowledge in many universities is little different to what Sir Isaac Newton would have experienced at Trinity College Cambridge in the 1660's.

Supply networks

Despite the experiences of the pandemic, many organisations ae still stuck in the paradigm of dependencies as linear supply chains, rather than as highly interdependent complex value networks of customers and suppliers. There is little deep understanding of the extent of these interdependencies and their inherent and potentially emergent vulnerabilities.

Complacency

Complacency is amplifying many of the already existing vulnerabilities within society, a lot of our public and private leadership is thinking about solving yesterday's problems rather than the problems we will need to fix ten years hence. Worryingly, many leaders in the public and private sectors seem satisfied with looking backwards and remain complacent about their indifferent or declining performance. For example, new infrastructure projects continue to be funded that have designed in obsolescence, using 15 year old plus technology that only just meet today's needs, but will be outdated in only a few years. A lot of much need thinking about major risks, such as climate change, societal cohesiveness, and aging infrastructure, are pushed away as a problem for tomorrow, and tomorrow these risks will again be pushed off to be dealt with in some undefined future. At a recent gathering of risk professionals, when I asked a question about climate change action, less than half of those present had included climate change in their organisation's risk profile.

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6 Tinbergen J. (1956). Economic Policy: Principles and Design. North-Holland, New York. Accessed at: https://repub.eur.nl/pub/16740.

7 Source: Global Innovation Index 2021.

Critical infrastructure and complexity

Much of our critical infrastructure is aging, and is highly complex with significant gaps in understanding of the nature of interrelationships and interdependencies. This is being further exacerbated by new systems being layered onto legacy systems in many situations, instead of complete replacement. Existing vulnerabilities are poorly understood, and the potential for more severe emergent vulnerabilities being rarely considered is infrequently explored.

No master view of resilience

Resilience has become *the* 'buzzword' over the last decade, and for many organisations has become a cynical rebadging of tired old business continuity management practices. More widely, the term has been applied in so many unrelated different ways that it is starting to become almost meaningless. There is no whole of society perspective on resilience, and little integration of thinking, analysis, design, planning, or mobilisation at a national level. There is no central body or node that can provide leadership or coordination in a journey towards addressing national vulnerabilities and building national resilience. Where effective approaches to resilience are occurring, these rarely stretch beyond an individual organisation's self-interests.

Figure 12: Crush-response model – the 2 D precursor of the MoM

Figure 11: National vulnerability scorecard (the greater the transition from green to red, the greater extent of potential vulnerability).

Towards a scorecard

A personal perspective on national vulnerabilities and resilience does not paint an attractive picture (**Figure 11**), which indicates that there is considerable work required to develop sufficient resilience to meet the immediate challenges of the next few years, let alone prepare for potentially decades long global instability The fear now is that our experience of the pandemic (which was in reality a relatively low morbidity and mortality event, compared to what it could have been) will create more complacency with respect to vulnerability and resilience, rather than raising a call to urgent action.

Margin of manoeuvre

Back in 2015, in collaboration with the US Office of Learning, we developed the concept of 'Margin of Manoeuvre' (MoM). It was based in part on the experiences of wildland firefighting in Australia, US military flying operations in Iraq and Afghanistan, and US Coastguard search and rescue operations. The MoM concept was an advancement of the crush-response model (**Figure 12**), where dynamic pressures on the system are countered by system capabilities, the effectiveness of which may be reduced by the presence of system vulnerabilities. The MoM construct reenvisaged this model as a three-dimensional sphere, the volume inside the representing the amount of space (physical, and time) within which decisions and mobilisation of capabilities can be made. We visualise MoM, in practical

terms, by using a Hoberman sphere (**Figure 13**), where stressors can push in and reduce the size of the sphere, and where the nodes represent opposing individual forces (capabilities) pushing out.

The larger the size of the MoM sphere, the more space is created within which to make decisions, act, experiment, make mistakes, and correct them. If the dynamic inward pressures are greater than the outward forces of capabilities (reduced by the presence of vulnerabilities), then the sphere will contract, until the opposing forces reach equilibrium or until the there is insufficient space to operate effectively. At some point the MoM sphere may be compressed to the extent that all 'resilience' is compromised and a catastrophic failure occurs.

Using MoM, we can derive a visual representation of our resilience, decide if we are comfortable with the available MoM space and if not, identify which nodes (capabilities) to pivot. MoM can also be used to provide a simplified 2-D visualisation, for example in reporting different aspects of selected national resilience factors (**Figure 14**)

Figure 13: MoM – Hoberman sphere used in decision-making exercise
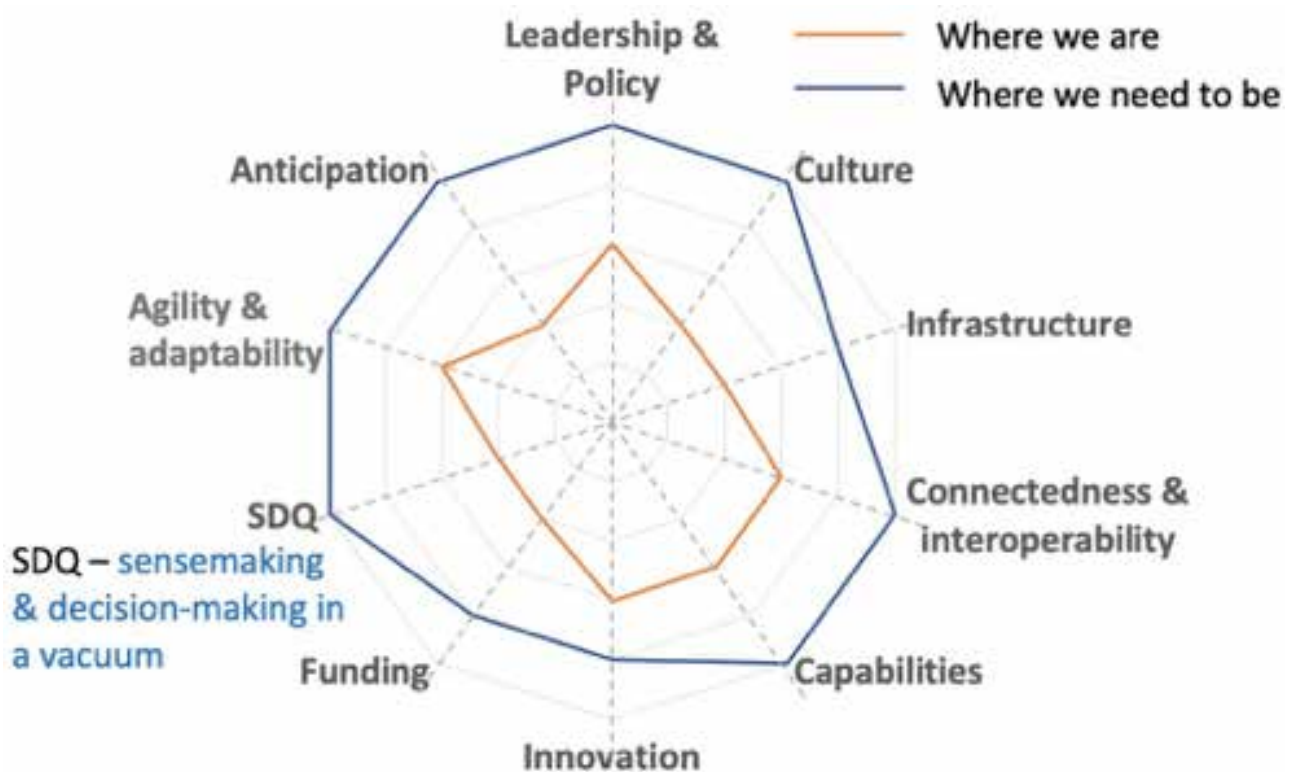
Figure 14: Hypothetical MoM chart for national resilience

To the future

From a national perspective we are far more vulnerable, far less resilient than many business and government leaders assume. Despite an increasing interest in reducing disruption, our resilience is not increasing sufficiently because the context (our strategic and operating environment) is often moving faster than our ability to build that resilience. One of the key issues for the immediate future will be to advance the concepts of national resilience. Organisations need to become more aware that their resilience is intimately dependent upon the resilience of the rest of society. By looking only to their own resilience, organisations are amplifying their own vulnerabilities and the nation's. Defence, along with other domains need to gain a more informed and nuanced appreciation of their role in contributing to national resilience, as they establish and enhance their own resilience (**Figure 15**).
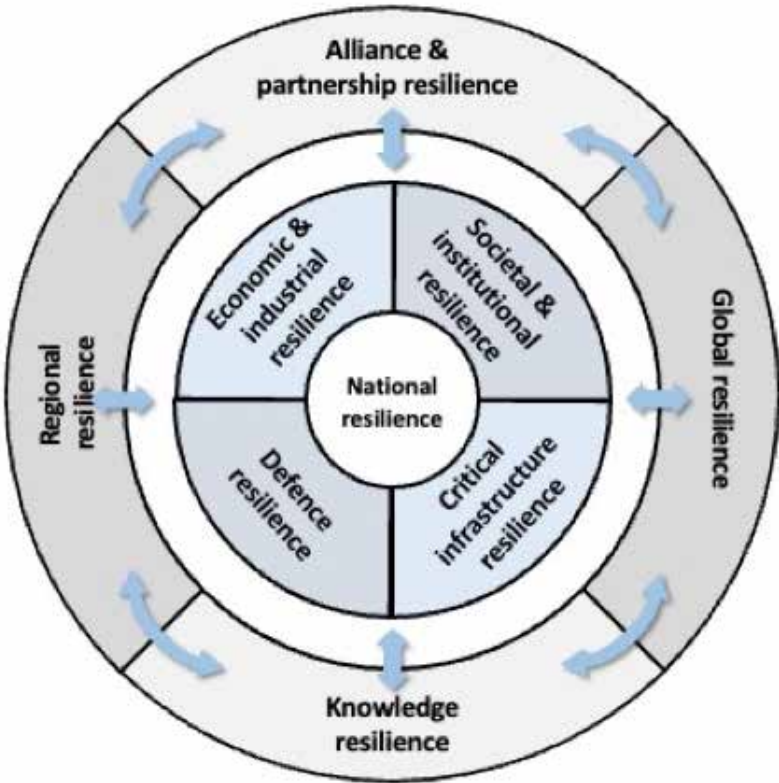
Figure 15: National Resilience Model

The nexus between resilience and innovation in the fourth industrial revolution

Professor Tanya Monro,

Chief Defence Scientist, Defence Science & Technology Group

An absolute pleasure to be here today to share with you some thinking around the nexus between innovation and resilience. To frame my thoughts, I would like to start with a couple of definitions to frame my thoughts. What I will not do is reframe and define 'resilience' because we have just had a tour de force on that, and we see the complexity that has come into that landscape over the last few decades. What I do want to do is start by defining what innovation means in a Defence context. I think innovation is too often seen as the new widget that solves your problem. If you are in an innovator, how do I get someone to care about the technology I have developed?

I would like to start by framing innovation as generating ideas and putting them into practice to give us an edge over our adversaries. That takes away from being purely technology; rather, it is, everything from our modes of operation, right through to the way our people work and interact with emerging technology. Just to give you a wonderful example from yesterday, we recognised this year's winner of the Minister's Award for Achievement in Defence Science. The recipient was Dr Alexander Kalloniatis, for his work on reframing how Joint Operations Command HQ works. So how our operators – when they deal with information coming in from operation – make decisions and interact with each other. It could not be a more vivid example of innovation as applied to the human and decision-making domain. As far as anyone could imagine from the traditional use of innovation.

I put it to you that innovation and resilience are inextricably linked. If we have the resilience to weather unexpected challenges, the better we are putting ideas into practice and the greater the likelihood that we will be able to have that space, and manoeuvre space, to prevail in the contested environment. Now, this audience knows that rapid advances in technology a mean that we are facing a range of threats as well as a range of opportunities. Over the last decade, it has been fascinating to watch over the last decade how

science capability is has become undeniably a theatre of strategic competition. There is a race for global dominance in critical and emerging technologies that promised military, economic, and social advantage.

I put to you that Australia must respond by bringing together all of the elements of power at our disposal. We must consciously and deliberately align diplomacy, policy, strategy, intelligence and investment. These all leverage off what I argue is our greatest strength: alliances and partnerships. Partnerships matter whether they are at home or with our international allies and partners. Working together, we can effectively compete and create that resilience. Critically, the strength and depth of our science technology innovation, and industry capability cooperation and ability to co-develop things rapidly, are critical to our allies. It underpins the credibility of our collective deterrence and national resilience. Because collaboration enables us to get a technological edge in combined military combat power. It enhances interoperability and interchangeability. It improves the security of our shared supply chains.

Now to embrace innovation in Defence, we must strive to harness the best ideas in the newest technology as it becomes available. We want to turn creative concepts and new ideas, wherever they come from, into capability advantage at the pace of relevance. We know that there are many areas of critical technology competition: hypersonic, autonomous systems, quantum computing, biotechnology, space, and advanced materials. Due to time limitations, I am unable to list them all, but I will give some really pithy examples as well and share with you a way of thinking that I think we need to embrace if we are going to change the way we innovate in Defence.

Of course, Australia is not alone in recognising the critical role that innovation plays in preparing our armed forces to meet the challenges of the future. The technology used by our partners, allies and potential adversaries is advancing at

pace. For me, this raises three important questions. First, to keep up. Can we adopt similar or better technologies to allow the Australian Defence Force to maintain comparative combat power? The second question is, can we adopt measures to defeat or minimise the impact of technology that might be used by potential adversaries? The third is, can we identify specific opportunities to give Australia a capability edge that suits our size, skills, and resources, which cannot be easily defeated, copied, or neutralised by an adversary? Answers to these questions involve harnessing niche research capability in our universities. They require building sovereign industry capability and require new ways of working and sharing information with our closest allies. It requires us to train our innovation systems to be mission directed. To tackle specific problems with speeding gusto and, in doing so, unleash the creativity of our people and deepen our relationships so that we have the muscle memory we need within our ecosystems to deliver capability advantage.

Before we analyse some of the really specific examples, I think it is important to reflect that an important element here is to not be surprised by the emergence of new technology. Of course, one of the best ways to weather challenges is to see them coming and to be prepared. And so, technology fore sighting is an area of significant growth within Australia. We are working across whole-of-government with a focus on developing a cohesive approach to monitoring, analysing, and evaluating the implications of science and technological developments to prevent strategic and tactical surprise. We are investing in improving technology fore sighting techniques and methodologies so we can enhance our ability to track, detect and model game-changing technologies. Disruption is not merely a characteristic of a technology, that is lazy thinking. Rather, it is rather a process that arises from the congruence of the technology, its concept of use and the environment in which it is applied. We see this routinely now with the quick adoption of commercial off-the-shelf technologies to new problems. Factors such as societal values, organisational culture, time, and technological integration are also important in determining the extent of disruption. Defence regularly evaluates trends across technology areas; filtering down to a small handful that are is potentially disruptive. So we know that we can do, what we can do about the. From my conversations with allies around the world, there is something quite special about the way Australia does this. We fuse together analysis intelligence and signs expertise in order to get this way forward.

I would like to give one example that is the tip of the iceberg. It is the question of autonomous swarms, which are fast becoming a technological reality. We know that swarming already allows the control of enormous amounts of assets in a scalable fashion. Operators will be able to control swarms as a singular entity at a macro-level level without needing to communicate or control individual elements of the swarm. And the impact, the disruptive impact of the swarm is countering large numbers of attritable drones is very difficult. Countering them is even more difficult. Our response must be multilayered and integrate both hard and soft kill techniques. In particular, what comes from focusing in on some of these emerging disruptive technologies is a whole new concept of operation, not just new technology.

What I would like to do now is quickly describe my role in some of the work my group does. As the Chief Defence Scientist, the role that it has been my privilege to be in for just over three years now. I lead Australia's Defence Science and Technology Group within the Department of Defence. I would like to take a moment to reflect on the fact that next month, Defence Science in Australia is 115 years old. Something, I think is under-realised and under-appreciated. It is an organisation that has delivered extraordinary outcomes for Australia in that 115-year history.

We have recently revisited the core purpose and mission of our group, and I will share it with you. It is to develop innovative technologies that can be delivered by industry and transitioned into Defence capability. To shape innovation, science and technology within Defence and across the nation and with our allies. We are the enabler for Defence capability, and we work with the national science and technology enterprise and partners to make sure we are solving Defence's highest priority problems. I am also the capability manager for science technology and innovation across Defence. Our aspiration in doing that is not to control innovation top-down. That never worked and does not make sense. The aspiration in that is to create a system in which good ideas can pull- through and be tested in a real context and get into the hands of the ADF early. They can be focused on our highest priority problems, and that we can remove barriers to quickly, accelerating and maturing technology.

Defence has really ambitious goals with regard to capability. To achieve them, we must work differently. We have to reduce the barriers between Defence, public service, industry, universities and our international partners. One of the best ways to do that is to increase the capacity of our people and our leaders. They were the two words that came up earlier today. To be able to work across organisations. It is very difficult to do that if you do not understand what it is like to stand in the shoes of the other. This is why we have been working very hard to activate some mobility programs that allow people within Defence to go out and work in universities and in industry and vice versa. Now if I reflect back, historically, Defence in Australia has tended to acquire products from large multinational companies who then themselves acquire or adopt emerging technologies to meet the needs of their largest customer. This does not give us the agility we need to meet changing strategic contexts. Thankfully, now our policy position and courage as a nation has changed, and we recognise the potential for Australian companies, particularly small to medium enterprises, to produce their own innovative solutions.

A significant feature of Australia's Defence industry policy is a focus on building expertise of Australia's Defence industry policy is the priorities. We are working with partner nations actively to improve and evolve our innovation systems and learning from each other. In doing that, we can then help accelerate opportunities for Australian companies in allied supply chains.

Back in May 2020, we launched the 'More, Together: Defence Science and Technology Strategy 2030', which sets the scene for the next 10 years of science and technology development within Australia. The core concepts with in this are that we focus on Defence's most significant challenges, but we generate scale by working with partners across the innovation system that we deliver impact by focusing on transitioning the most promising solutions to Defence capability. At the heart of this strategy are hairy audacious missions articulated by our Service Chiefs. Addressing problems that they know cannot be addressed by current day science and technology.

Noting this is the space and air power conference. I will use my remaining time to pick out a couple of examples of what we can do and I look forward to some of your questions on the panel to pull these elements out further. We all know we rely on space technologies or security, but there are increasing risks in the use of space. And a key challenge is the rate at which technological disruption is occurring, and space is being contested and congested. We need to focus on what we can do to change that dynamic. One of our key approaches is through the Resilient Multi-Mission Space Science, Technology and Research (STaR) Shot, resilient multi-mission SpaceStar shot which was established to focus Defence's activities in this area on a key problem. We are focused on delivering small satellite systems and missions to explore and demonstrate resilient, disruptive space-based technologies and operating concepts for ADF. The first missions are now currently under preparation for early 2024, and we are looking for opportunities to bring them left. We are partnering very actively with industry across Australia through mechanisms like the SmartSat CRC, which is the largest aggregation of space researchers and space companies. Some of the things we are doing include projects on combining radiofrequency and optical frequency communications and putting compact clocks on satellites that can give GPS denied navigation timing in global positioning system (GPS) denied environments. A lovely example that shows how we have done this recently is the Buccaneer CubeSat program. In collaboration with Air Force, Defence Science and Technology Group (DSTG) worked with the University of NSW and Canberra to undertake the Buccaneer CubeSat program.

Following the initial success in 2017–2018, we commenced work on the main mission CubeSat system. A key partner in this program is the company Inovor Technologies in Adelaide, and they are working with us in Defence to integrate payload. This has helped us build the skills that

we need to get develop great ideas in space and to make it easier for our collaborators to be able to put their ideas on missions and test the utility and in a Defence-relevant context.

Another relevant example in space is at the Advanced Radiofrequency Payload Research Network, which was established mid-last year to be able to develop and demonstrate advanced wide wide-area surveillance capabilities for Australia's vast maritime regions. Our objective here is to demonstrate an affordable, all-weather payload for a small satellite-based system that can be scaled to provide a resilient layer in Defence"s maritime domain monitoring capability.

Earlier today, we heard about the Russian shootdown of one of their own satellites. What you might not know is that at the very time that happened, serendipitously we alongside Air Force and Australian industry and academia and international partners where in the very process of testing some of our systems for space situational awareness and we were able to actively test the utility of those systems to monitor the generation and propagation of debris from that collision. This is a wonderful example of bringing emerging technology to a real problem – just only unexpectedly – and it required resilience.

To provide some other examples, then, before I finish on the broad themes of this conference. DSTG successfully developed and commercialised a world-first wingkit technology to convert a dumb bomb into a guided munition, and this Joint Direct Attack Munition – extended range JDAM-ER is the culmination of a long-term partnership with industry and across Defence, in particular with Boeing. This device consists of a set of deployable wings, steerable tail unit, navigation and targeting systems that result in a low-cost, long-range, precision guided bomb that triples the range of the standard JDAM. It is a wonderful example of Australian innovation at work and shows what we can do together. The US Air Force has already done follow-on tests on the system to demonstrate novel methods for deployment.

We heard today also about Ghostbat. I think it will take us a while to get out of saying Loyal Wingman. We have been very active partners with Boeing and Air Force from the start. Our wind tunnels were used to help refine and test some of the original designs and now we are actively focused on the human–machine elements and developing through live virtual constructive environments really clear models and scenarios for how ADF platforms can work together in operational scenarios.

Just as I wrap up and we lead into the panel, I think we are at a moment in time when we need to challenge and change the way we innovate for Defence. It is not OK now simply to identify an emerging technology, invest in it, and hope it delivers. We need to keep our mission orientation, that purpose front of mind, and we do that by making sure we

get emerging solutions into the hands of the war fighters as early as possible and that we do that and militarily-relevant contexts and scenarios.

Another wonderful example happening in just a few months is RIMPAC where we are taking some of the quantum-assured photomultiplier tube (PMT) devices developed by our industry and universities across our nation with Five Eyes collaborators and testing it in a maritime   environment. That will give us a sense of how they can be used and how we can accelerate the development of quantum assured PMT.

As I wrap up, we have been really focused on what we can do to change and grow the innovation system to be able to develop resilience, and to this end, I would like to give a small advertisement for something called the inaugural Australian Defence Science, Technology and Research Summit (ADSTAR). That is Australian Defence science and technology conference's inaugural summit   happening in Sydney in July

this year, and the theme of the summit is indeed resilience. We have three key themes for this conference, which really allow us to focus on what we need to do differently together and how we grow the relationships across our systems to deliver that resilience. We will be asking questions such as what techniques and tools and approaches will allow us to adapt and monitor systems to know how resilient they are? How can we help personnel develop some of the cognitive and emotional resilience that allows them to function at times of high cognitive load? And how do we facilitate rapid, agile learning in our human systems? If any of these topics interest you, please log on and have a look at the ADSTAR site and register because there will be a chance to engage with our ADF and with our scientists and technologists not just from DSTG but from across the nation and from a number of our allied nations as well.

Thank you very much indeed.

Air command perspective on the future operating environment – trends and challenges

Air Vice-Marshal Joe Iervasi

Air Commander Australia, Royal Australian Air Force

Distinguished guests, ladies and gentlemen, I would like to acknowledge the Ngunnawal people, Traditional Custodians of the land on which we meet today and the skies through which we operate and pay my respect to Elders, past, present and emerging and also pay my respects to Aboriginal and Torres Strait Islander women and men who have served and continue to serve in the defence of our nation.

It is a great privilege for me to be here with this august panel this afternoon. In the graveyard shift straight after lunch, it is our pleasure to be able to excite and also stimulate the senses as well.

The topic we have been given is the trends and challenges of the future operating environment as it pertains to resilience and innovation. That is the last time I will say those words in my presentation. I have been given a script to talk about what it means for exquisite capabilities. But those who know me know I seldom stick to the script. I will do it in my own way.

Let's talk about the future operating environment and how that is being framed. First, it is undeniable that climate is impacting security around the globe. For those who recently arrived here in Australia, you are aware we recently have gone through a major weather event with floods throughout the East Coast. We have, as of today, up to 7,000 ADF personnel available and/or in direct support of flood recovery. It is undeniable, and to me, this is the notion of the international standard atmosphere (ISA) versus climate change; what constitutes ISA today is different to what it has been.

The second aspect clearly has to do with global biological threats. We have the pandemic now, but the question really is, which pandemic will come next? That will continue to shape how we respond, and the longer-term economic, structural and societal impacts of that are yet to be fully realised. Within those two major environmental shaping of facts, we have how the world is organised today. We have

autocracy versus democracy. The key question for us is can they actually coexist? Is it about shared ideas? Shared interests or shared values? Is this a new world order that is arising? Further, is it about freedom from fear or freedom from want and what price are we willing to pay for happiness? We need a more nuanced approach in terms of how we understand how nations choose to govern themselves and understand their interactions and what that means to us.

The consequences of actually being at that level of connection and follow-on has certainly been a by-product of the pandemic; we started to recognise we have a certain number of vulnerabilities in the notion of what constitutes sovereign capability versus our dependence on a global network, I think it is also going to continue to dominate and challenge each of us as we start to realise that we, as an integrated network are interdependent; the notion of great powers going into conflict is probably not conceivable in the way we have previously thought. We need to understand the various dimensions of competition or conflict that may arise. The interconnectedness of our globe is now irreversible.

The other thing about the sovereign versus international is that geography still matters – where you physically sit in the world. The final part for me is the ongoing discussion on human versus machine and human quality versus quantity – the mass discussions. Is it exquisite versus low cost? Multirole versus specialist? These are the characteristics of our operating environment over the next few years that will start to shape us.

Over many years, there has been a group of intellectuals who have tried to describe natural reactions, from Isaac Newton – every action has an opposite reaction, whether it is equal or not, I guess we can judge that – to Rudolph Clausius, the second law of thermodynamics – for an irreversible process, disorder, entropy increases over time. The desire is to create order from chaos, where it is not physically possible to do so. The other guy on the end, where he forgot something –

the Heisenberg principle, the uncertainty in that you can only look at one thing precisely, but you lose precision in other dimensions as you try to measure. The key point, as Charles Darwin pointed out, and this is about adaptation, is that it is not the strongest of the species that survives nor the most intelligent, but the one most responsive to change.

Our former speakers have identified that characteristic as well. In the absence of having a unified definition of resilience, I leverage the United Nations Office for Disaster Risk Reduction. As John Blackburn pointed out earlier, it is the ability of the system, community or society exposed to a hazard to resist, absorb or accommodate or adapt to and recover from the effects of that hazard in a timely and efficient manner through the preservation and restoration of its essential basic structures and functions through risk management. I am sure there will be plenty of debates over that definition, but I will pick out the essence of that for my subsequent conversation. The issue of resilience is about adaptation. To me, the question is, are we adapting to survive, or are we adapting to thrive? And that depends as well.

If we take Maslow's hierarchy of needs, and as once quoted by the United States satirist Henry Louis Mencken, the average person does not want to be free; they simply want to be safe. From that notion and aspect, the way a nation chooses to interact with the rest of the world in an interconnected way comes down to what it is trying to achieve as a society and community and from a national perspective as well.

Geography matters too, and the context of where you stand is where you sit. If we look at Australia on a globe, there is a lot of water around – it is the bottom line. If you look through that lens, the nations who are physically closest to us are clear. Conversely, if you look through the lens of Mongolia, their geostrategic circumstances between Russia and China are uniquely different to our own context as well. Finally, if you look at it from the lens looking from Antarctica and out, the last frontier, it becomes evident where the influences and shapers are from there as well.

History matters as well. While history does not always repeat, it certainly rhymes in certain aspects. The notion of adaptability really needs to span a few dimensions, and we need to be thinking about the moral, mental, and physical aspects of adaptation. How have we responded from a Defence procurement or a force design perspective? What we have challenged is that we are always looking for innovation in one way, shape, or form.

The Force Design challenge for us has been that we fall into the trap of is it the last war or the next war that we are looking to fight. Getting stuck in that cycle constrains us to being binary in the choices we must take. Our developmental and adjustment cycles are too long, and the overall tendency is that we tend to favour the next war. The next war drives us toward innovation and the next cutting-edge technology,

to the point of sharks with laser beams. We always try to second-guess exactly what we are required to do for a future environment that is unpredictable and that we are unable to forecast. The natural consequence of trying to predict and sense the future is, lends itself to the concept that we want to drive for more in Intelligence, Surveillance, Reconnaissance (ISR – big data – and because we can now fuse information, it is tending to draw us to a more centralised approach to doing business as well.

Separate to the notion of mission command, we can potentially fall into reverting to a centralised system because now we have this exquisite, meshed network capable of shared situational awareness and drawing that into the centre. The question is, is that really the best way forward?

There was a bloke called John Boyd, whom most of us are aware of – certainly from an academic perspective, but notably those from the fast jet community – as the developer of the energy–manoeuvrability theory. From Boyd's perspective, the OODA loop is not a loop in itself. It is actually about the big 'O', and that is about orientation. You spend most of your time in the phases of orientation, but your ability to orient is based on your own cultural biases, your own context, your own intelligence and your own senses in the system as well.

If we consider our societies, our forces and our nations as their own ecosystem, if you are only looking from your ecosystem inwards but are not interfacing with the external environment, you might at best adapt to survive, but it is at the interfaces of the other ecosystems – at the boundaries – is where the changes actually take effect. So, the ability to sense those changes is one thing, but it is also your ability to adapt at the boundaries themselves.

This is a challenge for us all in terms of thinking about how we adapt our organisations. The tendency is that we drive decision-making and adaptation into the centre, and the centre will drive. The question is, is it better for the centre to be more stable with a longer-term vision and direction and mean line of advance but allow the freedom around the boundaries to actually do that quicker adaptation?

There is an analogy there not only for our Force Development cycles but about how we develop our people as well. Boyd had the notion, after studying conflict over the millennia, that to understand how to adapt more quickly, it is necessary to get inside the OODA loops, into that orientation phase. It was about the issue of having a variety of options. As Charles Darwin said, it is the ability to adapt; not necessarily the strongest or the smartest, but the *ability* for the organisation to adapt. Therefore, to adapt you need a variety of things that give you greater coping mechanisms.

There is variety. Then there is the speed of your adaptation as well. If you cannot rapidly adapt either at the periphery or in the centre, that is when things start to fall foul. Harmony is also a key point. That is about having a shared vision – a

unifying theme, a mission intent. Without that harmony from the centre, it is hard for the periphery to adapt consistently with a shared understanding of where you are from a societal perspective.

The final point is about initiative. You must take the initiative. More to the point, and to quote Boyd, 'Those who is willing and able to take the initiative to exploit variety, rapidity and harmony – as the basis to create as well as adapt to the more indistinct – more irregular – changes of rhythm and pattern, yet shape the focus and direction of effort – survives and dominate'. Or contrariwise, those unwilling or unable to take the initiative to exploit variety, pity and harmony, will either go under or, at best, adapt to survive only to be subsequently dominated further on.

Fascinating. What does this all mean? If we are seeking to connect a number of disparate organisms, the like-minded, to form a larger ecosystem in which we can both adapt to survive and adapt to thrive, we need to dramatically improve our boundary interfaces and, importantly, enable those boundary interfaces to adapt in their own organic way. This is critically important if the resources necessary to sustain our organism are dependent upon being fed by others. This is the global interdependency challenge. This is the central idea around sovereign resilience.

But building up sovereign resilience in and of itself will only contribute to enabling our organism to survive, perhaps, only for a little while longer. We still shape and are shaped by the external environment. Therefore, to adapt and thrive, we need to interact with the environment. That interaction happens morally, mentally and physically. But the essence is that the interaction is human. Those who are not connected – those who are isolated from the environment – will fail to adapt and,

at best, will only survive, but are more likely once again to be dominated. Our resilience, therefore, is predicated on human interactions, not solely data sharing or materiel sustenance. We need to increase how we physically interact, whether it is through training, education, forums like this or shared understanding, but also mutual respect.

As we say in the fighter community, you build up greater situational awareness by listening and not talking. Big ears, little mouth. We need to also provide a level of freedom and discretion for exploration at the boundaries to test and adjust. Having a unifying theme is important, but if we need to prioritise investment – and I take great credence from of those who have studied and analysed this in detail before – then it should be as John Boyd's priorities are: people, ideas and then things.

When we are thinking about our weight of effort, are we teaching people not what to think but how to think? There is a lot to be said about that. Said another way, it is about people in leadership. As Boyd said, monitored leadership. Monitored leadership from a mission command perspective is a model more organic in its nature that enforces the delegation of authorities and enables the workforce to operate at the edges, to adjust at the periphery, to be quicker with adaptation – to adjust, change and adapt.

Those are the fundamentals for where we need to move forward. We cannot predict what is going to happen next, and these are four possible futures are taken straight from popular contexts [slide shows four dystopian futures]. However, they are not necessarily so far-flung in terms of their absurdity to ask that question, as also postulated by Air Chief Marshal Binskin. Just because it is unprecedented, that is no excuse to be unprepared.

Regional perspective on the future operating environment – trends and challenges

Air Vice-Marshal Andrew Clark

Chief of Air Force, Royal New Zealand Air Force

Tena koutou katoa. Greetings to you all. It is great to be here today. The drawbridge is back down, you will be pleased to know, out of New Zealand. Once again, thanks to Air Marshal Hupfeld for bringing us together. New Zealand is one of the smallest countries represented here today. As such, an effective rules-based international system is central to our security. The piecemeal challenges to that system that we have seen over recent years have caused growing concern, and now the outright violent rejection of that system that we are witnessing is a rallying call. The survival of our rules-based order will depend on the strength of our collective determination and our sustained attention span over time. So, this is the context for the future operating environment. I am going to add a few words about that today from the New Zealand regional perspective.

Now the 'region' means different things to different people, so I want to narrow it down within the wider Indo-Pacific. I will be talking about the Southwest Pacific, which is a more immediate neighbourhood. We have quite an expansive definition of 'neighbourhood' around here, and it still stretches from the South Pole to the equator and from Australia halfway to Chile. It is still a fair chunk of the Earth's surface. I have to say, from an international security perspective, there are times when this large neighbourhood of ours seems to slip into obscurity. Right now, with the world's eyes on the other side of the globe, it might seem like one of those times. Someone from a much larger country than mine once described this region as strategically irrelevant because of its remoteness and small populations. At the time, I was a bit younger, and I was offended at first. That is, until I considered that strategic relevance is not necessarily the same as being a nice place to live. But the simple fact of the matter is that in the twenty-first century, nowhere on Earth is remote enough anymore. Nowhere is immune to the big trends that matter. They are truly global. What happens in Eastern Europe, or anywhere else for that matter, affects our region – especially when we are dealing with challenges to the rules-based

international system by powers that have a truly global reach. Rules that are successfully unpicked or violated in one part of the world are simultaneously weakened in other parts, including in our own neighbourhood.

A glance at the South West Pacific suggests that the region's security is all about water – that it is about trade routes, crime routes, maritime power, maritime claims and maritime challenges. There is no denying that is part of the picture. But despite the remote and disbursed populations, the region's security should, more importantly, be focused on the people. When the people here are secure and resilient, trouble finds it more difficult to get a foothold. There is less need and less room for malign economic or military influences to establish themselves, have freedom of action or threaten the security of others in the region. And it is the people-to-people relationships that endure.

Security is undermined here by those who fly in and fly out with opaque and one-dimensional interests, who remain aloof from the people who live here and their many cultures. Security is enhanced here by people who are known, transparent, trusted people who invest time to listen – people with history. That should not be surprising because that is what a good neighbour is.

However, sometimes, we look too quickly to solve our geographic and technical challenges at the expense of the human element. New Zealand's most recent defence assessment, completed last year, highlighted two key trends in the region that are increasingly going to challenge the security of those who live there. Those two trends are climate change and strategic competition.

Four years ago, the countries of the Pacific Islanders Forum signed the Boe Declaration on Regional Security and, among other things, declared climate change to be the greatest security threat to those who live in the region. Climate change is shifting the foundations. It is bringing more frequent and more extreme natural disasters, it is altering

the economics of major fisheries and income sources, it is undermining infrastructure, and it is threatening water and food security. Ultimately, for some countries in our region, the threat is existential.

This is a long-term issue that will gather momentum, and it is one that systematically weakens existing social, economic, and political foundations and exacerbates existing risk factors, whether it is good governance, debt levels or the need for external humanitarian and security support. Meanwhile, strategic competition like climate change is also a global phenomenon, as countries, including Russia and China advance their own visions for a different global order based on increasingly nationalist narratives.

Of particular relevance for our own region are China's conflicting approach to th UN Convention on the Law of the Sea, its fusion of military and civilian activities to pursue interests, its cyber activity, and its use of economic leverage.

Climate change and strategic competition will not play out separately. They will combine to complicate existing vulnerabilities. Major humanitarian assistance and disaster relief (HADR) events become more frequent, requiring more support from the state to may be competing for regional influence. Resource exploitation, for example, oil and gas or fish, from anywhere between Antarctica to the equator, may increase outside in rules and agreements and be enabled by military support. A military base or dual-use facility may become established in the region by a state that does not share our values or security interests, ultimately threatening the broader security of those who live in the region.

These regional trends are slow-burning strategic ones that do not respect short attention spans or distractions. We will need to be able to tend to current emergencies wherever they occur on the globe while continuing to take proactive and pre-emptive care in our own neighbourhood.

Pre-emptive care starts with awareness. From an air and space perspective, maritime domain awareness (MDA) across the region's vast distances has long been one of the major challenges. MDA is essential for fisheries protection, transnational crime and military movements. But most of the time, most of the world has not been particularly interested in the South Pacific, which means neither military nor commercial air and space coverage of the region has ever been very good.

That challenge stretches beyond just MDA into communications as well, especially when it comes to high southern latitudes. However, innovation in air and space is now promising to bridge that tyranny of distance for us. The air environment UAVs have obvious utility for persistent access to remote areas. In space, the opportunities are even greater. While the cost of commercial space base services has fallen, the availability and capability have increased. In the main, these are not exquisite capabilities; they are not one-stop-shop constellations that can solve the MDA challenge.

However, as individual constellations or services, they are building a layered picture, whether providing electro-optic imagery, radar detection, imaging or autonomous intelligent systems (AIS). These growing space capabilities are layers of cheaper constellation and layers of information – not a single solution.

To me, this is a positive step in building our resilience from a regional security perspective. This resilience becomes even stronger when we add our multinational military layers. So, increasingly, this aerospace innovation will increase our awareness in a more cost-effective and resilient way. At least in a technical sense, which is often our default setting as aviators. It also offers a different challenge to us in the human dimension that we will have to think about. These new air and space capabilities are becoming more remote from the visibility or experiences of other human beings. UAVs do a poor job of engaging with people. Space assets might as well be invisible.

As previously mentioned, security in our region is strongly linked to the people of the region. It is about human relationships and being present. Our challenge will be in humanising the security advantages that are possible with new technology. I suggest we will have to do that through a greater sharing and co-ownership of the information. While the capabilities themselves will be more invisible, we can increase their regional security value if there is a shared regional investment in the information that flows from them. In a sense, it is another way of being present in our own neighbourhood. We need to encourage greater co-ownership and a common regional security enterprise with commonly held information at its core – both military and commercial. How else will it be possible to confront the information warfare threats of the future? How else will we hold a shared view of what is true? How else will regional governments make well-informed decisions about security while retaining their autonomy?

It will require from us a mindset of greater transparency even as our technicians try to solve the headache of variable information security access that comes with it. One only needs to look at current operations globally to see the value of information transparency. It is not achieved without risks. It might not even prevent open conflict, but a stronger collective response is more likely.

We have other opportunities to improve the resilience of regional security. Interoperability between regional partners builds resilience. Involving more of the neighbourhood and areas such as mission support, air movements and logistics can all strengthen the sense of a common security enterprise, and that is very much the kind of enterprise that South Pacific leaders called for in the Biketawa Declaration of 2000. In essence, this is neighbourhood countries managing neighbourhood security.

Meanwhile, in the air, it is clearer than ever that high-end military capabilities will be needed to ensure security in our

region in the future in light of the strategic trends at play. But that does not mean we should overlook low-cost, low-end capabilities as well. Light, multirole aircraft provide good presence, interaction and utility throughout the region in a proactive way. Again, it is about layers.

The future security environment of the South West Pacific will be increasingly challenged by the big trends, which will combine to weaken the region's foundations. There is good innovation in air and space technologies that will help us manage that. Still, in harnessing those technologies, we need to ensure we do not undermine the people element. More than that, we have an opportunity to put information at the heart of a shared regional security endeavour. Resilience can come from layers, transparency, strong co-ownership and strong relationships, and so innovation should follow in those veins.

I want to note that progress does get made, and regional resilience has been made, and it is useful to think about what that progress looks like in practice. The fact is, it is often invisible because it is about the things that never happened. For example, just in the last five years, there have been major cyclones that have hit Vanuatu and Fiji that, even 10 years earlier, would have required external involvement from other countries. These events were largely self-managed.

I will leave you now with one even more invisible example. Four years ago, a small fishing boat set out from Tuvalu. It broke down and became lost at sea. For decades, these kinds of events required another country to send an aircraft 2,000 miles or so to assist. On this day, though, the fishing boat had a 406 MHz distress beacon, and the fishermen activated it, it was detected by search and rescue satellite aided tracking (SARSAT), the information was shared between New Zealand, Fiji and Tuvalu and they were rescued by another boat from Tuvalu. It is not an exciting story that never made the news, and it is not a big deal. But boring can be good in the South Pacific. Resilience can be a story of many small things done well.

International perspective on the future operating environment – trends and challenges

Lieutenant General Jacob Luyt,
Commander, Royal Netherlands Air Force

Air Marshal Hupfeld, thanks for bringing us together again for this unique occasion. After two years of COVID-19, I think we are all glad to be able to meet physically again. Thanks for organising that and allowing us to be here together. It is good for us all as we sit here, although on the other side of the globe in Europe right now, there is a war going on. Who would have thought a few weeks ago that that would happen? That stark realisation of what is going on in Ukraine is also something that drives home what is going on right now, and that is that the world as we knew it only a few weeks ago has changed. The way I always like to talk about this realisation is that in the Netherlands, in the western part of Europe, we look around us and we see how far away from us, 90 minutes, 1,300 km from our capital, in Amsterdam there is a war going on. The same distance from Amsterdam to the south of France; that brings

home the message that the war is closer to us right now in Europe than we would want it. In those three weeks that we have been in that operation with the NATO allies, we have learned many lessons already. In this short talk, there are a few things I would like to share with you about that.

I would also like to connect that to some of the trends and challenges I see in our air and space domain as we work together as a coalition. The image below shows a map of Europe: Artic, Cross Domain, Arc of Instability and Easter Borders and depicts our neighbourhood right now in Europe with an aggressive Russia that invaded a sovereign nation, Ukraine. With much activity connected to that, including a vast flow of refugees, with more than 4 million out of Ukraine flowing into Europe and other nations. That brings home the message that something is really happening there.

In the north, we see everything happening there is related to climate change; the water is becoming more available, different flows are happening there in the high north and the Scandinavian countries. As the Dutch forces, we are looking at what that means to our security. In the south in the Sahel region in Africa, there is a lot happening there; many operations we are conducting with the nations together, and we see also the threat of terrorism. It is still there and will not go away for the foreseeable future, as we expect. On the left-hand side of this slide, you see some other domains that overlay all these things happening in Europe, things that are happening in the space domain. Space is becoming more contested, so what does that mean for the availability of products we need from space?

We see the effects of cyber activities, and that is cyber connected with info wars, it is also fake news, those kinds of things are also injected into what is happening with the war in Ukraine and the effect it has on our people and the way people view this war and look at its facts and realities. On the next slide, there are a few things that are connected to the phase we are in in the war happening in Europe, the operation we are in as NATO right now.

First of all, grey-zone ops. For the last 20 years, I would say it was almost a neat division between war and peace. Peace we had at home, in Europe – we were safe and secure – and the operations we have done over the last 20 years have been expeditionary. We have done operations in Iraq, Syria and Afghanistan, and we were involved in operations in Africa. Obviously, we were also involved in operations nationally. The pandemic we have witnessed and are still in – the last bits of it, at least let's hope so – is also an example of a national operation that I think all

nations had a big impact and the military also played a role. That is normal in war and peace.

The operations of choice that we have been involved in have now rapidly changed to a war of necessity. That is all about defending our NATO alliance against threats, in this case, from the east. It requires almost new rules sets because now we are operating not in this clear-cut situation of war and peace, of at home and away on a mission somewhere far away, but we are in this grey zone where within our nations, we are generating sorties. This goes for all of us, and I am looking at the European Air Chiefs here. We are all involved in these operations, generating large amounts of sorties from our airbases, flying sorties from our home bases, about one hour away to the eastern border of our NATO alliance, flying long missions, five to six hours, with air fuelling and sustaining that for a long period. It eats up many hours right now. At any one time, there are hundreds of aircraft involved in this operation on our eastern border, and it eats up a great deal of capacity. It forces us to ramp up our sustainment efforts, and this is just for the operations as we are doing them right now, which is basically air policing.

Imagine what would happen if Mr Putin decided to cross the Article 5 threshold with NATO, which would force us to ramp up the number of sorties we fly and the efforts we put into this operation and what that would do with our sustainment efforts. That is something – with shrinking air forces over the last 20 years – that brings home the realisation that we need to invest once again in expanding our capabilities and increasing numbers as well. A second point on this slide (see image below) is understanding. If there is one thing we have learned from the operation that is going on right now, it is the importance of understanding

what is happening on the ground, in this case, in Ukraine and its neighbouring countries, Russia, Belarus, the Baltics and the nations around the area that we are talking about. Other things we have learned are the importance of understanding indicators and warnings and investing in capabilities that allow us to understand them better.

The realisation for most European countries is that we need to take steps forward there. Right now, we are still relying a significant amount on US assets that have been deployed from across the Atlantic to Europe. And we need to work harder on working out that part of the puzzle as well, creating situational understanding. What does not make that easier – and I am seeing this also as a nation that operates F35s and aircraft with the special axis program – but if you have many of those special access programs in operation, you will see many stovepipes starting to exist. You will have to ask, how do we cut across those stovepipes so the cutting-edge technology can connect and talk to each other so that, as a coalition, we can share the situational understanding much better.

There is a big risk of creating stovepipes with all these high-end capabilities. In the end, it is all about deterrence. What we are doing now as NATO is putting a clear line in the sand on how far Mr Putin can go. Sending a clear message about deterrence helps bring home the message to him. Then the question becomes, what does deterrence mean now, and what will it mean in the future? How will we posture ourselves as air forces? Flying missions from home base, but also forward deploying, doing more dispersed ops across our nations, how do we organise that, how do we ensure we can generate sorties regardless of which airbase in Europe it is from? Those things that were common knowledge in the past before we went into all the expeditionary operations, we now need to rediscover and determine how to be most effective in that arena.

A lesson we have also learned from being in this operation is that lead-turning is once again important. Lead-turning – which is a term fighter pilots know well – is trying to understand your opponent, trying to understand what the opponent will do, trying to predict their actions will become more important. That will also go back to information sharing. As a coalition, how effective are we, how well do we understand the need to share information such that we have a common operational picture and we can act accordingly in that grey zone? Speed and robustness, the two combined, I would say, is really something that we know as airmen and airwomen, this operation shows, really the understanding the importance of speed. It is vital that we know what is going on and have a pushbutton available as an alliance, as a coalition, to react rapidly.

In that sense, the classic understanding of speed is something that we as pilots understand really well; it makes us – as has been talked about within NATO circles now – that air is really the manoeuvre force. Of course, there is a great deal of activity in the land domain, with a great deal going on the eastern borders of Europe, and there is a great deal going on in the maritime domain, but air is the manoeuvre force right now because we are able to react quickly and respond with effects that are timely and relevant.

Looking to the future and looking towards trends in general, regardless of operation, it is not just about speed itself but also our speed of change. Are we able to accelerate our change in all those developments in airpower such that we can meet new scenarios rapidly? Robustness connected with that is also about mass – about being able to operate 24/7 again, generate sorties from our home bases, and having the numbers being able to operate in two shifts. Trust me, when I look around the room, I think there are a couple of Air Chiefs here with us, including myself, that look at their organisations and say, 'We built an organisation over the last 20 years that is really equipped for one-shift operations'. And now we are going to two-shift operations again, so we need larger numbers and we need to sustain that.

Robustness is also about fourth- and fifth-generation integration, and I think we have invested in that with our F35s all of our nations with fourth gen assets. What we are seeing now is that we are effectively able to employ both assets together to be really effective. But it is also going to be more and more about men and women teaming. I would like to put a challenge to this room: we need teams that can operate in a swarming environment in about four or five years. Are we able to do that? Can industry provide us with that option in that short time?

We have heard a great deal about resilience already. So I will not go into all the definitions. But I would translate resilience not just in the info domain or the cyber domain, which is another whole topic. When we talk about resilience, this operation we are in right now in Europe has driven home to us the fact that it is also about physical resilience. So, are we able to protect our people in our nations? Are we up to the task? It is a whole-of-government task, not just the military that needs to do that. The age that we are in right now drives home that message that we need to invest in those kinds of capabilities as well.

I would like to close with unity. Given the scenario we are witnessing right now in Europe, but also in any scenario, unity is our best weapon, and as we sit here together as nations from all over the world, I think unity is something we continually need to work on. Unity is about standards; it is about being able to operate and train together with our weapons systems. Our men and women are really good at that. We can be confident in that. But it is also about relationships. Events like this, and once again Air Marshal Hupfeld, you have created an event where we can work on those relations, and that is an important part of providing the unity that is part, a very important part, of the solution in all these scenarios that we will be working as a coalition.

Industry perspective on the future operating environment – trends and challenges

Mr Hugh Webster

CTO Boeing Australia

Good afternoon distinguished guests, first nations people, ladies and gentlemen, on behalf of the entire industry thank you for the opportunity to talk to you about industries perspectives on the future operating environment.

This story begins in an office building in a city centre, behind a door where a team of analysts have spent most of January and February pouring over Defence Strategic Guidance; they have been looking at open-source reports and soaking up classified intelligence reports. The group were methodically building a picture of regional politics, economic forecasts, social and environmental issues and future technology trends in Asia and South-East Asia region out to 2030. They have looked at the implications for the ADF – what are the threats? What are the capability and readiness levels that Defence needs? But they were not ADF personnel, they were not Defence civilians, they were a team of Boeing former operators, engineers and strategists who were tasked with figuring out what the ADF really needs in the coming years so we can make the right set of decisions relating to innovation, investment and the workforce.

The million-dollar question is, what did they find? Like many strategic intelligence reports, the conclusions were pretty sobering. Our assessment was that the capability gap between what Western Defence forces need and what you have or are going to get, is large. Integration, and interoperability across the joint force is desperately needed, but slowly being delivered. The cost to sustain increasingly more complex weapon systems is steadily growing; the pace of acquisition process reform will never solve that capability gap because its fundamental design addresses internal process contests rather than warfighter capability contests. These latter contests will fall to those forces who are best equipped and trained for the conflict at hand; military advantage will depend not just on the training of military personnel but on how quickly the Defence industry can develop, deliver and sustain capability for Defence in time of dynamic need.

Industry is concerned that without philosophical and actual reform and then acceleration, our forces will not be adequately able to deal with the threats in the coming decade. This is not just an Australian situation; the US DOD's annual Industrial Capabilities Report stated that the Defence industrial base has reached an inflection point in its history regarding the balance between its vulnerabilities and its opportunities for modernisation and reform. Our situation is structural; there has been a steady decline in Defence industrial capability facilitated and encouraged on the industry side by free-market forces that value shareholder outcomes and reward behaviours like outsourcing and offshoring. On the Defence side, value for money evaluations that favour the lowest cost for acceptable capability discourage capital and technology investment. Further, the entire machinery is sustained by an ageing and shrinking workforce. This cannot just be solved with more money or a little bit of Australian ingenuity where we cobble together something novel using chicken wire and fence posts; it will require a large-scale industry and Defence rethink, innovating not just what we acquire but also innovating how we acquire it.

Our combined challenge is to create and sustain a Defence industry based advantage that is enduringly innovative, leverages the breadth and diversity of Australian and international expertise, and continually delivers real sustain capability outcomes for the warfighter. That this is not just about who can best deliver the next generation of aircraft, ships and tanks, we also need to adapt emerging technologies from the commercial sector and merge them into military use on top of our legacy platforms. For example, there is a long list of exciting technical things I would like to bring into the hands of the warfighters, like artificial intelligence (AI), biotechnology, autonomous systems, non-kinetic weapons, robust C2 and comms, hypersonics, quantum products, and the internet of military things.

The interesting thing about that list is that they are revolutionising commercial markets in addition to Defence

and unarguably are being invested in by non-Defence companies in orders of magnitude greater than Defence R&D planners could even plan. However, if we just cherry-pick individual bits of attractive technologies and try to shoehorn them into stovepiped programs, we are going to relearn the very lesson the Pentagon learned with its third offset strategy. Without the systemic rethinking of the relationship between Defence and this new industry base, the operational benefits of all this new technology will be minimal, and the road to get there will be hard.

Two issues to be explored include how do we field, scale, and sustain these new technologies into Defence at a much faster pace, and does the rapid evolution of technology give us an opportunity to rethink what the 'life of type' means? And whether attritable platforms with skinnier support systems are more effective investments because we plan to replace them in any case. Do we need new Defence or government organisations not just to create policy for innovation and industrialisation but to actually together achieve those outcomes?

Of course, modernisation and the technology revolution on top of Defence's existing recapitalisation plans will all affect the Defence budget bottom line. If we move from a traditional mentality to something that includes these continual capability uplifts or evergreening, as the Navy calls them, budget pressures will only increase. But there is an upside, though. There is strategic value in signalling to our adversaries and to our Defence industries that we are going to back our talk about technical superiority, innovation and Defence resilience with real money. Such a clear plan, backed by a detailed roadmap timed together Defences vision, such as AI and internet of military things, provides clarity to industry and stimulates innovation investment Take for example, the Australian Space Agency, who recently published capability roadmaps for seven national civil space priority areas cost-cutting technology areas that support those, and then back to those with new investments.

I mentioned at the outset that a vital plank is innovating not just what we acquire but innovating how we acquire it. Capability acquisition processes tend to favour a top-down, requirements-driven approach, but this leaves little room for innovation. Large, formal contracts with highly prescriptive plans, processes, specifications, and penalties leave no space to innovate, particularly if there is a chance of failure of the technology. Avenues for companies to offer new ideas and technologies are small and tend to focus on off-the-shelf, existing things. Innovative capability development requires adaptable, affordable, and agile processes. Defence needs to take a hard look at the Capability Life Cycle (CLC) and acquisition machinery where we often see risk conservative, linear, probity-driven processes ultimately to Defence's overall detriment. If we were to use our generational language, it is like we are trying to acquire and innovate a fifth-generation force using, at best, third-generation

processes. If you are buying information-aged technology such as software or doing complex systems integration then you need to use modern, best-practice acquisition and development systems. What does this mean? This means driving agile practices not only into our acquisition systems and contracts, but into our programs and cultures. We need to embrace things that commercial software development companies do and, as a result, fundamentally reform the belt and braces nature of our Defence contracts. We need to develop and allow novel execution and program strategies; we as industry need to come to grips that everything will not be procured through some big programs of record. Sometimes programs are going to be a series of many, many small projects that incrementally deliver capability to the warfighter much faster.

The acquisition of space domain awareness systems is a good example of how this might play out. In an early tranche, Defence is selecting up to three 'data as a service' providers where Defence actually owns no infrastructure, while lower Technology Ready Level (TRL) level tech is given an opportunity to mature in the later trenches. We need to encourage these flexible and innovative approaches. There needs to be increased collaboration between scientists, acquirers, operators and industry professionals. There needs to be greater industry engagement during early requirements and capability phases, and by that, I mean in operational and technical workshops and not just with our Managed Service Providers (MSPs) and 'above the line' contractors.

There is a model that is already bearing fruit for Defence. The Force Design team have lent forward and is successfully engaging in four different ordinarily competing prime Original Equipment Manufacturers (OEMs) and conducting workshops where the engineers are sitting side-by-side in the same conference room, helping to collaboratively build Defence's Integrated Air and Missile Defence (IAMD) system of systems. So it can be done. Innovation also means looking at how we develop our capabilities; we need to do more prototyping, then experimenting, then fielding, then using and take that process, rinse, and repeat. We need to do more Force-level work in labs, prior to operations. Several of the prime companies have integration labs here in Australia, and many Small-Medium Enterprises (SMEs) have great capabilities.

We need Defence to bring these together and do some 'risk retiring' integration work. Defence will need to solve some heady US export issues, and industry will need to work hard to resolve intellectual property concerns. The overall size and composition of the defence industry also offer some insights into other innovation challenges. Industry can be characterised as bimodal with a large number of smaller SMEs and primes but very few mid-size companies. Across the Western world, there has been a long-term decline in the capacity of the industry base.

What structural things do we need to do to restore that? What role does innovation play in that? How do we broaden the industrial base to incorporate those non-traditional partners developing commercial technology that is quite a novel? Do we do it by throwing away valued Defence industry expertise related to unique things like military air readiness and security? Security, in particular, is a considerable challenge for the Defence industry. Faced with increasing security on Defence networks, attackers are turning to industry networks instead. Just like Defence, with sustained and increasing cyber threats, threats related to intellectual property, espionage and hacking are a daily challenge for our IT teams. The challenge is to ensure that industry is resilient and Defence weapon systems are secure without adding many new cyber security requirements that drive compliance costs spiralling upwards or stifle the very innovation that Defence is going to depend on in the future.

A future industry base that includes these non-traditional partners is an exciting future, not only because of the technology that Defence can leverage but the diversity of the workforce that then becomes available. However, this is a double-edged sword since the wage-based cultural expectations and security clearance readiness of these people will be a challenge. But if we can solve those things and bring the smarts from the Silicon Valley campus into an original equipment manufacturers (OEM) prime like mine, then Defence has the opportunity to gain the benefit of that sixth-gen thinking, and we have the opportunity to solve some of those structural ageing STEM problems.

All this needs to happen within a reimagined innovation ecosystem; sometimes, we apply a lens that innovation is just about R&D, that it is only something the DSTG or CSIRO or a handful of small groups do. I would argue that the innovation ecosystem needs to be thought of as much broader than that. Yes, research and prototyping need to be done, but we also need to solve the effective transition of that capability into service, and that means agile software

development at scale, large-scale military equipment manufacturing, in-service support and possibly even export. This is an industry-wide endeavour that needs a range of organisations to build resilient innovative sovereign capability.

The keys to success are tight collaboration, which means teaming and partnerships, and joint programs with Defence, operators, acquirers, and engineers working side by side. For example, our Airpower Teaming System brings together diverse companies with strengths across the value chain, and then we work as one with the Commonwealth team to design, to manufacture and flight test. In this sense, the Loyal Wingman itself is delivered with a team of Defence and industry wingmen.

Thinking more broadly about the whole Defence industry ecosystem, what does that collaborative thing look like at scale? Are there new organisations required to facilitate primes, SMEs and Defence researchers to drive technology into service as quickly as possible? What is the balance of public and private funding that will make this succeed? How do sustainment companies who are aiming to evergreen the Defence system reach back into that innovation value chain?

To conclude, building innovation and resilience in the Defence industry for the future operating environment is a demanding challenge, and – even with a small number of factors that I have outlined here – a multifaceted approach is required. We need to transform our current CLC systems so they focus on innovation and agility focus. We need to modernise acquisition processes. We need to find new ways to organise, fund and drive private sector innovation so that tangible warfighting outcomes are delivered quickly. We need to knock down barriers that stifle industry innovation between allies and partners. Above all, we need to remember that while our organisations sometimes want to conduct endless reviews that generate mountains of PowerPoint charts, our adversaries are busy building warfighting capability. The time to innovate is now.

Air and Space Power Manual launch

Air Marshal Mel Hupfeld,
Chief of Air Force

Good afternoon all; as alluded to in my opening address, today, I am very proud to announce the publication of the 7th edition of our Air Power Manual and the very first edition of our Space Power Manual.

These manuals represent an evolution in our thinking about air and space power, moving away from service-centric roles and missions to properly situate them inside the enterprise of our nation – and within our community of like-minded nations.

Reflecting on the Australian experience of air and space power, I do not think there has ever been a time in our history where the unified purpose of the ADF under One Defence has been so strong.

That is why it is important to make it clear to all – especially those more junior members in our virtual audience who collectively represent the future of air and space power – that I am not only speaking to you today as Chief of the Air Force, I am speaking to you as the Air Domain Lead and the Space Domain Lead for Defence.

Throughout my tenure as Chief, I have been impressing on our aviators the importance of expanding their expertise outside of the air or space domain – to appreciate how those domains intersect with all others in pursuit of common purpose.

We cannot contribute fully to the Joint Force if our knowledge is limited to just one or two of the five 'operational domains', especially when they are all interwoven in the real environments in which we operate.

Our integration as part of the Joint Force is already extensive, but one of the things I want to impress upon you today is that the days of traditional thinking about Navy, Army and Air Force as independent arms are far gone.

One of my goals as Chief of Air Force has been to ensure aviators understand our tradecraft in terms of the effect those capabilities have on our environment in concert with other ADF and whole-of-government elements, along with those of our interagency partners and, when in coalition, with our allies and partners.

The 7th edition of the Air Power Manual and the 1st edition of the Space Power Manual are intended to expand thinking about the future possibilities of air and space power from an Australian view, with a regional context and support the necessary development of air- and space-mindedness within Defence.

To summarise both manuals in a not so short sentence:

Air and space power contribute to joint effects as part of the military instrument of national power for the purpose of supporting whole-of-government efforts in pursuit of national objectives.

As our thinking about the application of air and space power has evolved, so has our thinking about how people best engage with the ideas articulated within such manuals.

That is why I hold in my hand – as you can also do if you reach into your gift bags – a physical copy of our new Air Power Manual. It looks and feels like what we have come to expect, even if its content has evolved somewhat.

But these are just a limited print of the manual – so we can have it physically with us here today – hard copies will not be sent out by the thousands throughout the Air Force as has been the case with previous editions.

The Space Power Manual is different, and its development challenged our way of thinking with respect to the content, and, critically, how we reach and educate our current and future force. It has been so challenging that it reminds me of our Air Force motto – per Ardua ad Astra – through struggle to the stars. Without challenges, however, there would be no reward. I am excited to say that we have produced an electronic manual, with links to YouTube videos and online references – aimed at the digital natives who serve in our ADF.

The manuals can be amended as quickly as we evolve our thinking with changes in the strategic environment. For space power, this will be rapid as we accelerate our knowledge of the domain and operationalise our space capabilities.

Of course, the option to create physical copies always exists – alongside opportunities to be innovative with both
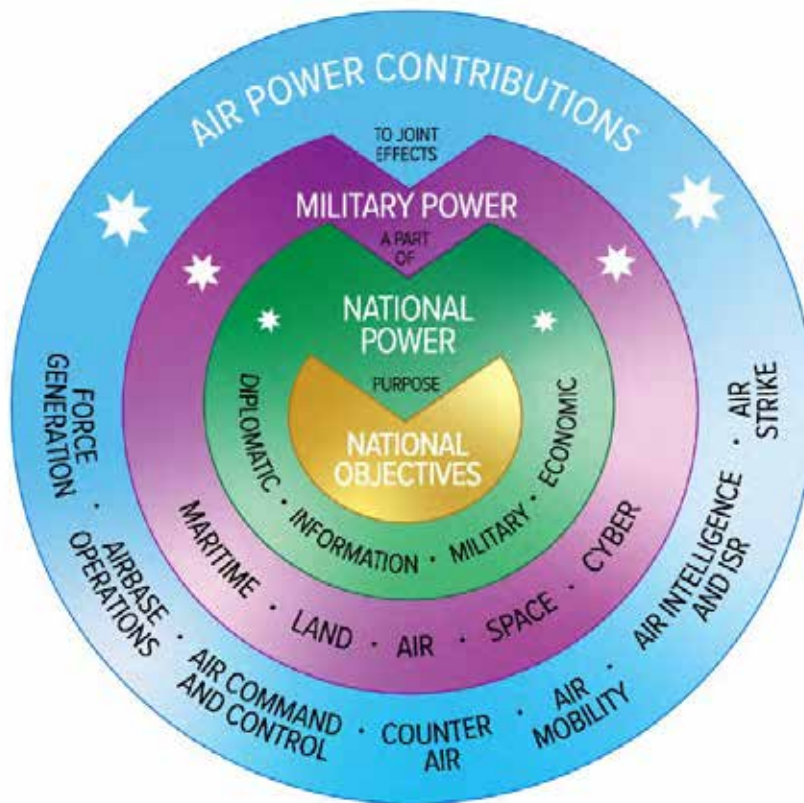
Air power contributes to joint effects as part of the military instrument of national power for the purpose of supporting whole-of-government efforts in pursuit of national objectives.

manuals to make them as attractive as possible to those who consume information in various ways across all generations.

The singular master versions of the Air Power Manual and the Space Power Manual are hosted on the Air and Space Power Centre's website, and they are living documents.

They will only ever be a few clicks away regardless of what device you use to connect to the internet – our virtual audience can easily access them right now by simply searching for the Australian Air and Space Power Centre – or typing in airpower.airforce.gov.au (https://airpower.airforce.gov.au/publications).

We want the content of these manuals to reach and educate the broadest possible audience, as we recognise that the generation and continual renewal of resilient and relevant air and space power require engagement across the entire enterprise of our nation and beyond.

I encourage you all to actively engage with the Air and Space Power Centre to provide feedback on what works best for you to achieve this end.

Both manuals outline the foundational properties of their respective operational domains.

For the air domain, this includes its ubiquity and the potential that holds for the application of military power, along with the human–technology relationship required to unlock that potential.

This is also true for the space domain, but the ubiquity of the space environment expands to be truly global in nature – the ultimate high ground for activities on and off our planet.

While focusing on space, it is important to note that advancing Defence's space power relies on a shift in thinking that moves from us from being a consumer to a contributor, recognising we are operating in an increasingly contested domain.

Both manuals highlight the essentially human endeavour of air and space power and resist viewing this simply as a collection of platforms. We aim to create professional masters who are not only experts in air and space power practice but also skilled and adept in the collective outcome.

While technologies and systems are important, they are only one part of what enables the delivery of military power. Without people intelligently wielding them, cutting-edge technologies serve no real purpose. Both air and space power practitioners need to be not only technically adept

but also strategically aware and understand their place in the Joint Force and their responsibilities to government – they must strive for professional mastery to maintain an intellectual edge.

These manuals serve several nested aims. First and foremost, the manuals exist to support the training and education of those who will employ and enable air and space power.

They also situate military power within the Australian strategic context, highlighting that the generation and employment of air and space power is not an end in or of itself – its purpose is to achieve national objectives.

To achieve this, the manuals present the theory of air and space power, albeit at a high level, and note the military power contributions model to explain the practical aspects of its employment.

The contributions framework is designed to expand thinking on the possible application and utility of both air and space power. It aims to ensure they, as a part of military power, are continually enhanced to best support national objectives.

The contributions framework seeks to avoid arbitrary divisions and implied hierarchies; rather, it is designed to promote the integration of air and space power capabilities with all other aspects of military and national power.

The Australian Government, like all governments, uses national power to pursue national objectives. We define national power as the total capability of a country to achieve its national objectives, devoid of external constraints and without being subject to coercion.

National power is generated through a complex set of interdependencies among departments, agencies and organisations.

National power can be described as having four principal instruments: diplomatic, information, military and economic.

In the context of Defence, air power is focused mainly on contributions to the military instrument. However, it can also provide support to the other three. For example, Humanitarian Aid and Disaster Relief operations will use Defence to support a nation affected by disaster while also helping shape Australia's diplomatic and economic interests.

Space power is different. It still focuses on contributions to the military instrument of national power, but with a much broader focus from the start across all instruments of national power. Space is critical to our way of life – banking, navigation, weather, communication and even our national broadband system. In that context, space power is closely linked to our civil agencies, and there are many continuous national missions, not just military missions.

Australia's military strategy, as a component of national strategy, describes the manner in which military power should be developed and applied to achieve national objectives.

For the ADF, the Australian Government has outlined our military strategy through the three Strategic Defence Objectives of shape, deter and respond: deploy military power to shape Australia's strategic environment; deter actions against our interests; and, when required, respond with credible military force.

Pursuing these objectives requires more than simply providing a military response after the occurrence of an event that negatively impacts our national interests.

These three overlapping and concurrent objectives require the military instrument of national power to be postured to continuously contribute to shaping, deterring and responding through a range of military activities. This also demands that military activities be aligned and coordinated with whole-of-government efforts.

The concept of pursuing national objectives by creating outcomes through the employment of national power, including military power, is not new. War has long been considered 'the continuation of policy with other means'.

The instruments of national power have always been used in efforts to change an adversary's beliefs and behaviour – which we refer to as effects. These effects concentrate on outcomes and how they may be achieved – ends – rather than the mechanisms and tools that enact them – ways and means.

The military effects that support the pursuit of national objectives can be delivered from tasks in support of civil authorities through to the application of lethal force. They also come from any mix of military capabilities from across all the domains of the operating environment.

While Defence has divided up the operational environment into domains, it is important to keep in mind that military operations themselves are conducted within a singular unified environment – the real world. Our world is indivisible, complex and dynamic.

It follows then that every operational environment is comprised of all the domains interwoven and is interdependent with the information environment.

While boundaries are drawn to allow for the practicalities of resource apportionment, prioritisation and accountability, it must be recognised that these boundaries are self-defined and therefore both malleable and porous.

The ADF embraces a multi-domain approach to harmonise the contributions from each of the domains into the Joint Force – emphasising the importance of thinking laterally about the full range of capabilities available. Wherever possible, the ideal is to incorporate agencies, departments and domains into a single cohesive network.

What is crucial to the utility of the multi-domain approach in Defence is that there are practitioners with expertise in each domain involved in designing and developing military

capabilities, along with planning and conducting military operations.

These manuals aim to ensure air power and space power practitioners have the foundation on which to develop and grow to be effective within this construct.

The fundamental nature, characteristics and operational considerations within both the air and space domains cannot be adequately covered in this presentation – but they certainly are within these manuals. I encourage you all to engage with them and become involved in the constructive debates that will help to improve them continually.

These manuals are designed to give readers the mindset they need to be creative and encourage their curiosity – to best enable air-minded and space-minded practitioners to conceive and build the Joint Force contributions we need to meet future challenges.

The air and space power manuals' highest aspiration is to expand thinking about the future possibilities of air and space power.

Innovation comes from learning, critical and creative thinking, experimentation and practice. These manuals are written to give the reader the widest possible aperture to figure out what next.

This is the most important message within both manuals – the future of both air and space power is you.

This message is especially important for our large virtual audience, many of whom have long and influential careers in air and space power left in front of them. I certainly expect many aviators at all levels to be tuned in. We all have an important role to play.

Air and space power is realised through the ability of humans to use technology to unlock the latent advantages of these operational environments for any given purpose.

It is this air- and space-mindedness that underpins the ability to integrate effectively with those less familiar with our profession. To act as leaders in these domains, with good awareness and relationships, where possible, with others active within them.

Alongside mastery in all other operational domains, professional mastery of air and space power are essential to crafting optimal Joint Force contributions that best support whole-of-government efforts to achieve national objectives.

It is in this spirit of collective efforts for a unified purpose that I welcome my fellow Domain Leads to address the conference and then join me to discuss whatever issues you wish to raise – starting with the Chief of our senior Service, the Royal Australian Navy.

Air and Space Power Manual launch

Vice-Admiral Michael, Noonan
Chief of Navy

First of all, I acknowledge the Traditional Custodians of the lands on which we meet today, the Ngunnawal people, and I pay my respects to Elders past, present and emerging. I also pay respect to the Aboriginal and Torres Strait Islanders who have served in our ADF in times of peace and war.

I would like to pick up with my brief remarks today where the Chief of Air Force left off – on the notion of curiosity because it is only through encouraging professional curiosity that we take calculated risks and that ultimately that we will succeed as a Joint Force. I am reminded of the excellent series called Military Effectiveness, edited by Alan Millet and William Murray. In the first volume, Paul Kennedy, and I am paraphrasing here, concludes his chapter by saying that a rare kind of imagination allows us to plan for not only the current state of our profession but also for its future development. Without that imagination, that professional curiosity, we are unlikely to be effective in the first place.

So, from the outset, I would like to recognise and acknowledge the great contribution that the air and space manuals are making to encouraging and enabling curiosity and, of course, imagination. The Air Power Manual, in its seventh edition, has come a long way since the very first edition, and this is indicative of the growing maturity of thinking around and about the importance of air power in the ADF. I note and commend the use of language, airpower practitioners who are found not only in the three Services but throughout the public service and, of course, in the Defence industry. This is a really good way of encouraging, and making more easily and accessible, the relevant information that is so important to all of us.

The same logic applies to the development of the Space Power Manual, and it is in a very good place. How do these manuals contribute to the Joint Force and, at the most fundamental level, by making them relevant to all of us? That is the way in which all airpower practitioners will consume, digest, and ultimately make this information their own as they apply it in their own domains. It would be remiss of me as the senior Service not to point out that the first naval aviation flight from one of our ships occurred 105 years ago from HMAS *Sydney I*, when she launched the very first aircraft from a warship on 8 December, 1917.

Why do these manuals mean for the integrated force capabilities? And, if you have an integrated force, you first need to understand the elements – the components, if you will – that you are integrating. The creation and exercise of power in all five domains is a substantial undertaking.

If I focus just on sea power for a moment, getting a ship to sea safely, reliably and predictably is a significant undertaking. It is one that stretches beyond the people in our uniforms and the partners in government and industry. We rely on education – on academia – and we rely on the skills of others to support us at sea. Of course, this can be said in all five domains. It is only once you have a level of understanding of a domain that you can start to consider how it interacts and relies upon those other domains.

So, how integration is best achieved? What is necessary, and what is sufficient? You *can* begin to understand all the things you can do and distinguish them from what we *should* do. So, these two manuals, which have been launched by the Chief of Air Force today, will be essential reading for all of us because the knowledge that they impart and the thinking that they invoke will be necessary for all of us to operate in an integrated force, and that is essentially what we are and what we will continue to aspire to.

Air and Space Power Manual launch

Lieutenant General Rick Burr
Chief of Army

I congratulate the Chief of Air Force on the launch of the Space Power Manual and the updated Air Power Manual today. Great to be with you all, and welcome to everyone that is here, in person and virtually and in particular those from overseas. It is great to be back together again, and I also take this opportunity again to acknowledge Air Force's 100 years, a celebration last year that was disrupted, but this serves as one of those opportunities to all come together, celebrate, and recognise what has been a tremendous first century.

These manuals are indicative of the thinking about how we embrace the next 100 years. It is recognition that, like land power, air and space are not the domains of any single Service. They are important to us all. This is reinforced by the fact that we are all here as the professional heads of our Service, but also as the Domain Leads. In Army, we talk about being ready now but also future ready, and unsurprisingly, the Air and Space Power Centre have invested a great deal of thinking to ensure we are prepared for the challenges of tomorrow.

The interplay of technology, geopolitics, and economics is an exhilarating change in the character of war. I am focused on ensuring Army, in support of the Joint Force, is prepared for the challenges and uncertainties of the future. Advances in space power, as an example, are enabling new technologies and tactics in the land domain. The democratisation of space is creating new and unique threats to land forces to compete and win in what we are calling accelerated warfare; land forces must orchestrate effects across all domains and integrate with like-minded partners and allies. The more cohesive and integrated network our Force is, the more effective we will be in achieving our strategic objectives of shape, deter and respond.

The need for interconnectedness competes with the need for greater dispersion and survivability. Unifying domains allows the land to be connected and dispersed at the same time. Now, and increasingly so in the future, Army's teams will need to contribute more to air and space power and access other joint capabilities at ever lower echelons. Air and Land have always worked together to achieve military objectives. Since the early days of the Army Flying Corps

in 1911, Army has been providing aviation reconnaissance, airpower support, battle power and surveillance for ground forces.

New capabilities have proved or are under consideration by government allowing Army to better contribute military power enabling the ADF to shape, deter and respond at the heart of the nation. To deliver some of these capabilities and be set for the demands of continuous competition or conflict, we are proactively redesigning our organisation's command and control arrangements. In December last year, we established Army Aviation Command as part of this important work.

Army Aviation Command has been organised to strengthen command, leadership and management of increasingly complex systems and, in turn, strengthen air-worthiness and air-mindedness in Army and help enhance multi-domain operations. It will coordinate the introduction into service of new helicopters and unmanned aerial systems and enhance the effectiveness, sustainability and safety of our current systems. This is important, for example, as we replace the ARH Tiger with the AH-64 Eco Apache Guardian, with its much more capable weapons systems and sensors and enabling integration and teaming with unmanned aerial systems. Already a prolific user of unmanned aerial systems, this area will only increase in scale and complexity, including the potential for armed capabilities in due course. I expect we will deepen cooperation with the Air Force's Air Warfare Centre to develop concepts and tactics further.

Similarly, in air and missile defence, we are introducing – as we speak – the enhanced National Advance Surface-to-Air Missile System (NASAMS) to the ADF, which will ultimately nest within the broader AIR 6500 air defence project. Within the future investment in long-range fires and land-based maritime strike capabilities, Army is considering raising a fires formation to centralise, optimise and integrate integrated air and missile defence and strike capabilities being introduced into service. All these capabilities support not only the land but also the Air and Space Power Centre, extending the reach, capacity, persistence, and presence of the Joint Force.

Army's contribution to space power is also not new. However, the launch of the Space Power Manual today is extremely timely as we are all absolutely focused on that, in a more unified way. Technological advances in both military and commercial sectors are accelerating, and the number of actors who use space is increasing. As the ADF continues to conceptualise and implement diverse workforce requirements, expertise will be drawn from Army's existing workgroups that are specialised in electro imagery analysis, radar surveillance, ballistics and electromagnetic spectrum operations. Many of these specialists reside within Army's Sixth Brigade, which is responsible for generating Army's air defence formation, ISR and electronic warfare force elements. These skills are readily employable in the space domain now.

Our satcom professionals are pioneering how Army maintains assured access to a contested space domain. These people have been posted to a long-standing engagement with the US satcom support Centre-Pacific where we provide officers and soldiers in support of satellite planning and operations. In addition, Army personnel are now embedded in the US Space Force. We are building the expertise to introduce Defence Project 9358 Phase 1: space electronic warfare.

Space provides the higher-ground advantage over land forces. Space power enables land forces to be connected and disposed of simultaneously through access to space-based systems for global positioning, navigating and timing, satellite communications, targeting intelligence, surveillance and reconnaissance mapping and weather forecasting. The generation of space power will require more, though, than just the employment of space systems. It will demand a coherent, joint and integrated culture in the space domain. Increasing the awareness of space power within Army will be a critical part of this cultural development.

Indeed, last year at the Chief of Army's Symposium in Brisbane, Mr Enrico Palermo, Head of the Australian Space Agency, joined us to discuss the journey that we must all go on. We must understand how each of the constituent parts of military power is enabled by the other. This prepares people for roles across the ADF, expands our thinking and will ultimately contribute to success in multi-domain operations.

I will finish by discussing Army's people, of course. Army's workforce will continue to contribute to the development of air and space power, but this technical experts and as Joint Force fighters. This Friday, I will promote to Brigadier Christopher Gardiner, who will be the ADF's first Director-General of Space Operations within Space Command. Our people are the strength of everything that we do. It is people who make stronger and more capable teams and build strong partnerships between the Services, other nations and with industry. Army is focused on the future workforce challenges as we seek to leverage more talent and people in our community to realise some of the ADF's military capabilities. They are already out there. Last Friday, I was in Lismore visiting our Service people supporting the floods, and I came across a young Army Reserve Signaler. I asked him what he did when he was not doing his Army time. He was a spacecraft engineer. He was also a signaller in the Army. We must harness these specialist skills. I think we are all absolutely determined to do so. Our doctrine – and training and education – remains pivotal to maintaining our professional mastery and intellectual edge, and the launch of these two manuals is very welcome, providing the framework necessary for people in any Service to embrace and enhance air and space in support of unified domain operations.

Air and Space Power Manual launch

Rear Admiral Ian Murray

Chief Joint Capabilities

Good afternoon to all of you here and to the many more participating virtually in this 2022 Air and Space Power Conference.

I would like to start by congratulating Air Marshal Hupfeld and the Royal Australian Air Force on today's release of two excellent publications:

- the 7th edition of the *Air Power Manual*
- the 1st edition of the *Space Power Manual*.

Much has changed since the first edition of the *Air Power Manual* was published 32 years ago, in 1990. The changes made in this 7th edition and the content of the new *Space Power Manual* clearly demonstrate Air Force's focus and commitment to the One Defence approach. Evident in both manuals is the clear understanding that achieving integration across the five warfighting domains is essential to generating a joint force capable of effectively contributing to national power.

Before we commence the plenary session, I will take this opportunity to briefly highlight some of Joint Capabilities Group's contributions to air power and space power and raise some considerations on how the ADF might seek to generate and deliver joint effects in the future.

As the foundation of the Joint Force, my group's capabilities enable and are embedded in, the generation and application of air power and space power.

Joint Capabilities Group's mission is to *prepare warfighting and support capabilities for the Joint Force in peace and war.*

JCG and its spectrum of joint enabling capabilities are unique in Defence and exemplify the One Defence approach.

As Acting Chief of Joint Capabilities, I am responsible as Defence's lead for the cyber domain. Since the establishment of the Joint Capabilities Group, including the Information Warfare Division, just under five years ago, significant progress has been made to enhance Defence's cyber capabilities. During this relatively short period, it has become increasingly apparent that emerging capabilities

managed in the cyber and space domains have changed the strategic environment in ways that have made the boundaries between warfighting domains less clear and more tightly interwoven.

The ubiquity of the space and cyber environments are now truly global in nature. This creates an opportunity for effects in these domains to be applied without the geographic considerations that have traditionally been so central to actions in the maritime, land and air domains.

While all other warfighting domains are closely interconnected with the cyber domain, the realisation of capabilities in the air and space domains is particularly reliant on effective *air-cyber integration* and *space-cyber integration*. Through the Information Warfare Division, JCG leads Defence's cyber domain comprising three principal parts: cyberspace, the electromagnetic spectrum and the information environment.

The cyber domain is joint by nature, and Joint Capabilities Group delivers three key programs in the cyber domain that are central to the delivery of air power:

- the Joint Cyber Program
- the Joint Command, Control, Communications and Computers Program (more commonly referred to as the Joint C4 Program)
- the Joint Electronic Warfare Program.

The capabilities delivered by Joint Capabilities Group in the cyber domain both enable operations in the physical domains and are reliant on physical operations and assets. Air domain, space domain and cyber domain capabilities must continue to be developed and employed in close cooperation. Realising integration between the domains is essential for our future operational success as a Joint Force and with our coalition partners.

As *airpower practitioners*, you will know that 'dependency' is the first operational consideration for the employment of air power. Joint Logistics Command, as one of the commands in the Joint Capabilities Group, is an integral enabler of air power systems. Though the national support base, it maintains supply chains to enable the sustainment

of airbases and specialised naval assets from which aircraft operate and facilitates the provision of aviation fuel and EO payload replenishment, delivers spares, maintains ground support equipment and coordinates joint movements.

Within another command of the Joint Capabilities Group, the Australian Defence College is working closely with the three services to soon release the Australian Joint Professional Education Continuum 2.0. The increasing connectedness of our joint professional education and domain-specific education is clear in the two manuals released today. Air power mastery and space power mastery, encapsulated in the concepts of *air-mindedness* and *space-mindedness*, are nested in the joint concept of professional mastery. Together, our joint and domain education continuums prepare personnel with the domain expertise and the joint understanding required to build the Joint Force.

Our education and training systems recognise that while embracing technology is important, warfare is essentially a human endeavour. It seeks to foster the human–technology relationship required to unlock the potential of capabilities. An important dimension of our future-proofed joint professional education system is recognising when and how to off-load lower-order cognitive activities to automation through human–machine teaming while simultaneously exploiting augmented cognition for the most challenging problems.

I would also like to highlight the work of Joint Capabilities Group's Sovereign Guided Weapons and Explosive Ordnance (GWEO) Enterprise, which is improving Australia's stock surety and supply chain and developing Australia's GWEO industrial base. The enterprise's work highlights the interconnected nature of all elements of national power, including economic and industry, to generate and sustain the Joint Force. The success of the GWEO Enterprise is inextricably linked to the successful application of air power during the conduct of war.

Throughout my career, I have observed the evolution of the joint approach to warfighting. With the continuous changes in Australia's strategic environment, we are increasingly recognising the need for a joint approach to raise our effectiveness and deepen our interoperability.

Chief of Air Force just commented in his address to launch the *Air Power Manual* and *Space Power Manual* that every environment in which the ADF operates comprises all five domains—maritime, land, air, space and cyber. The boundaries between the domains are useful for Defence to manage the practicalities of resource apportionment and accountability. They are, however, self-defined and provide us with an opportunity to consider how Defence can most effectively and efficiently structure and generate capabilities that build the future ADF Joint Force.

Over the next two decades, Defence will grow by 18,500 people. Much of this growth will be focused on enhancing joint capabilities. As we develop this larger, more joint force, the evolving strategic environment will make the practical divisions between the five domains increasingly porous. We must consider which capabilities are best generated by the Services as Domain Leads and which might be better delivered in a consolidated or collaborative model as joint capabilities or delivered by our industry partners. These conversations will challenge traditional structures and ownership models. However, even with future growth, the ADF will remain a relatively modest force asked to deliver significant capability. Siloing limited capabilities within domains will not always deliver efficient or sufficiently connected capability to the future force. Growing a larger ADF with more Joint Force elements will require trust between Groups and services. As we have embraced a One Defence approach in recent years, I have seen the trust in our joint capabilities continue to grow.

To conclude, I would like to thank each of you participating in this 2022 Air and Space Power Conference. The broad participation from across Defence and by our partners is a great reflection of our One Defence approach. Our future successes as a Joint Force will be underwritten by our collective commitment to develop and nurture the joint approach.

Keynote address: Reflections on establishing the US Space Force

General John 'Jay' Raymond,
Chief of Space Operations

It is really great to be here, first of a kind Air and Space Power Conference. Great to be here in person and do it without masks on.

To Air Vice-Marshal Roberts, congratulations on being selected to lead the newly operational Space Command. I have had opportunities, as highlighted, two new organisations over the last three years, first US Space Command and then US Space Forces the I have a pretty good understanding of the challenges you will face, but also the opportunities you will have as you build this command for great effect for your country and for nations around the world.

Australia has long had an important role in space. And if it went for Australia, those of us old enough to remember 1969 would not have been able to watch in real time Neil Armstrong descend from the Eagle land and take those first steps on the lunar surface. That is because, of the three antennas that were transmitting this historic broadcast, two were Australian. Because of the moon's position at the time, there was no dish in the United States that could pick up that feed. So a radio antenna at Parkes Observatory in New South Wales stepped in and transmitted that broadcast to 650 million people around the world, who were glued to their TV sets. Among them was a 7-year-old young boy named Jay. And I remember those few minutes very clearly, they changed my life forever, I remember my Dad was in the military, we were based at Westpoint, New York, and I sat on the living room floor and watched those critical events, watched those first steps and immediately turned around and went to the dining room table and built an Apollo rocket. That began my love of space. So, thanks, on behalf of me and the other millions of folks that had an opportunity to see that, for being there at a crucial time.

Another story, a few years later, I was stationed in Germany with my parents. And I had my appendix taken out. I was at home for a couple of weeks recovering and had to do a report in Australia, and I did this spectacular report. And it solidified my love for wanting to come and visit this country, and so I had not had until 2012. I got a chance to speak at Baker's Creek Memorial, a small town built this to commemorate and recognise the airmen who were killed in a World War II plane crash. I remember getting to the airport and going up to get a rental car thinking: I have the full day and I will explore Australia, and I pulled out my driver's license and ID card, and low and behold, my driver's license had expired. In the US it is not a big deal because it you are in the military, your driver's license never expires. But I learned that this rule does not apply in Australia they said you can go home and rent a car there, but you cannot do it here. So I got a chance to Sydney hotel room but I got a chance to participate in an incredible ceremony and I will talk more about that at the end of my talk. It highlighted to me the value of partnerships between admissions. That partnership is alive and well in space.

My point for bringing up Australia's role in the 1969 broadcast is also because Australia still plays a crucial role in space. A lot has changed since 1969 but the United States is located exactly where it was back then, squarely in North America. We have good visibility over part of the globe from our vantage point but your location in the southern hemisphere, it makes for a really great team, we each bring to the table with the other cannot. We are stronger together and our cooperation goes well beyond space – the last century proves that across all domains, our nations are stronger when we are together.

I'll talk some more about our areas of mutual cooperation in space in a few minutes. But, first I want to start off by congratulating you on your recent initiatives to prioritise space from the funding boost that the Australian Government has recently announced and given to the space sector, to the publication of the Space Power Manual, and most importantly to celebrate with you the concrete steps you are taking to operationalise the space domain. With the formation of your space division in January and the formal ribbon-cutting of that new Defence command later this morning.

I want you to know you are in good company. As we got the space up a few years ago, several of our other partners and allies have also joined in elevating space to the level of importance for their nations. So why now? Why this recent movement to reorganise our forces for better understanding and operating in space? For starters, space is just cool! I always say that back at home, all the cool kids want to come this way, but I have known that since I was seven years old and I wish I could say that that alone was what was turning our attention upwards – to what is going on 100 km above the Earth's surface. But the reality is more complex.

First off, space has become necessary to our modern day of life. From navigation, to precision timing, banking, agriculture, climate change mitigation, and so much more. We all make use of space assets every single day whether you realise it or not. Our reliance on space is only going to continue to increase over time.

But more importantly, we can no longer take space for granted. A few years ago, would not have stood up here and say space and war in the same sentence, but the actions of a few nations in space have made this ultimately, that space is a warfighting domain but we cannot operate under the illusion that our assets in space, which we rely on heavily for our security as well as for our way of life, will remain safe from potential adversary reaction. We no longer have the luxury of taking space for granted. If we were to lose our ability to use our space-based assets, it is not just our space operations that would be impacted, our land, sea and Air Force missions cannot close without space.

Many of you here, or those that are watching online from around the world, who have served in Iraq and Afghanistan where US, Australia and many other allied nations conducted operations side by side on the ground and in the air. Space was a key enabler in most of those operations. And today, more than ever, we see the value of space in providing awareness of events around the world from natural disasters to missile launch warning. No matter where you are, your security in some way depends on space. And on our ability to access the data, collected by our on-orbit assets and the security and effectiveness of our joint coalition forces depend on space.

As I said earlier, we are partnering with more and more nations on the national security space front. And we deeply value our partnerships with those that are here in this room with us today. Perhaps most important example of our collaboration is an area of space situational awareness. In November 2013, we signed a memorandum of understanding that relocated the space surveillance telescope from the United States to the Harold E Holt naval communication station in Exmouth. After it was reassembled in 2019, US and Australian forces jointly performed operational maintenance on the telescope and after calibration and recalibration, some testing and evaluation and a trial period, that will start this July, the space surveillance telescope will be operational by the end of this year. Thanks to its new location here in Australia, the telescope will have observation over the southern celestial hemisphere, adding a significant data collection capability to our coalition forces.

I just want to add I will be visiting Exmouth tomorrow and I could not be more excited to see the space surveillance telescope, and the folks who are stationed there in Exmouth. But it is not just the SST that we have worked on together, and 2014, our two nations along with Canada and the United Kingdom, signed a combined space operations (Cspo) memorandum of understanding, to help us all get smarter on the current and future space environment and to enhance our military to military relationships in this area. Later, New Zealand, France and Germany also joined, understanding that the true multilateral nature of this initiative. And after meeting late this year, this February Cspo will release the combined operations vision 2031, which outlines our overarching purpose and reiterate our guiding principles, namely: keeping space free and accessible, ensuring responsible and sustainable use of space, and upholding international law.

Another area of cooperation is the Advanced Extremely High Frequency, or AEHF system, a consolation of communication satellites that provide services not just to the US forces, but to Canadian, Dutch, UK and Australian forces. Thanks to AEHF, our combined forces, whether on the ground, sea or in the air can make use of vastly improved global survivalable and protected communications capabilities.

One last example is the wideband global satcom system – or WGS – another strong area of cooperation between our two nations. With Canada and the Czech Republic, Denmark and Luxembourg. The Netherlands, New Zealand and Norway are also partnering with us, WGS provides flexible, high data, long-haul communications for our warfighters and is the backbone of military satellite communications.

The programs I have mentioned are just the beginning. I hope to continue to strengthen our collaboration in space, on many examples of many projects here to come. And that is because we all have so much to gain, by working together in space. Went we partner with other nations to share our security interests and our basic values, we benefit in several ways.

First off, we share costs. As military leaders, we must be responsible stewards of the resources our nations allocated to us. We must find ways to develop more resilient capabilities without breaking the bank. Through the commercial space sector, we see a rapid expansion, you could even say it is exploding, that is a bad word to use in the space business. We are seeing more competitive pricing throughout the space sector

Second, we share knowledge, experience, and expertise. For example, we have two Guardians embedded within the Royal Australian Air Force and eight Royal Australian

Air Force personnel embedded in the space was. We have plans for these numbers to grow and we have similar personnel exchanges with several other close allies and we value all of them. These personnel exchanges allow us and our people to train together, to operate together, and build strong lasting relationships. Which enhances our Force's ability to conduct real-world missions when needed.

Third – and even more important – by standing together, we bolster deterrence; decreasing the chances of aggressive acts, both in space and the other domains. Working together helps us move faster in our urgent goal to remove our legacy space architecture which is made up of very small numbers of highly exquisite satellites and we want to replace that with a more resilient network, one that can withstand the contested environment we face today. By doing so we will also eliminate the first mover advantage a potential adversary have if they would think to take action first. Our cooperation and collaboration enhances security, stability, and sustainability of the domain and therefore of the world.

And now I would like to offer a few reflections on our own stand up. Just over two years ago, on 20 December 2019, the United States established this new Service, the first time we have had a new Service since the Air Force was created in 1947, separating from the Army. I hope some of the thoughts I share might be of some value to you as you think through and begin building this new Space Command.

The Space Force is an independent Service like the Army, Navy, Marine Corps and Air Force and similar to the Marine Corps – which is organised under the Department of the Navy – the space Force falls under the Department of the Air Force and we remain very tightly linked to our sister Service, our Air Force. Our secretary of the Air Force Frank Kendall, has championed this relationship with his motto of one team, one fight and we live it each and every day. That same year 2019, a few months before the Space Force, we established the 11th Operational Combatant Command, the US Space Command. It is commanded by General Jim Dickinson, who is with us here today. It is a joint unit – analogous to INDOPACCOM – so if you look at it in our structure in the US, we have both Services and Combating Command. Services organise, train, and equip operational capabilities under the authority of a Combatant Commander. And so we have normalised that structure across our Services and Combatant Command as it relates to Space.

As a military Service, the Space Force recruits, trains and equips Guardians. These guardians operate capabilities all around the globe, again under the authorities of US Space Command. The Space Force works across the whole of government to maintain space security, and the differences I have observed between the time – just two years ago and now – are striking.

And so now, let me share two things we have done again, as a precursor to things you might be thinking are well. As we stood up, I told our team we have two risks, the first is we do not think bold enough, that we make some incremental changes. We have been given an opportunity to build a Service with a clean sheet of paper and to move at speed and build a Service for today, not trying to make incremental changes of a Service that is much older. And the second risk we have is that when we do think bold, that the bureaucracy will get anyway and keep us from being able to implement new ideas. And so, I would guess for my Australian partners, if I were to give you one piece of advice, it would be bold and go big. We need this command to help us all get to where we need to be in this new operational domain.

A few things that we have made great strides on. First of all was improving the professional development of Guardians. We stood up our own Space Training and Readiness Command – dubbed STARCOM – and Space is no longer a side note of professional military education. That was one area that Congress was pushing on us when stood up our Space Command – they wanted us to increase that. I can tell you having an opportunity to chat with several of your folks over the last couple of days, I want to sit down and pick your brain because there are things you are doing in the Australian Air Force that we think would be ripe for innovation in our Service and I look forward to exploring those with them.

We also have a much greater sense of unity and effort across the Department of Defence. Back in the Space Force was established, it was thought that there was 65 different organisations across the Department of Defence that had a role in space. Sixty-five them could say no, but nobody could say yes. But you now have a Service, and with the Service brings with it a little bit of centre mass that allows you to get some things through the building and to say yes.

We have a much stronger voice in requirements. As a Service Chief, I have a strong voice in requirements and we are part of the Joint Requirements Oversight Council (JROC), which allows us to be the integrator for all joint space requirements, so now if Congress wants to yell at someone, if our programs get disconnected, they have one person to yell at – and that is me.

Our Defence budget reflects the importance of space and although if I were to share our Defence budget today, my career dissipation light would be blinking because it has not been released yet. I will simply say that when it is released, you will see that the Department continues to prioritise Space for our nation, allies, and partners.

Our space-based intelligence capabilities – which reside in several organisations across our government – are also much better coordinated.

And finally, I think the thing I am most proud of – by establishing an independent Service – we can reach out and engage directly with our allies to work on space security together. The result is, in the past couple of years we have been changing our relationship with our international

partners in space from capability development to operations and collaboration across the board with the benefits I spoke about a few minutes ago.

And we need every advantage we can get. Our challenges have been extremely fast-paced and we have got to move faster to stay ahead. Working with allies and partners is one way we can accomplish that goal, to stay ahead. Another way we are working on is to change our acquisition processes to allow us to capitalise on this new commercial industry we have got.

Two years ago, in January, I visited Space-X satellite factory in Washington State, in the United States. And Mr Elon Musk was there, and took me into a factory, it was a big empty room, the size of this auditorium but flat. And there was nothing in it, some tables and some smart people and a vision. He said 'Jay, I have 2 satellites in orbit that I do not like. I am going to redesign those satellites, and then I am going to build this factory and then build satellites, and then I am going to integrate those satellites on the launch vehicle, and then launch them. That was in January. In April, less than four months later, he redesigned the satellites, built a factory, 60 satellites, and launched them. And today he has over 2000 satellites providing internet to the world – including Ukraine. We want to be able to leverage that, when I talked to innovative business folks, they say they are tired of the Department of Defence coming and dropping a stack of requirements to speak on their desk and saying build this. What we would like to do is have a conversation with them and say 'Here is the challenge we are facing, how would you build it?' And that is what we are now doing.

We set up an organisation called the Space Warfighting Analysis Center (SWAC), they are doing our Force Design work for our space capabilities to be able to pivot, from the architectures we have today, to be more resilient by design. We have done all the modelling of that and then called industry in together and handed it to them and said here you go. Here is what we are thinking, how would you do it differently? And get their ideas early on. We have also done

that with our closest partners, and look forward to be able to share those with the goal of being able to collaborate more closely and capability development in the years ahead.

I hope what I have shared can be of some use as you make your own path and prioritise national security space. Before I wrap up, there is one thing I did not mention about my first trip to Australia, that is what I learned. First of all: do not let your driver's license expire. But what I really learned, and what made a profound impression on me then and has stayed with me ever since, when I watched the parade, the town put on a parade at Baker's Creek Memorial. They built on their own to recognise US airmen that were killed during World War II. I watched the parade, put on by the residents of a small Australian town, to honour the lives of American soldiers who had died there over 60 years ago. When I realised only a handful of those present were alive or remember those events, but several generations later they were still not just willing but a sense of duty and honour in remembering our fallen. It gave me a great sense of faith in the power of friendship among nations. And in the enduring gifts that such friendships bring.

So today as we gather to discuss Resilience and Innovation in Space, I like to offer this thought, that this is not just about shifting resources or advancing space technologies or space for space sake. It is about helping to keep the world safe. Is about maintaining space as a realm of peaceful scientific and commercial endeavour, about safeguarding the idea that our universe is open for discovery, and increasingly for human travel. So that tomorrow's seven-year-olds may safely look up at the night sky with a sense of wonder and awe.

Again, I thank you for the opportunity to be here. I have a much greater appreciation for all of our Australian friends when I see you in the US, you do a lot more travelling over there than we do here, it's a long way to go. Thanks for being such good partners and having me yesterday, I look forward to taking any questions.

Thank you.

General Raymond Q & A

[MODERATOR] General Raymond, thank you very much for your words and insight. Your emphasis on the importance of like-minded nations working together will have resonated, as well as your comments on how to advance more efficient capability development. Thank you also for your mention of Australia's role in transmitting the 1969 Apollo Landing. For those who have not seen it, there is a great movie called The Dish, which covers that event in some detail.

[QUESTION] It seems the US Space Forces had only just announced its own establishment of US Space Forces when Hollywood launched comedy spoofs about. Our Space Command was announced yesterday and there are already viral videos. What is the impact of those stand-ups on reputation? Does it detract, or is it good PR?

[GENERAL RAYMOND] It depends. I have an opportunity, there was a show called *Space Force* on Netflix, and season one, came out one year ago. I heard it was coming out and there was a lot of, I was interviewed, someone would ask what my thoughts were on the show. The guy that played me in the *Space Force* show is Steve Carell, and my line to get out of that question was they picked the wrong actor; they should have picked Bruce Willis. Right before the show started I got word he wanted to talk. It was in the COVID era, so we did a zoom call from my office, and he came up on the computer and said 'So, I hear you wanted a different guy?', and I said 'Yes, you have too much hair'. I then proceeded to have a great conversation with him about space. I think it is just a reflection that there is a lot of interest in space, it is not surprising that there would be show is being done here. I think it is a good thing, and we have embraced it, and I think all in all, the publicity helps.

[QUESTION] When does territorial encroachment into space become a major source of international conflict?

[GENERAL RAYMOND] I think it depends. I would not want to speculate, on it. It depends on what is happening around the world. A lot of times I get asked about space war or space deterrence. And what I say is I do not think there is such thing. I think it is just deterrence. I think it depends on what is going on around the world, nations have chosen in history to fight wars and on land and in the air and on the sea, and now they have opportunities to fight in space. I think you have to put into the bigger context of what is going on, on the ground, and I would not want to speculate on what may or may not be considered hostile. You have to look at it in the broader context. I get asked how do you deter in space, deterrence is just fundamental calculus. Imposing costs and denying benefits. There is a way to do that in the

Space Command, there is a way space can help amplify deterrence. Again, without speculating, I think it depends on the broader strategic context.

[QUESTION] You mentioned advice to Australia to be bold. With Australia starting our own space journey, what is it you know now that you wish you had known when you embark on the journey?

[GENERAL RAYMOND] I think the be bold mantra was good. I think it served us well. We moved at a great speed to establish the Service. I think one of the things that we really wrestled with was what is the right size of the Space Force? And what we wanted, the initial plan for the Space Force, for example, for the headquarters in the Pentagon, would be 1,035 people. When I had been stationed there before, there is about 50 space people running around the building. So, what is 1,035 people going to do? We whittled it down, cut it down to about 600.

Our desire was to be small and bold and go fast. I think you have to balance that with you also operate inside a bureaucracy and have to have enough mass to be able to work through and be effective in that bureaucracy. I think we have hit it about right at 600. The first few years, as we were building to that 600, it was challenging just to be able to cover the meetings. I think that is one of the things you have to look at, how do you position yourself to be innovative? Which is really what the space domain requires. You have to move it speed. Things are going 17,500 miles an hour just to stay in space. You have to go fast but have enough mass behind you to get your, to get what you want to get done through the bureaucracy.

[QUESTION] How important is a national approach to space power? Can you tell us how your organisation works with NASA?

[GENERAL RAYMOND] It is really important to have a national approach. There are three different sectors in the US space, there is national security sector, there is a civil sector (NASA) and a commercial sector. All three sectors are really alive and well, the Space Force on the national security site with the US and its partners wanting to go back to the moon here in the near term on the civil side. And then looking even further. And then on the commercial side, I talk about the explosion in commercial space activities. Those three things come together. Let me give an example. A year ago I was down at the Cape watching a NASA launch of astronauts back to the International Space Station from US soil. It was a national launch on a commercial market on a DOD range. We all came together.

I think that partnership and synergy is really important. NASA is focused on science and exploration. We are focused on national security, but we operate in the same domain, we share, we trained together, we educate together. We protect and defend the domain together…protect the International Space Station from for example debris in space. We leverage some of the training tools they had to do rendezvous proximity operations. That was all done for NASA for Apollo missions. So we have leveraged the tools they have worked make sense, where we can save some dollars and moved out at speed. And also I would say we are working on norms of behaviour together. NASA and international partners have the Artemis Accords to foster cooperation for space exploration of the Moon and Mars. As you know, those in this room work together, we also work closely with our partners on norms of behaviour. We think there are some partnerships to be had between the civil side and the national security space. I would say it is very important to take that national perspective. I think that is why in the United States, the National Space Council has proven to be so valuable. Is the only place where all the sectors come together.

[QUESTION] In terms of personal development, do you see unique and straight Space Force careers or do you seek exchange with other areas?

[GENERAL RAYMOND] There was one person in the Space Force when it was stood up on 20 December, and that was me. The Army had a slogan years ago, 'Army of One', no kidding, that was it. We took all the space folks in the Air Force and assigned them to the Space Force. And since that time, we have transitioned them into the Space Force. There are five career fields that came in: operations, intelligence, acquisition, engineering, and cyber. All critical for the space domain.

We went through and sought volunteers and brought them from the Air Force to begin. In this past year we opened it up to other Services as well. We are going to start by bringing in 50 people from other Services and we had 4,000 applications. We upped the numbers now and I think by the end of this year we will have about – do not quote me exactly – around 900 folks who will come in from other Services. Along with some missions that the Army did, it operates a payload on WGS, those missions will transfer into the Space Force really soon now that the Appropriations Bill was signed. And the Navy operates UHF satellites and they are now transitioning in.

One of the biggest benefits we have had on standing up a Service is the advances we have made in professional development. We think we can do things differently and we have more people knocking on the door wanting to come in than we have spots for. We only recruit about 450 per year

and when you only bring in those numbers, you can be really selective in the talent we are getting, not just in numbers, but in capability. It has really skyrocketed.

I was fascinated yesterday when I heard about a program where somebody in the Australian military can go and work for industry for five years and come back. We are looking to get to that same whole-of-nation approach to space. How can we take people from the Space Force, move them to industry, move them to NASA, bring them back – and be more fluid and I think there is a lot we can learn. In fact, when we were building up or studying how we would do our total force integration with the Guard, the Reserve and Active, we looked to Australia as a model on how we might do that. I am eager to explore with you more as we progress down this path.

[QUESTION] Your approach to engage with industry to look at novel ways to achieve outcomes is welcomed, but will be challenged by our slow traditional acquisition processes. You have any more tips on how we can resolve that?

[GENERAL RAYMOND] I gave an example of how, when I went out to visit SpaceX – and that is just one company – if I were to give you another example and say that another company has a GPS satellite orbiting at 11,000 miles above the Earth and I wanted to buy an exact clone, that process today in our military is a five year deal. Juxtapose that with four months designing and building a factory, building 60 satellites, and then launching them. We are trying, as we build this new Force Design, to leverage this new emerging class of space that commercial pushes, proliferates lower orbit for example, and what I have learned is, you cannot just attack the problem with acquisition, it starts much earlier than that.

It starts with how do you design your forces, and if you design your force structure to be three or four or five really exquisite, highly exquisite, highly expensive satellites, you are going to get a different answer at acquisition. It will take you a long time to build it, they are exquisite capabilities and they cannot fail. If it fails, you do not get a do over, you cannot bring it back down and try again. It has to be perfect and that drives a risk calculus and a business model that is different from one that you have something coming off an assembly line, but if it did not work, you have another coming off in six minutes.

So the Force Design piece is critical and our priority here, between now and the end of the decade, is to make a pivot in our structure to a more resilient by design architecture. I think this will free up our ability to use commercial – to a greater extent than today – and frees up incredible opportunities with our allies and partners as we do this

together to build complimentary systems that add to this capability and add to deterrence.

I think the other piece of this is the requirements work I talked about. After you have built the design, you have to turn it into requirements and we are trying to change the way we do requirements on a digital basis. And doing it in partnership, and in collaboration, much earlier within industry.

I do not know how many friends of mine have come up to me and said that you do not understand how much time or dollars industry spends trying to figure out what is in your head. And I say, that is pretty sad because I will just tell them. They do not have to figure it out and spend a dime or a day, I want them to spend a dime in capability. So, we want to have this dialogue early and make sure we have got their best and brightest helping us think through this and getting it right.

[QUESTION] Can you please explain the relationship between the United States Space Force, the COCOM and the NRO?

[GENERAL RAYMOND] I shall will, it can be confusing. I will throw in NASA as well, I addressed that a little bit earlier. When the average American thinks of space, they think of NASA. That is what is visible. They watched man walk on the moon and that has been the public face. But a lot of folks do not realise that the military has been involved in space since the beginning, since the 50s, but NASA has been involved in science and exploration.

In the Department of Defence – there is a law in our nation called the Goldwater-Nichols Act established in the 80s – and that law says there is two different functions in the Department. One function is to organise, train and equip – that is what Services do. Think Army, Navy, Air Force, and Marines… and now the Space Force. The other is a warfighting function and operating under the authorities of those combatants commands. There are 11 combatant commands in our nation: Africa Command, Central Command, Cyber Command, European Command, Indo-Pacific Command, Northern Command, Southern Command, and Space Command. There is a mixture of geographic and functional combatant commands.

So, the Space Force is a Service that organises, trains, equips, operates and provides capabilities to General Dickinson and other combatant commanders around the globe for them to conduct operations each and every day. That is that relationship, it is a normalised relationship just like PACAF [Pacific Air Forces] inside INDOPACOM, a service relationship vice a combatant command.

And the National Reconnaissance Office (NRO) is another great partner with us. They are an intelligence organisation and we partner very closely with them. There is about 800 Guardians who operate, or are assigned to the National Reconnaissance Office, and their mission sets are focused on intelligence, surveillance, and reconnaissance. Ours are focused on missile warning, communications, GPS, space situational awareness, so a different mission set – but with great ties between the two of us.

Defence's space mission, research and education capability at ADFA – UNSW Canberra Space

Russell Boyce

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Established and grown with the assistance of approximately $30m of public money, UNSW Canberra Space has one of the largest concentrations of space researchers in Australia, some 30 academic and professional engineering staff covering all necessary engineering disciplines and with access to the necessary facilities to enable end-to-end space mission capability. UNSW Canberra Space is Australia's most experienced capability for the development and deployment of miniature satellites (CubeSats) and is currently successfully operating its fourth mission for Defence and third for RAAF – M2, launched on March 23, 2021. M2 consists of two advanced satellites that have and will continue to demonstrate technologies for Earth observation (particularly maritime surveillance), Space Domain Awareness, SATCOM and in-orbit artificial intelligence for Defence (see **Figure 1**). Our space research is focused on two core themes: the science of Space Domain Awareness, and the development of intelligent constellations of intelligent satellites. The M2 mission includes research and technology demonstrations in both of these core areas, and is growing Defence's capacity and capability for developing and operating space technologies and training the requisite future skilled space cadre.

In parallel, the Australian National Concurrent Design Facility (ANCDF) operated by UNSW Canberra Space has developed into a national asset for the early feasibility studies and design of space missions. The software engine that underpins it, derived from the French Space Agency and further developed by UNSW Canberra Space, enables best practice concurrent engineering design and analyses to be performed to develop detailed space mission and architecture concepts and test their technical, schedule and budget feasibility against requirements. Twelve studies have

Figure 1. M2 is a twin-satellite mission. Both satellites are equipped with advanced radios and telescopes for maritime surveillance demonstrations, as well as inter-satellite communications and a number of science experiments.

been conducted to date, including with Airbus, the French Space Agency, the Office of National Intelligence, Geoscience Australia, CSIRO and the Bureau of Meteorology.

The team has now spawned three Canberra-based spin-off companies, has established a domestic supply chain of approximately 30 organisations to support the missions, and is a major contributor to the growth of the Australian space sector.

The presentation will explore these various developments and their implication for Defence space capability.

Manoeuvre detection and analysis of the M2 CubeSat separation using optical data

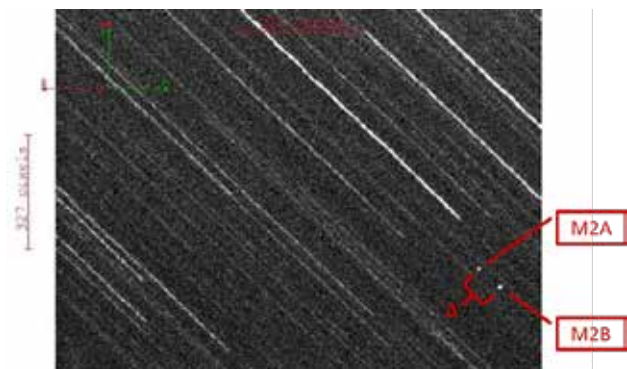Steve Gehly[1], Brenton Smith, Melrose Brown, Andrew Lambert and Russell Boyce
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Extended abstract

The most fundamental challenge of space domain awareness is the accurate estimation and prediction of objects orbiting in close proximity to one another, both to facilitate conjunction assessment and to maintain situational awareness of objects operating in nearby orbits. Optical data collected from ground-based telescopes provides a good candidate for this task. Although radar is commonly used for orbit determination for objects in low Earth orbit, the relatively long wavelengths mean it can be difficult to distinguish multiple objects close together. Optical sensors can detect and distinguish objects even at close separation distances (**Figure 1**), but yield angles-only measurements that can make accurate orbit determination difficult, particularly in sparse data scenarios.

This research examines methods of relative orbit determination using angles-only measurements of objects in low Earth orbit, as exemplified using the M2 CubeSat mission. Launched in March 2021, M2 consists of two identical 6U CubeSats joined together as a single 12U satellite. After completing a series of activation and orbital test sequences, the two satellites performed a separation manoeuvre in September 2021, with radar and optical observations collected by multiple sensors. The satellites have since been operating in a drag-manoeuvre controlled formation.

Using the separation event as a case study, this research examines several methods of relative orbit estimation for the purpose of detecting and reconstructing the manoeuvre, thereby satisfying one of the primary mission objectives of the M2 flight experiment. Estimation results are compared against GPS-derived orbital states downlinked from the satellites and match within 1-σ. Test cases make use of both simulated and real data collected during the M2 separation manoeuvre, and demonstrate the efficacy of relative orbit parameter estimation using angles-only measurements.

Figure 1. Image collected by CMU-Falcon Telescope approx. 5½ hours after separation.

	$\bar{y}_0$ [mm/s]	$\sigma_{\dot{y}_0}$ [mm/s]
Optical	19.7	0.2
GPS	19.92	0.02

Table 1. Separation velocity results.

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Buccaneer Main Mission

David Lingard[1] and Chris Peck

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Extended abstract

Small satellites including CubeSats are a recent paradigm that has significantly lowered the bar in terms of entry to space, even allowing universities to develop space missions. Australian Defence is also exploring this paradigm to better understand its potential military utility including through the Resilient Multi-Mission Space STaR Shot program. One of the first initiatives in this area in Australian Defence is the Buccaneer Program comprising two missions, with the first being a pathfinder 3U CubeSat mission in partnership with UNSW Canberra that launched in November 2017 and operated for just over 12 months (Hollick, et al, 2018). This presentation will focus on the second mission called the Buccaneer Main Mission (BMM) that will feature a 6U CubeSat in low Earth orbit to explore new approaches for calibrating the Jindalee Operational Radar Network (JORN), an over-the-horizon radar network that stretches across the Australian continent. After launch in 2023, BMM will also seek to demonstrate optical communications between space and ground, as well as novel technologies for deploying optical apertures externally to the spacecraft body, thereby allowing the spacecraft to be self-imaged. BMM was announced in a press conference by the Hon Melissa Price, Minister for Defence Industry, in November 2019. In addition, space has recently become a Sovereign Industry Capability Priority (SICP), and Buccaneer contributes significantly through procurement of the spacecraft bus from Australian industry (**Figure 1**). In the spirit of "More, Together" that underpins the Defence Science and Technology Strategy 2030, the Buccaneer Program includes significant contributions from international partners, and Australian industry and academia.
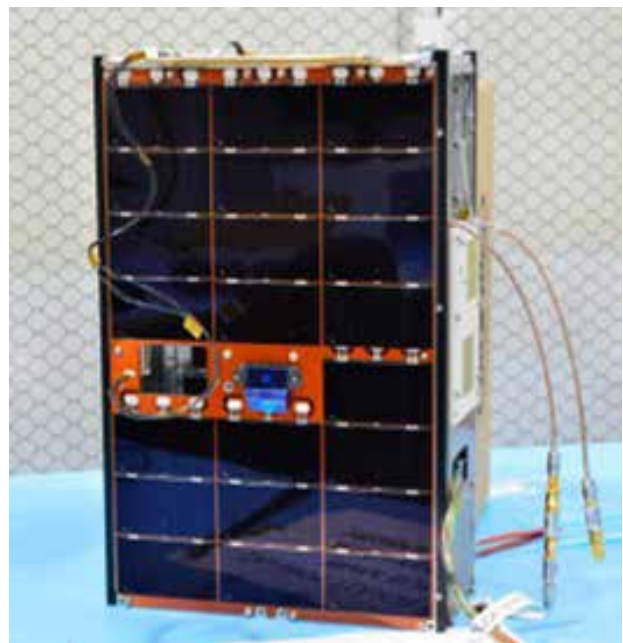
Figure 1. 6U spacecraft bus for BMM from Inovor Technologies.

Reference

1 Hollick, M., Lingard, D., Stevens, N., Peck, C., Alvino, P., Duong, H., Hu, G., van Antwerpen, C. (2018) Buccaneer Risk Mitigation Mission Operations – Lessons Learnt. Proceedings of the International Astronautical Congress, Bremen, Germany, 1-5 October (IAC-18-B4,3,7,x42484).

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Development of space environment testing capability for improving resilience of low-cost commercial small satellite spacecraft and payloads

Harrison Bennett[1], Paul Alvino, Monique Hollick and Christopher Peck

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Extended abstract

The barrier to entry into the small satellite industry is lowering considerably in terms of manufacturing cost, time for construction and cost to launch, enabling rapid experimentation and large constellations. Space has been listed as a Sovereign Industry Capability Priority (SICP) and there is a wide range of space applications that Australian Defence can undertake to achieve its goals in the harsh environment of space. With the shift in the space industry to small satellites using commercial off-the-shelf products, this has reduced standards around space resiliency, and recent results have shown that approximately 40%[1] of all small satellites launched in the past two decades experienced total or partial mission failure (Jacklin, 2018). However, reduction in mission assurance has not reduced the operational mission expectation. In order to ensure a resilient spacecraft that meets the demand for Australian Defence capability, Defence Science and Technology Group (DSTG) has been developing its testing methodologies and capability in relation to the space environment. This presentation focused on the test planning, execution, and early results for the Buccaneer Main Mission (BMM): space thermal testing using a thermal vacuum chamber, magnetometer testing using a Helmholtz cage, life cycle testing using external radiation chambers, and shock and vibration testing using a shaker table as shown in **Figure 1**.
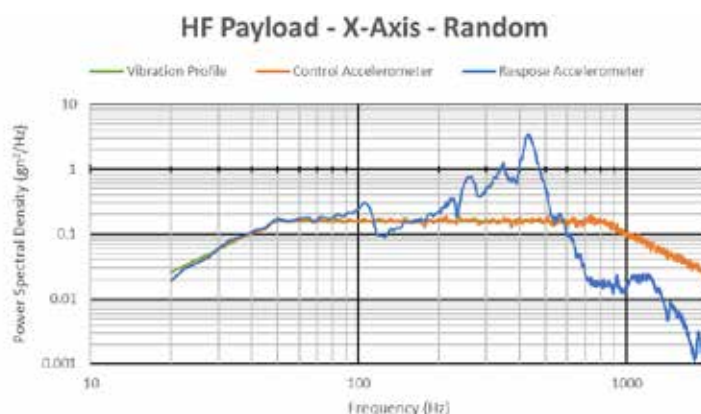
Figure 1. BMM primary HF Payload mounted to B&K table for vibration testing (left) and vibration results in the X-axis (right). The green line represents the vibration profile applied to the payload. The orange line indicates the response of the control accelerometer attached to the base plate. The blue line represents the X-axis acceleration PSD. Shaker table, right.

Reference

1 Jacklin, S (2018), Small-Satellite Mission Failure Rates, NASA Technical Reports Server, NASA/TM – 2018– 220034, Page 3.

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Efficient verification of micro satellite systems

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Extended abstract

Space based capabilities are being revolutionised by the miniaturisation of electronics and decreasing launch costs. This brings about a fundamental change to space system architectures, where space-based systems are increasingly shifting from a small number of large and expensive spacecraft to large constellations of small, lower cost spacecraft.

The trend towards lower cost spacecraft presents challenges for some traditional satellite verification methods. Some of the verification activities adopted for large and long-life satellites can exceed the cost of entire satellite programs.

Modern commercial industry methodologies offer alternative methods for developmental verification that are applicable to small satellite programs. Simulation, hardware-in-the-loop simulation and testing, compartmentalised verification versus whole-of-system verification, and delaying verification activities until the satellite is on-orbit, are all viable investigations to creating a more efficient verification program.

Analysis of project and system risk aid in the selection of efficient verification methods and the structure of a verification program. A lower cost program has inherently lower risk, which guides a different overarching verification framework. Elements of the system have varying levels of criticality for system survival and achieving mission success. It is appropriate to tailor verification methods to match the risk profile of the subsystem, function and requirements being verified, as shown in **Table 1**.

High Risk = Must 'Work'	Fixable = Low Consequence of Failure
Structures	Payload Software
Thermal State	Mission functionality
Power System	Ease-of-operation functions
Communications	Pointing modes/performance
Command and Telemetry	Data storage and transfer
Payload Hardware	

Table 1. Spacecraft subsystem risk categorisation with updatable software.

Towards quantum-secure free-space time transfer

Ben Sparkes[1], Sabrina Slimani[2], Nicole Yuen, James Quach[2], Oliver Thearle, Ken Grant, Andre Luiten[2,3] and Fred Baynes[3]

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Extended abstract

Modern Australian Defence operations have evolved a deep reliance on the precision position and timing signals of the Global Positioning System (GPS). Access to GPS is critical for navigation, battle-field manoeuvring, precision guided munitions, widespread force coordination and secure communication networks. In a contested environment with GPS denial, jamming or spoofing, there is need for alternative resilient and secure position and timing signals.

Quantum time transfer is a potential alternative technology that could be deployed for point-to-point synchronisation of remote platforms. This technology is based on transmitting quantum "entangled" photons between two platforms and using their time-of-arrival to discipline local clocks. The entangled nature of the polarisation of the photons means that the time-transfer signal is secure against spoofing or hacking, and the high level of temporal correlations between the photons will lead to a level of timing precision better than GPS and on-par with state-of-the-art classical fibre-based time-transfer systems such as White Rabbit, which operate at the 10 ps level.

Our project aimed to characterise the performance parameters of a free-space quantum time-transfer system and determine whether it would be a viable technology for sychronising Defence assets in a GPS-denied environment. Towards that end, we have already demonstrated transmission of a quantum timing signal over a 100 m free-space link with up to 37 dB of loss and a signal-to-background ratio of 1:240. With this set-up we have achieved a timing signal precision at or below the 100 ps level. This demonstration lays the first building blocks towards a secure, flexible and locally deployable quantum-secure timing and position network (**Figure 1**).

Figure 1. A distributed quantum timing network can be used to provide a locally deployed GPS-like network for position, navigation and timing.

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Human-AI-teaming for autonomous aerial drones for agile mission planning

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Artificial intelligence (AI) is already part in our daily lives – self-driving autonomous cars are conquering our streets, and how humans team with those to prevent accidents gains more and more of importance. In an aviation context, the trend towards fully autonomous unmanned aerial vehicles is clearly foreseeable and just a matter of time till they are reality. In a defense context today, the effectiveness of a 'small and many concept' of deploying UAVs as key part in defence, has been clearly shown in the war in the Ukraine. Nevertheless, fully autonomous drones bring similar problems to those of smart cars – the integration of unmanned aerial vehicles into airspaces occupied by manned aviation traffic, airspace management, and human factors of how to effectively team humans with AI empowered devices.

Despite the great benefits of unmanned aerial vehicles, they still require a large operational team – pilots, camera operators, intelligence and other ground staff. This yields in a very poor efficiency dividend: people focus on flying the drone rather than focusing on the real mission; fatigue management to cope with routine jobs and cognitive workload; spending hours looking at visuals to identify objects; and lack of efficient communication and collaboration between AI, operators, pilots and intelligence. To cope with these challenges, UXMachines Pty Ltd is working on a cloud-based software solution to support data capture and collaboration between humans and AI enabled drones through analysing cognitive human-AI team performance. The AI empowered software tool allows an enhanced analysis and decision support to gain new insights into the captured data and learn mission critical parameters for future missions. The key component of the tool is a human-AI performance measurement tool, which measures teaming performance and cognitive load to increase efficiency in future missions. The tool is accompanied by an AI empowered octocopter (Kiwi-001), which will be the main test platform for conducting autonomous missions. The goal is to develop a solution where the interaction with humans is on the level of goals, intentions and missions rather than simple flight planning and putting waypoints on a map. The solution shall ease unessential cognitive load and enable 1) autonomous flight planning and 2) autonomous mission execution.

UXMachines Pty Ltd is a Perth-based startup company, which works at the intersection of aerial robotics, data analytics and human factors. Our vision is to team up humans and AI to work jointly on complex tasks and enable collaborative mission execution. We develop smart solutions to enable human-AI teaming for agile mission planning. As alumni from DStart Ignite in 2021, we are greatly thankful to all the members of the Department of Defence Australia, helping us in our journey. The demo video of the program is available on https://youtu.be/2IGpy_sCX2Y. Northrop Grumman selected UXMachines as finalist for the Australian tec and innovation showcase in 2022. More information about UXMachines Pty Ltd on www.uxmachines.com.

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Towards blind micro drone collision avoidance

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Micro drones promise to be very useful devices for remote exploration, especially in urban operations, moving ahead of war fighters in potentially dangerous spaces. Employment as 'pathfinders' to identify terrain, hostiles and possibly booby-traps in place of humans naturally places them at increased risk of attack and destruction. Thus, expensive or fragile sensor systems such as LIDARs are not appropriate for miniature aircraft that must be attritable. Furthermore, these aircraft must operate in darkness, atmospheric particulates and possibly countermeasures that render cameras, time-of-flight sensors and maybe even ultrasonic rangefinders ineffectual.

We propose instead to use the aerodynamic forces generated by a drone's rotors during flight as a sensor. The interactions between the air and surrounding surfaces can be detected by the rotor through the propagation of the rotor's flow field. Small, embedded force sensors integrated in the motors measure these changes and use them to drive a collision avoidance algorithm.

Furthermore, we propose a novel thruster configuration that builds on our prior work on aerodynamic aircraft-object interactions. The mechanical structure of the drone's rotor array causes the aircraft to pitch or roll away from nearby objects through entirely passive means. We have improved this structure to allow for directional repulsion of objects in proximity. By combining the sensing and unsensed modalities, we aim to allow miniature drones to sense and avoid obstacles in any conditions in which flight is possible.

Small drones pose a new threat to the battlefield

Maj. Taro Tsuchimochi and Maj. Hiroshi Nakatani

Center for Air and Space Power Strategic Studies, Japan Air Self Defense Force

This talk will address small drones, the so-called "IEDs in the sky", and will analyse the current situation in which it is increasingly becoming difficult for airbase-based warfare and traditional air defence systems to cope with them. As there are numerous types of UAVs, from small ones to large ones, we will focus mainly on small drones that are less than about 20kg in this presentation.

Small drones are characterised by their low detectability, price and their flexibility. That is to say, they have characteristics not previously seen in the conventional air power, and they can pose a huge threat to air defence capability as follows.

First, small drones' low detectability makes it possible to carry out relatively silent and swift attacks. This character might undermine our geographical advantage as an island nation surrounded by the sea. Now it is time to revise our assumption due to the emergence of drone threats.

Second, one of the disadvantages of air power is its great dependence on base support. The base infrastructure consists mainly of immobile facilities. Furthermore, the aircraft are vulnerable on the ground – however powerful they are in the air. Therefore, small drones could cause a huge disruption to aircraft operation instantly if they are navigated with precision.

Last, by installing explosives on commercially-available drones, it is possible to convert them into weapons very easily. You can also manufacture drones by using open-source information from the internet and also 3D printers. We might not be able to tell whether or not they are a threat until they actually attack us, which means we will have only a limited preparation time.

For these reasons, small drones could be called "IEDs in the sky", enabling attacks with ease and efficiency, and making it possible to fight an asymmetric war.

That being said, there are many methods of how to deal with small drones. We can detect them by radar, passive and active optics, acoustics, EM emissions and so on. We can also neutralise them by missile effectors, guns and ammunition, laser systems, ECM, HPM and so on.

Still, detecting and shooting them down would be extremely difficult. Therefore, it is vital that we keep our system up and running even after receiving an attack. In other words, resilience in operation and mission assurance are vital.

In order to limit the impact of their attack, we could adopt such flexible operations as maintaining MOS (Minimum Operating Strip) by RADR (Rapid Airfield Damage Recovery), building bunkers, and protection by dispersal, using mobile units to minimise damage, deploying drones from movable units and force projection from the home front.

What does herding sheep have to do with future capability?

Kate Yaxley[1]

Royal Australian Air Force, 2021 Sir Richard Williams Scholar, Canberra, ACT, Australia

Extended abstract

What is a swarm? A swarm is a team of agents who act synchronously to provide a coordinated effect. As a team, the agents will coordinate based on both internal and external direction, but the outcome will be towards a coordinated effect.

Nature offers multiple examples of swarms, such as flocks of sheep. Given the battlespace is becoming more congested, contested and complex, it is important for our understanding of capability to evolve from 1v1 to multiple agents coordinating to achieve different outcomes. Consequently, understanding swarming behaviours offers us an insight into how the battlespace can be shaped.

Sky Shepherd's research considers the influence of swarms, or more commonly, the herding of sheep. Sky Shepherd's research explores the full system of the shepherding problem, from the impact of introducing alternate technology to the

system, to the social influences the cognitive swarm has on the herding outcome, and the sociotechnical relationship between the human and herding agent.

In this presentation, the outcomes of Phase 0 and Phase 1 testing to realise Farmer and Sky Shepherd Teaming (FaSST) are discussed. The phases pertain to the level of computational intelligence that exists in the meaningful human autonomy sociotechnical relationships between the controlling agent and Sky Shepherd, denoted as M-HAT 1 in **Figure 1**.

The outcomes presented include welfare implications to using a commercial off-the-shelf uncrewed aerial vehicle (UAV) to muster sheep, discussed in Yaxley, Joiner, Abbass (2021) and the concept of centre of influence to understand internal swarm behaviours, presented in Hepworth et al. (2020). The journey of innovation is also discussed, including challenges in fusing data, piloting a UAV in an agricultural setting, and the implications of introducing technology in biological systems and the lessons learned as a result.
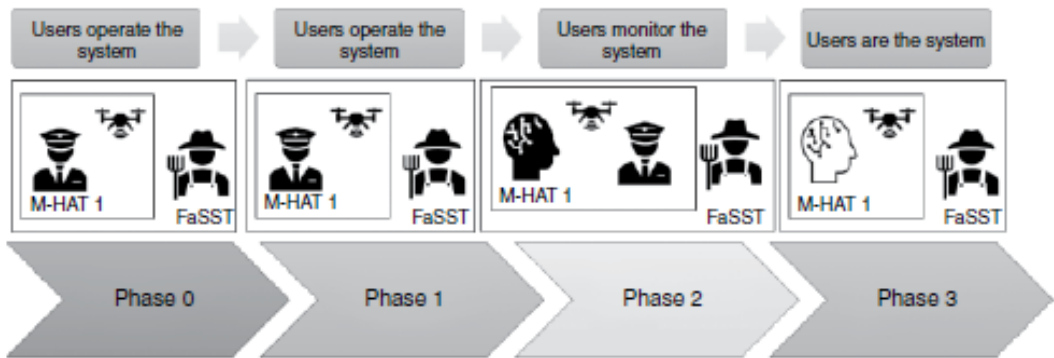
Figure 1. Phases to realise Farmer and Sky Shepherd Teaming, page 54 of Yaxley et al. (2020).

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# Jericho Smart Sensing Laboratory

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Extended abstract

Jericho Smart Sensing Laboratory: Sensor fusion for situational awareness

The Jericho Smart Sensing Laboratory (JSSL) is a collaborative project between the University of Sydney and the Royal Australian Air Force (RAAF). Established in 2019, the goal of the JSSL is to enable the design, development and rapid prototyping of the future generation of smart sensing platforms and capabilities to strengthen Australia's Defence. The JSSL is utilising its expertise in physical layer sensor technology, particularly sensors based on photonics and acoustics with data fusion, to deliver a network of interconnected smart sensors forming an Internet of Defence Things (IoDT) prototype. The goal is to gain full 3D-situational awareness using a mixture of sensing modalities such as acoustic, passive and active radar, and optical (with various apertures) sensing, as illustrated in **Figure 1**. JSSL is reimagining the future intelligence, surveillance and reconnaissance (ISR) situational awareness landscape by employing the latest developments in advanced sensing technologies. These will be made up of a mixture of high and low fidelity sensors, forming multiple layers of capabilities. The low fidelity sensors will be utilised across a wide range to perform initial basic detection ('Find'), which then pass this information to higher fidelity sensors to perform more detailed analysis down the 'Fix', 'Track' and 'Target' chain. AI is used wherever possible in the chain providing on sensor intelligence and passing-on only critical information from the sensors to the users. Being based in the Sydney Nanoscience Hub, the JSSL team has access to advanced lithography and packing capabilities that allow for integration of smart sensing technologies to reduce the size, weight and power consumption. The JSSL pursues leading edge science with embedded design thinking to extract the maximum creative solutions in the shortest possible time from these projects and through close collaboration with DST and broader academia.
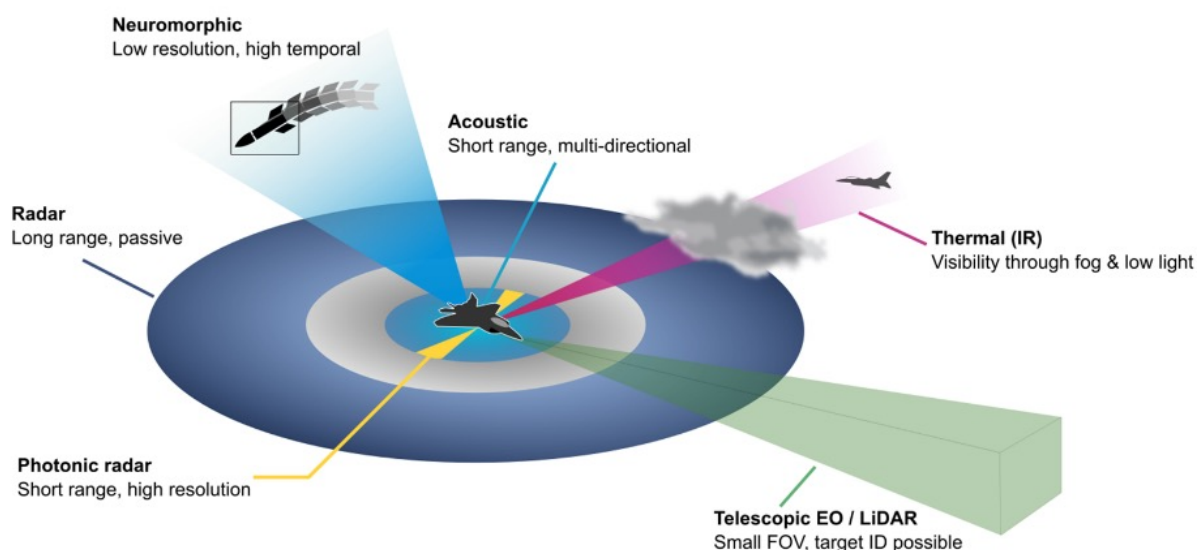
Figure 1. Exploring the combination of sensors in unique ways.

# Neuromorphic event-based sensing for airborne surveillance

Vladimir Perejogin[1], Simon Meaney and David McAfee

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Defence Science Technology Group (DSTG) has recently demonstrated a world-first airborne neuromorphic event-based sensor (EBS) on-board the Defence Experimentation Airborne Platform (DEAP) aircraft, with great potential for maritime and urban surveillance. Neuromorphic EBS are low SWaP-C visible band sensor arrays that operate at extremely high temporal resolution, which give them the ability to adequately sample and overcome motion and scene instabilities.

In early 2021, the DEAP was fitted with a Prophesee Gen3 EBS co-located within a sub-window of the Angelfire wide area motion imagery (WAMI) sensor, and an optical lens selected to provide a ground sample distance of 1m. Data was collected over the Adelaide region from altitudes above 20,000ft, both inland and along the coast to represent maritime and urban surveillance scenarios. It was demonstrated that EBS could detect small sea surface objects both stationary and moving without requiring traditional background estimation and subtraction pre-processing workflows. This offers a significant processing advantage and reduction in on-board storage requirements for electro-optical surveillance technologies. Spatio-temporal filtering of the EBS data was also applied and demonstrated that underlying ocean surface features and foreground clutter due to thin cloud could be effectively filtered out to enhance the presence of sea surface objects as shown in **Figure 1**. Future work involves algorithm development for real-time clutter mitigation, data reduction techniques, and sensor fusion with a focus on real-time edge processing for automated decision making.

(1)   (2)   (3)   (4)
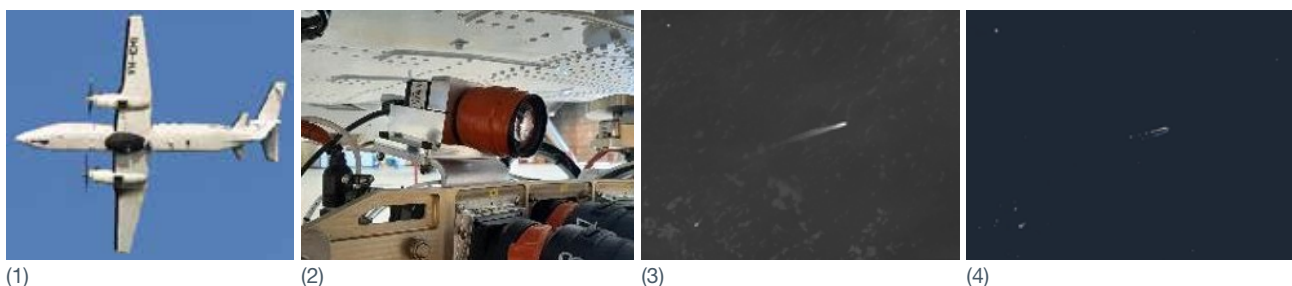
Figure 1. (1) DEAP aircraft, (2) EBS sensor, (3) cropped WAMI image frame of a small maritime vessels and wake, (4) EBS image of the same small maritime vessels and wake.

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Neuromorphic event-based sensors for machine vision applications

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Extended abstract

Optical sensors are used in a broad range of Defence applications, from overhead image acquisition to target detection, and missile guidance to space surveillance. But although vision sensors can acquire large amounts of information from a scene of interest, doing so often requires the transmission, storage and processing of huge volumes of data. This can be especially troublesome for applications that require high temporal resolution or have low data link budgets. In addition, managing varying brightness within scenes can be challenging, often requiring either the brightest or faintest parts to be sacrificed. Inspired by biological vision systems, neuromorphic event-based sensors overcome many of the limitations of traditional optical sensors and open the door to entirely novel methods of vision processing. Because each pixel responds independently, asynchronously, and only to changes within a scene, data rates are usually far lower than equivalent traditional optical sensors. This is despite the fact that change events are recorded with very impressive microsecond temporal resolution. Additionally, due to the logarithmic response of the pixels, event-based sensors have very high dynamic range – up to 130 decibels. This allows for very faint and very bright details to be simultaneously observed, as depicted in **Figure 1**, where the conventional camera cannot resolve details in the dark part of the scene, yet suffers saturation effects from the street lights. One of the many promising fields for event-based sensor application is space domain awareness. For space surveillance, since the scene is almost always very sparse, and light sources are usually point sources, the event-based sensor's key advantages over traditional optical sensors promise significant performance improvements for both satellite tracking and characterisation.

Conventional sensor   Event-based sensor

Figure 1. Comparison between conventional and event-based sensor output.

Capturing disruptive innovation for Defence Aerospace

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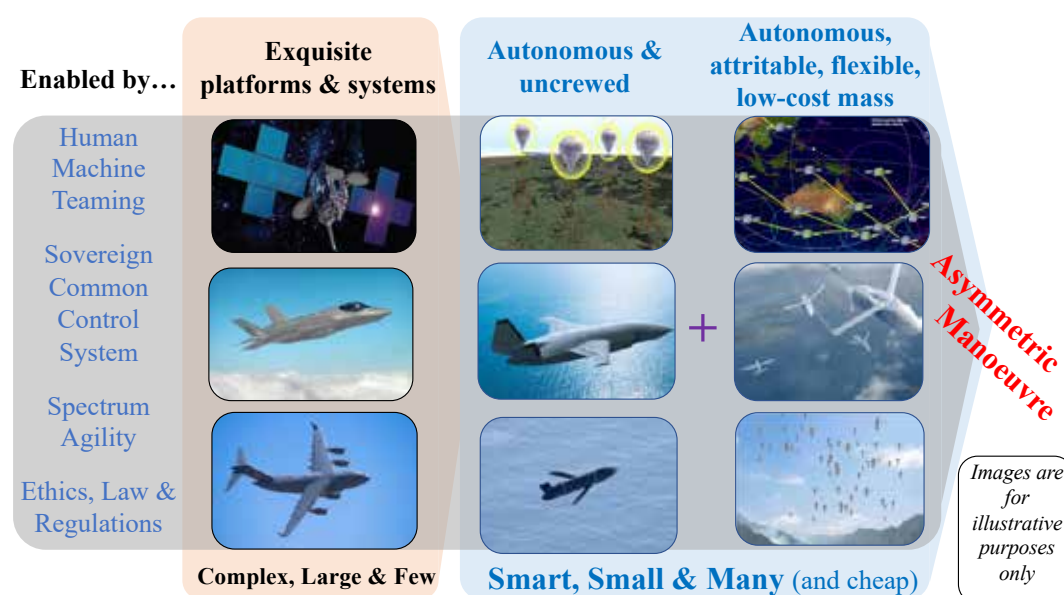
Andy Kornios

Smart Sat Cooperative Research Centre, Australia

Extended abstract

Defence acquisition is experiencing Christensen's 'innovators dilemma' and is unsuitable to land 'disruptive' innovations needed by Airforce operators. In this age of 'free silicon' which integrates AI, quantum, materials and energy technologies, 'Smart, Small and Many' low-cost robotic, autonomous systems (RAS) and AI systems are inevitable, and will augment the 'complex, large and few' crewed platforms that we cannot afford to buy enough of. This puts a different perspective on aerospace acquisition, splitting it into two parts: platforms vs systems; risks to crew vs legal and regulatory risks for autonomous use; sustainment and through-life-support vs adaptable 'digital' acquisition to use once and change; kill chains vs adaptable kill webs enabled by common control and autonomous spectrum management.

To achieve this, Defence Aerospace must draw on external innovators and create a new acquisition organisation and culture. The Defence Cooperative Research Centre (CRC) in Trusted Autonomous Systems and SmartSat CRC together engage in disruptive sovereign aerospace technologies, and grow sovereign industry capability for Australia's Defence, industry and research. We outline principles for capturing the value of disruptive innovations to accelerate the OODA loop. Our CRCs offer the ability to: pick disruptive industry winners; nurture emerging leaders and entrepreneurs; maintain ambition and risk appetite; find novel solutions to needs and demonstrate them quickly; create, capture and manage a complex portfolio of trade-able sovereign IP; build more high-tech Australian jobs; and support industry delivery to Defence in the near term. Noting the success of these disruptive technologies in recent military conflicts, we ignore this at our peril.

Enabled by…	Exquisite platforms & systems	Autonomous & uncrewed	Autonomous, attritable, flexible, low-cost mass
Human Machine Teaming			
Sovereign Common Control System			
Spectrum Agility			
Ethics, Law & Regulations			
	Complex, Large & Few	Smart, Small & Many (and cheap)	

Asymmetric Manoeuvre

Images are for illustrative purposes only

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Advances in drag-reducing sharkskin films for enhanced aerospace capability

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Sharkskin inspired "riblet" microstructures are a well-known method of reducing skin-friction drag experienced by aircraft (Dean & Bhushan, 2010). However, riblets have not yet seen widespread use in commercial, private or military aviation primarily due to challenges inherent in reliably fabricating microscopic structures for large surface areas, and customising these designs for optimal drag reduction performance whilst ensuring they are durable enough to withstand these demanding environments.

MicroTau's Direct Contactless Microfabrication (DCM) technology solves this problem by drawing on photo-lithographic techniques developed for computer chip fabrication capable of achieving structural features several orders of magnitude smaller than the features required for drag reduction. Using tailored microstructured light patterns, riblets are grown on a substrate, with the riblet size and profile determined by the exposure conditions. Advancements in this technology, including improvements to riblet geometry resulting in MicroTau's highest quality riblets yet, are discussed.

Recent developments in DCM technology, including a new optical unit, have resulted in riblets with peak sharpness of <1 µm and geometry closely matching the ideal 'blade' type. These changes have been made to tighten manufacturing tolerances and have reduced the variance in the riblet height and increased peak sharpness to near or below the critical 1% of spacing.

Flight testing of riblets with 78 µm spacing have been tested on an aerobatics plane with results indicating a 1% speed increase, which correlates to a 2% net efficiency gain. In the future we aim to conduct further drag-reduction testing and in-flight tests on larger platforms.
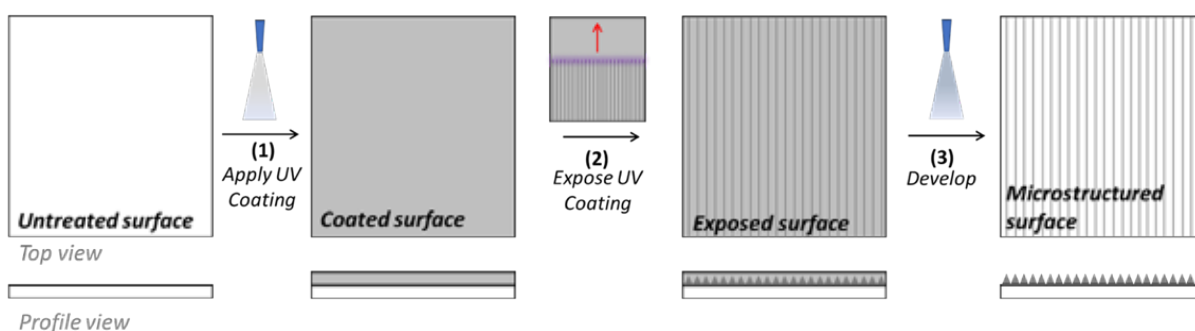
Figure 1. Three-step DCM process with top- and profile-views.

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Materials design of next generation aerospace alloys via conventional and advanced manufacturing routes

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The demand for engineering alloys that can withstand high mechanical loads under harsh, high-temperature environments for aerospace and defence applications is growing. Despite impacts by the global pandemic, market forecasts predict a demand for ~35,000 new aircraft in the next 20 years[1], with the Asia-Pacific region accounting for >40% of this demand. Here, the development of engineering alloys such as superalloys has been the critical enabler for jet-powered civil aviation over decades. Today, the key reason for their ongoing technological success is their multi-scale hierarchical microstructural design with contributions from across all strengthening mechanisms.

A typical microstructure of an advanced alloy for modern aerospace applications exhibits features across several length scales such as (i) interfaces, (ii) micron-scale precipitates, (iii) complex stacked nano-scale precipitates, and (iv) various types of solute atom segregation. This multi-scale hierarchy will provide superior mechanical properties if the desired microstructural evolution can be achieved via advancements in processing methods. Here, critical enablers can be advancements in conventional thermo-mechanical processing or, more recently, metal additive manufacturing methods such as powder bed fusion processes. The success of materials design approaches is largely based on advanced microscopy over several length scales, providing fundamental inputs into through-process modelling approaches aimed at unlocking superior properties.

This presentation gave an overview over handpicked projects on materials design, advanced microscopy and modelling of manufacturing processes for modern aerospace alloy parts. The first part focused on advancements in industrial forming for making next generation aircraft engine parts such as Alloy 718 disks[2] and Rene 41 parts[3]. The second part showcased relevant handpicked results from the so-called AUSMURI project on powder bed fusion metal additive manufacturing of Alloy 718 and traditionally non-weldable Inc738[4,5], under the Next Generation Technologies Fund, which is led by Defence Science and Technology (DST) Australia.

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Persistent monitoring and early bushfire warning system using high-altitude balloons

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Adithya Rajendran and Katrina Albert
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This work was presented during the conference but the abstract was withdrawn from the proceedings at the request of the authors

Enabling Australia's hydrogen industry development: The role of CSIRO's Hydrogen Industry Mission

Patrick G. Hartley[1]

CSIRO Hydrogen Industry Mission Leader

CSIRO's Hydrogen Industry Mission was launched in May 2021 and shares the vision of Australia's National Hydrogen Strategy of a clean and globally competitive hydrogen industry for Australia. The Mission's specific goal is to deliver research, development and demonstration partnerships that help activate Australia's hydrogen markets.

The mission is supporting activities across four strategic pillars:

- **Hydrogen Knowledge Centre,** capturing and promoting hydrogen industry developments. Online modelling tools and educational resources.

- **Demonstration Projects,** RD&D in support of industrial technology deployment and hydrogen value chain validation.

- **Feasibility and Strategy Studies,** trusted strategic and technical advice to de-risk projects in partnership with industry experts and project proponents.

- **Enabling Science & Technology,** delivering technological solutions and socio-economic analysis to remove barriers to hydrogen industry scaleup.

This presentation will comprise an overview of the current status of Australia's hydrogen industry and will showcase selected examples of recent activities across the Mission's pillars, including technological developments in areas relevant to innovation and resilience in air and space power (**Figure 1**).
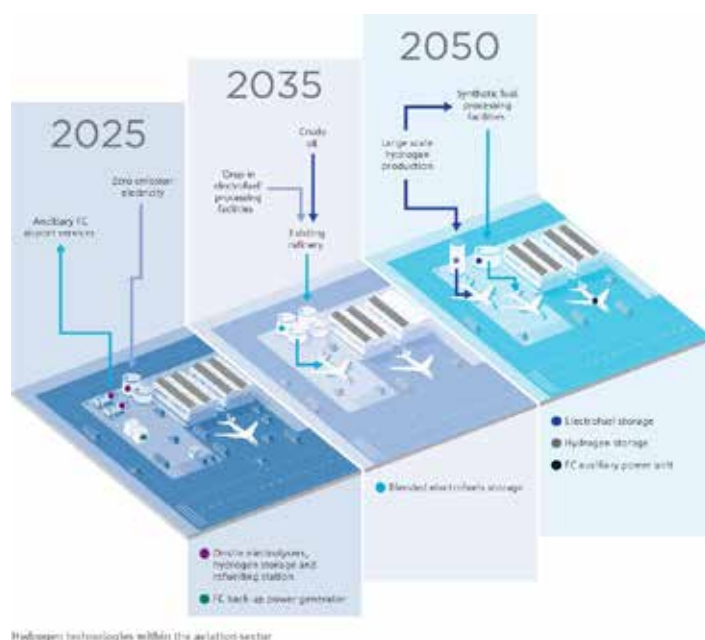

Figure 1. Hydrogen technologies within the aviation sector[1].

Reference

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Developing a modular demonstrator kit to produce 'drop-in' alternative jet fuels

Ulas Yildirim[1]

Australian Defence Force

Faced with the challenges of energy security, oil price fluctuations and a rising emissions footprint, there is an immediate need in implementing measures to meet the ADF's growing jet fuel demands through the development of a resilient and distributed network capable of operating on alternative jet fuels produced from indigenous feedstock.

This presentation will discuss the history in the development of jet fuels, rationale behind the need for alternative jet fuels and the advantages/challenges associated in their uptake (U. Yildirim, 16 Mar 22; U. Yildirim, 29 Jun 22). This will be followed by an overview of the work that the Air Force has been conducting alongside CSIRO to develop a modular demonstrator kit that is able to produce 'drop-in' alternative jet fuels produced from indigenous feedstock.

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# Alternative aviation fuel pathways for the RAAF

James Deverell[1]

CSIRO Futures

Strategic fuel security continues to be an important issue for defence forces around the world, particularly in light of increasing geopolitical uncertainty, supply chain disruptions, and pressure to reduce emissions in response to climate change. New technology developments in hydrogen, biofuels and synthetic fuel production could play a major role in helping countries achieve greater fuel security (see **Figure 1**).

The Royal Australian Air Force and CSIRO – Australia's national science agency – recently analysed alternative aviation fuel (AAF) pathways that could contribute to Australia's fuel security. Of the seven ASTM-certified pathways reviewed, 19 configurations were identified based on feedstock and technology. These configurations were assessed to determine suitability using several key criteria: technology readiness, indigenous feedstock availability, modularity/deployability, and sovereignty.

Two categories of pathways were recommended for more detailed analysis. First, those with commercially available solutions that could be adapted and progressed immediately to a demonstration/pilot. And second, those that lack fully-demonstrated maturity, and will require further development over the next five years.
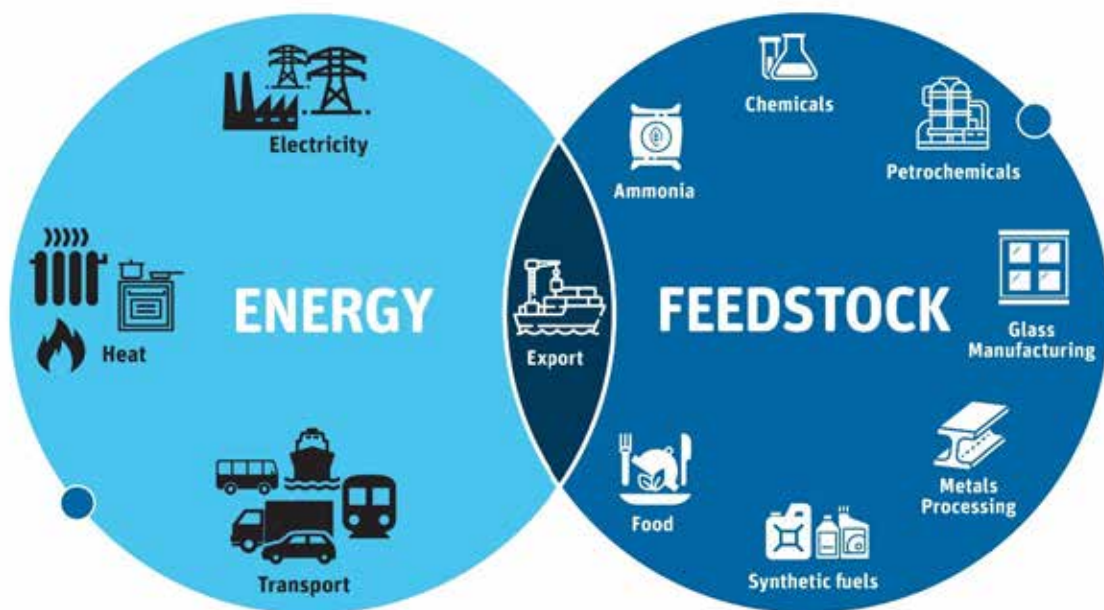
Figure 1. Applications for Hydrogen[1].

Reference

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Establishing a sustainable STEM pipeline for Australia

Brett Biddington

Biddington Research

The Magic Pudding, first published in 1918 and written by Australian author Norman Lindsay, is about a pudding called Albert. When a slice is taken out, it magically regenerates. In Australia, we have a Magic Pudding approach to the STEM workforce. Our leaders build new programs with the assumption that the driving STEM workforce magically regenerates. Yet, programs and initiatives have simply failed to achieve the numbers of STEM qualified graduates and technicians that Australia needs today and into the future. This applies in Defence and across society and the economy more broadly.

What can be done to overcome this problem? First, we need to acknowledge the existential nature of the challenge. Second, we need to adopt policies and strategies that are evidence-based. And third, we need to revalue, re-invent and properly reward teaching and teachers.

In particular, we need to devise and implement policies that bring women into the STEM workforce (only 20% of workers are women). There are many initiatives that aim to redress this imbalance. However, a 2020 meta-analysis of 337 Women in STEM programs suggests there is little evidence that they are effective (McKinnon, 2020)[1]. Perhaps we need to look more deeply for structural barriers to female participation, including the casualisation of labour and the costs of child-care and housing.

We need to change the perceptions of STEM in our society. The relevance of the STEM disciplines to daily life is not well-explained and is unduly influenced by stereotypes, such as the wild-eyed scientist, in a white coat, cutting up rats. Expressions such as "She has a head like a planet" and "It's not rocket science" elevate the STEM disciplines to being the preserve of the very smart – the gifted and talented – and beyond the reach of mere mortals. These attitudes quickly slide to an elitist view that STEM is only accessible to the best and brightest and at that point, many students simply self-exclude. We need to challenge and change this deeply ingrained set of attitudes.

What can we do now?

- Start a deliberate planning process for the big changes – these cans cannot be kicked down the road.

- Invest in sending more Australians to overseas research organisations and universities, to experience in S&T research at levels we cannot match in Australia. This experience will come home.

- Urgently invest in providing primary school teachers, as a cohort, with the competence, confidence and enthusiasm to teach mathematics. STEM competence needs to become part of life and common experience. And that starts with students in their earliest years of school.

Magic Pudding thinking has no part in developing the sustainable STEM pipeline of citizens on which the security and future of the nation depends.

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Additive Manufacturing air and space power concept development

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LOG Branch, RAAF

In March 2020, the Director General of Logistics – Air Force commenced the exploration how the RAAF may leverage the technology known as Additive Manufacturing (See Roadmap in **Figure 1**). AM is the creation of a physical object by adding material, usually in layers, from a digital model. Typical materials that are used include: polymers such as nylon; metals, including titanium; concrete and even biomaterials like synthetic 'meat'. There is a wealth of strategic opportunity for the RAAF, and the challenge was understanding what we should do, as opposed to what we could do. The key principle was providing value to the joint force and be uniquely air and space related. The approach taken started with an extensive desktop review that leveraged internal fore-sighting reports as well as an open source literature review. Interviews with Defence Scientists

and academia were also undertaken. This formed the basis of the workforce engagement component. It was critical that the top-down desktop review was critiqued by the workforce from their bottom-up perspective. A key point of difference is the RAAF's engagement of a university to facilitate the workforce engagement. Deakin University professors of disruptive thinking, additive manufacturing, engineering and design met with junior ADF personnel from a wide variety of backgrounds. The series of three workshops were crucial in getting closer to the 'ground truths' and develop over a dozen concepts the RAAF could explore further. The workshops also provided a means for the RAAF to begin to materialise future capabilities that truly leverage the fourth industrial revolution technologies.

Figure 1. Air Force additive manufacturing roadmap.

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Virtual trades – an opportunity to unlock workforce potential in emerging skillsets

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Extended abstract

The modern strategic environment requires Defence to rapidly adapt to emerging technologies and skillsets. The Virtual Trade concept presents an opportunity to enable this adaptation through unlocking the latent talent potential within the workforce. The Virtual Trade framework is intended to support the identification, development and accreditation of skillsets that are not tracked by existing workforce management systems. Furthermore, the traditional mustering framework requires a level of rigour and governance that prevents it from rapidly responding to emerging trends.

Plan Penumbra is an initiative by Air Force Workforce Design and Reserves to modernise the current workforce management system such that it is agile, efficient and effective, and is focused on objective and future force capability needs.[1] The Virtual Trades concept could complement Plan Penumbra by providing a flexible environment in which emerging skillsets and technologies are explored before being considered for inclusion in the employment category framework. Virtual Trades may also be used to incentivise the establishment of emerging skillsets and provide a talent pool to meet future capability needs.

Logistics Branch – Air Force is utilising Advanced Manufacturing (AM) as a prototype to explore the Virtual Trades concept, and is collaborating with Deakin University and Jericho Disruptive Innovation's Bottom-Up Innovation program, Edgy Air Force,[2] to identify and examine potential means of identifying, developing, accrediting, supporting, and utilising AM practitioners.

A number of challenges are being examined. Firstly, scoping how the emerging skillset will be utilised, including how it will interface with existing and emerging systems. Secondly, developing a competency framework that details proficiency levels and provides guidelines for further skills development. Finally, challenging the perception that early adopters of new technologies and skills are hobbyists rather than professionals implementing innovative approaches.

The outcomes of the Virtual Trade AM prototype have the potential to be applied to a range of valuable skillsets such as data analysis, strategic thinking, and cultural affinity. Logistics Branch – Air Force will work with Air Force Workforce Design and Reserves to explore this potential, and welcomes engagement from any interested parties.

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Capability delivery at Warp Speed – Industry 4.0 and CASG NX

Mike Moroney[1]

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Extended abstract

In the 21st century, how Air and Space Power is acquired will have a more significant impact than what is planned for acquisition. Capability that does not materialise is not capability at all. Capability that does not materialise at the speed of relevance is equally useless in an age of constant digital disruption. Consequently, Defence and its partners are transforming how capability is delivered by leveraging Industry 4.0.

Rapid advances in digital technology are driving the disruption of global commercial affairs. The UN, the Commonwealth government, and other nations recognise this disruptive time as the Fourth Industrial Revolution (also known as Industry 4.0).

CASG Next Generation Acquisition and Sustainment (NX) has used Industry 4.0 to set new benchmarks in agility, efficiency and integration for capability delivery. In shifting paradigms for capability delivery, CASG NX has borrowed a model from tech industry consisting of three steps:

1. Thing Big

2. Act Small

3. Scale Quickly

The model above is adopted and augmented with one key addition of "Embracing Different". It is only by Defence embracing different ways of working that Industry 4.0 technology, practices and business models can be effectively realised. Following this model and CASG NX has demonstrated progress in facilitating the Integration of Industry 4.0 with Industry, Academia, Government and Allied collaboration including:

- Developing and Integrating a Deep Learning system for Aircraft Maintenance reporting automation known as the Airmen's Autonomous Digital Droid (A2D2).

- Collaborating with CIOG for a DevSecOps pathway to enable Augmented Aviation Asset Intelligence at speed and scale.

- Rapid development, integration and support for Fleet Planning Optimisation Software to assure effective aircraft fleet recovery from a hailstorm at RAAF Base Edinburgh.

- Conducting the Military Additive Manufacturing Experience (MAX) in which an interface between small RPAS and larger RPAS was designed, produced, tested and delivered. Instead of taking months as would be expected using previous practices, this activity took five days using additive manufacturing, 3D scanning, digital design and Agile collaboration paradigms.

- Development of 3D printed parts for C-27J to build certification experience and pathways for Defence and its industry partners.

CASG NX is building on its progress, momentum and growing partnerships to scale this digital transformation for capability delivery.

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Military additive manufacturing experience

Myles Clarke[1]

CASG NX-03 Venture Facilitator

In future high-end warfighting, contingency capability needs that are currently met in months or years, must be met be within days. In this presentation, NX shared the results from an exercise in which an example high-end capability had a solution designed, produced, tested and delivered in a week. Numerous elements of industry, academia and Defence are examining how Additive Manufacturing (also known as 3D Printing) may impact Defence. Through Innovate@CASG and building upon Air Domain's Lessons in Augmented Aviation Asset Intelligence (A3I), CASG Next Generation Acquisition and Sustainment (NX) formed a pathfinding venture known as NX-03. NX-03 is an undertaking to expedite the speed and scale of 3D Printing across Defence acquisition and sustainment by leveraging Agile paradigms and collaboration with partners across industry, academia, allies and government. As part of NX-03, MAX was a collaborative activity facilitated by NX that demonstrated how Industry 4.0's technologies, practices and partnerships can revolutionise the agility with which soldiers, sailors and aviators receive solutions to their

capability needs. It is the first step to realising Dr Leyton's vision in his paper Prototype Warfare, Innovation and the Fourth Industrial Age (Leyton, 2018)[1]. An overview of the MAX ONE problem set is depicted in **Figure 1a** with the realisation of the solution illustrated in **Figure 1b**.

Industry 4.0 and in particular 3D Printing is the key to unlocking Australian capacity to produce sovereign capability at speed and scale with Defence providing the demand signal for industry to grow. This technology has the ability to counter supply chain vulnerabilities, be it from natural causes or adversary action, as so clearly demonstrated in recent events such as COVID and Ukraine. MAX is ultimately a chance to learn-by-doing and consequently share with Defence and Industry the potential, constraints and opportunities associated with Industry 4.0 and a digital transformation of acquisition and sustainment. Through MAX and other initiatives, NX is materialising the next generation of capability delivery technologies, practices and models for Defence.
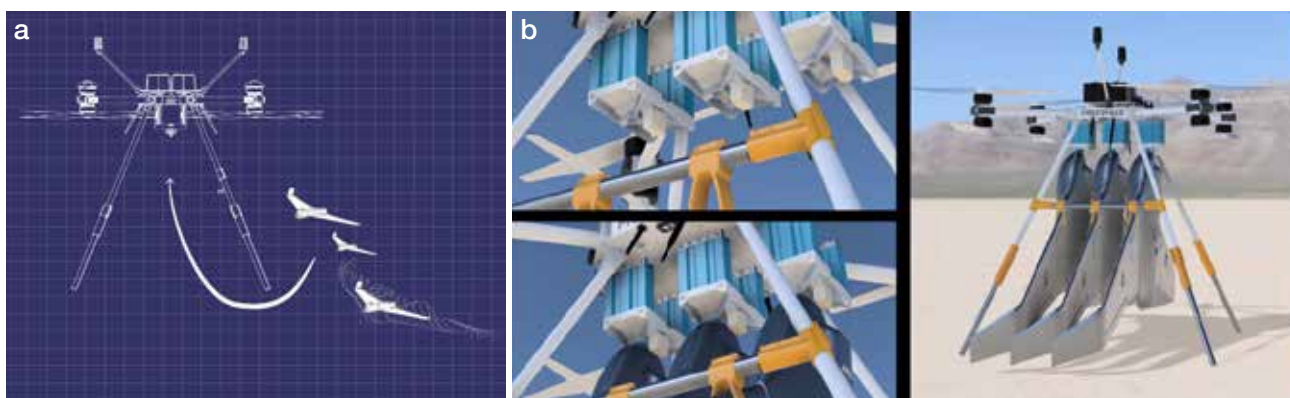
Figure 1. MAX ONE: (a) Problem; (b) Solution.

Reference

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Autonomous systems and artificial intelligence in space: the next frontier

SGT Amy Hestermann-Crane
Royal Australian Air Force

Space technologies will remain a critical infrastructure as humanity continues through the 21st century, with autonomous systems and artificial intelligence (AI) integration becoming relied upon for space operations in areas of control and management, data processing and mission execution. The benefits of incorporated automation and AI are varied, allowing for alleviated burdens on terrestrial communication and human operators. With improved capabilities equating to increased data size, advances in AI aid in on-orbit processing, improved downlink communications, analysis of mission uncertainties, and execution of manoeuvres.

It is in this area that autonomous systems and AI offer a distinct advantage to space-based technologies. They also offer unique methods of collision avoidance and debris removal within the increasingly congested near-Earth environment. It is important to understand capability vulnerabilities and gaps within current technology, as well as critically analyse the means by which these issues can be overcome. Autonomous systems and AI integration and development are increasingly proving to be an efficient enabler of mission success.

This paper will explore the means in which autonomous systems and AI are currently being utilised in both space-based assets and terrestrial ground stations. An examination of the emerging and future uses, alongside the benefits, of these technologies in space operations will be undertaken. However, no technology is free of issue or concern. Thus, there will be a discussion of the current and potential issues and ethical concerns of autonomous systems and AI, and their uses in space technologies.

Embedding innovation and agility within the Capability Life Cycle

Air Vice-Marshal Robert Denney,

Head Air Force Capability, Royal Australian Air Force

I have the joy of talking about innovation and the CLC. What is the CLC? The Capability Life Cycle, which fell out of the First Principles Review (FPR) in 2015. According to the manual, the Capability Life Cycle provides Defence with an end-to-end process for delivery of capital project and associated through life support related to a major capital equipment [deep breath] infrastructure enterprise and communication technology. It sounds like something full of innovation and agility. It is an interesting process that is how Defence acquires and manages capabilities. And in reality, there are two Capability Life Cycles. There is the long written version that you can download off the internet as a pdf. And then there is the actual Capability Life Cycle that is executed and practised by those involved in it. It is an interesting and challenging place to work within.

Initially when preparing the slides for this presentation, my staff gave me a quote from Steve Jobs about innovation, but the reality is he used to work as a CEO and Chair of a corporate entity, which is a little bit different to being in the largest government department, in Defence. Then we dug out this quote:

> *"Success no longer goes to the country that develops a new fighting technology first, but rather to the one that better integrates it and adapts its way of fighting …Our response will be to prioritize speed of delivery, continuous adaptation, and frequent modular upgrades. We must not accept cumbersome approval chains, wasteful applications of resources in uncompetitive space, or overly risk-averse thinking that impedes change."*

— US Secretary of Defense, Jim Mattis
2018 National Defense Strategy

This is a really powerful quote from my perspective because at the end of the day, in my words, brilliant ideas and technologies are good but bringing good ideas to actually become a reality is brilliant. Because too often we have great ideas but we do not have the means to turn them into reality and that often becomes the issue of our innovation.

What is innovation? Lots of definitions out there. The Defence Capability Manual talks about the process etc. but the interesting challenge is centrally managed and controlled innovation. Is it the great oxymoron? Can you innovate in a large government department that centrally controls and directs innovation? And you get posted into innovation and you are now posted out of innovating, is that something we can actually achieve? Or is it something more of a cultural and behavioural activity that we need to get at? My contention is it is the latter.

Permission to innovate

- **CAF Licence to innovate, 2020 AFSTRAT**
- **COs are to empower their people to have a go**

We can have innovation hubs themselves but ultimately it comes down to how do we enable it? From our perspective they are three ways you can get innovation. The first is about having permission. People need to have permission to innovate, need to believe they can go ahead and shake things up and get it in a different manner of going about it.

Senior leadership buy-in is critical and commanders at every level need to get that.

The reality is – innovation brings risk. It brings the potential downside of time and money, all being lost, and people need to realise that taking that risk is a good thing. It is the way we actually get improvement; it is the way we enhance our capabilities. Having that permission is critical. You need money, you need funding, you need assured funding, you need to know there will be dollars there when you need to reach into the cupboard and reach out for that.

Assured funding

- Identify gaps, risks, issues and opportunities
- IIP Program/Projects priorities
- Air Force Capability Committee and Air Force Board oversight and off-ramps
- Innovation projects funded, with agreed deliverables and off-ramps

Within Defence, we have a number of mechanisms, capability development investment development funding, which is money that we allocate to doing pre-Gate Zero approvals. But the reality is, where innovation can really pay dividends is upfront and where the funds are available, is not necessarily in the same location. So the challenge is, committing those funds where you can most realise the benefit and how do we do that? We can fill up the corners with Air Force Minors Projects and manage in-service thing with Air Force Minors but that is only the small adaptations that we will get it. The real benefits come early on.

Culture

- Work in progress, to educate and train for innovation
- Need to invest in our people (Skills development and time to innovate)

But the main issue is culture. A supportive culture for people to innovate, continue to innovate even when it does not work. Defence has a very results-oriented culture and behaviour and the science, if you look in the sporting analogies, is that results-orientated cultures do not necessarily inspire the right behaviours.

If you look at a professional sports athlete, they don't necessarily measure themselves on results and outcomes. They actually try to assess themselves on did I have good decision-making? Was I having a clear mind when trying to do the right things and positive images and they set themselves on that because whether the ball bounces over the net, or under the net, or bounces off the tree into a hole or whatever, depending on the sport, are things they cannot influence. They try to influence only what they can – and that is how they assess themselves.

And if we took that analogy over to Defence and major projects, we would be looking about: Have we taken sensible risks? 'Have we managed them appropriately?' 'Was the risk with the reward?' versus 'Did I take a ridiculous risk and pull a rabbit out of the hat?' Too often when we do not do the right things and then we pull a rabbit out of the hat, we reward ourselves – medals all round – but we do not necessarily realise we took the wrong path.

I would contend that it is OK to fail. The culture of encouraging people to innovate, to fail and pick themselves up and, more importantly, identify the off-ramps when you can realise that

this is going sideways, move away from it or correct it and move on, is actually the culture that will set a condition for transformation about innovation.

So, how does Air Force do? AFSTRAT (Air Force Strategy) is an attempt to give our people permission to innovate. It refers to effective management and exploitation of ideas to give people permission to innovate.

We have assured funding, through some areas where, we can identify gaps, we can fill holes, we can use integrated Investment Portfolio project or acquisition funding, to get after innovation. To go after the things that matter versus the things that are shiny and attractive. But sometimes that comes along too late in the program to really make a difference.

Jericho Disruptive Innovation

But perhaps the greatest benefit we have in Air Force, in innovation, is Jericho. It is a program of innovation established back in 2014, by the then Chief of the Air Force. The greatest thing that Jericho does, is it gives people permission to innovate. People who are going to try new things and get after new things – 'I will Jericho it up and do some innovating'. It also provides some funding, so they can have the funding and ideally it would be changing our culture such of those people that are going and *Jerichoing it*, would have the consent of the commanders to go there and fail. The interesting thing, however, is that Jericho is not part of the Capability Life Cycle.

Jericho is an Air Force initiative where we attempt to encourage and foster innovation across our capabilities. So it is not necessarily being driven by the Capability Life Cycle. In fact, it is not. It is Air Force's attempt to work in parallel to it. Because it is critical that we develop that within our folk.

Innovation and the CLC

Where do we apply it? There are a number of areas along the life cycle that we get after innovation.

Strategy and Concepts

We have the new concepts and ideas and requirements phase so we have the ability to get people in Jericho. You have seen some stuff out there where people are dreaming ideas that we can roll into concept development and building it up.

Risk Mitigation and Requirement Setting

We can use it as risk reduction. Part of it is about wrapping, too. One person's tinkering is another person's risk reduction. Things that are interesting experiments to some, are actually critical to devising requirements and setting the pathway of how we will innovate and adapt in setting the future path.

Acquistion

Acquisition – that is probably where we struggle a bit. Because we get locked into a path that is aligned with an

approval and a budget and potentially, that is where we lose our ability to wriggle around and get that innovation going. This is where the real ground-up staff applies at the Air Force cutting edge, as those folk out at the squadrons, in units, making adaptations, thinking of good ideas, bringing it to the fore, bring it to their CO, commanders, empowering them, authorising them and cracking on.

In Service and Disposal

That is where we try to emphasise Jericho, in a way of furthering adaptation and improvisation. You can see there is a gap there, right? There is a gap that we would typically describe as 'in the valley of death', where we sometimes have problems bringing those capabilities that are great ideas and bringing them all the way through to capabilities and execute. That is a challenge for us of how we manage and grip that up.

Innovation Examples

There are things we can do now. We are looking at algorithmic assurance. So in those concepts, we can figure out where we can design algorithms to give us a higher reliability to get certification. We can talk about where we are going to operate, what concepts we are going to employ moving forward.

Some other things we have got there. The electronic boost vehicle. An alternate method of delivering things in contested environments. Or expendable ISR. EO sensors that are projected into an area, provide the information update and then are disposed of, or not attempted to be recovered.

In-service, we have got deployable air traffic system, a human portable system that our folk have developed to go around and give traffic awareness in disaster relief airfields or similar. And Air Mobility Optimisation is a program where we are trying to get every spare drop out of air lift support through synthetic and decision support tools.

You will notice that there is a gap in Acquisition Phase, and that is the part where we are still working at and need to keep our focus on.

So, innovation into service. The criticality for us is trying to bridge the *valley of death*, of developing that great idea into a capability that we can field an employee in the operational Force. And it is a challenge.

Getting agreed capability off-ramps where it does not come to fruition is a challenge. As is developing all the other Fundamental Inputs to Capability (FIC) to build that idea into a capability. Workforce facilities, systems, et cetera. Because we had the innovation and tools to get the idea off the ground, but keeping it airborne is our challenge in terms of that. We have alternate acquisition pathways, but they are limited in authority, in terms of funds and scope that we can get after. Part of that is due to the authorities that lie down and part of it is due to the behaviours in terms of what we practically execute as authorities out there. But we can achieve innovation and we can make things happen.

This photo is special because there is actually a bunch of innovation in that, that we did not necessarily go after with the Jericho structured program or whatever. When we deployed the E7 to the Middle East, there was a bunch of innovation capabilities on it, that did not go through a funding thing.

That is a photo from the Pacific Endeavour from a couple of years ago, which came through an adaptation of what we are after between Navy and Air Force to make it happen. I contended that, at the working level, the coalface, the squadron level, we are actually progressing, but our ability to impact the acquisition timeline is a challenge.

Not all good news, it is just the news.

Agile models for capability development

Mr Michael Shoebridge
Austrian Strategic Policy Institute

The Australian Defence Organisation and the ADF – like partner militaries – is already a joint force and an integrated organisation and as we have heard a lot during the conference, it seeks more power from deeper integration. There is some real power here, orchestrating multiple systems and effects over time and in different places. And bringing together the different capabilities from these multi-domain complex systems.

This deep integration has been the defining factor of Defence's business processes, whether it is Force Design, investment decision-making, contracting, sustainment or operation. The result of these elaborated, complex business processes, there are two primary things:

- Forces that work well together and with key partners, are also complex and highly integrated.

- Capabilities take a very long time to move from idea to reality.

There are some real successes, in fact, pretty much Air Vice-Marshal Denny's slides had them on there, except say the Collins submarine, Wedgetail, and also – piggybacking off US DOD processes that are eerily similar to Defence's, maybe that are even more complex and extended – have resulted in capabilities like the F-35, Growler, and the C-17.

Some absolute successes and power from this drive to deep integration and business processes wrap around that. What is the problem? Here is part of the problem and it is called: the rest of the world. Some of it is, time is not our friend and these processes take a very long time and war is credible within this decade. In fact, it is happening now in Europe, so that makes it extremely credible this decade. Then time is a problem, and that is a big bang on the screen what is happening in Ukraine now. War is back in the world, and it is credible in our region. We know that from government documents and from Europe.

The second problem is that technological change in terms of real disruption is present and it is overturning expectations in conflict. Examples include the Armenian-Azerbaijani war in

2020, where small pieces of high technology and advanced missiles, drones, destroyed the military that was operating in a more conventional way. And then there was the 2019 missile and drone strike on a Saudi oil refinery despite their investment through time and extensive air defence systems and sensors. And every day that the Ukrainian military inflicts large losses and reverses on the Russian military, is another graphic demonstration of change in warfare and overturning expectations.

The last example is Chinese hypersonic weapon tests, with a light beam going up into the sky and also an assessment of the PLA's rapid progress and proliferation of uncrewed armed and unarmed systems. The scale and proliferation of Chinese military development and adoption of novel weapons and concepts for using, not just the things. And of course, the technological change that is happening so quickly, outside the military sphere.

There is an ASPI report there about quantum technologies and the way they are becoming, things that have real applications in our world and they are being applied outside the military sphere, at the moment. Time and speed of change are part of the problem with doubling down on this deep integration.

There is another problem, because the downside of complex integration processes looks a bit like a Swiss Army knife. It is probably the most densely integrated, joint pocketknife weapon system on the planet. But, while that is attractive in some ways, sometimes you do not want deep integration, you just want a really big knife. Or, you might just want a really little toothpick, you do not want them all integrated into this giant, complex packet.

Another result of the extended and elaborate integration that we see with Defence – and a whole set of business processes, not just the CLC – is time. Two examples include Hunter program, which is now delayed even further than its extended time frame of first delivery in 2034. That is 12 years from now, but it will be longer for the first ship.

And just recently, the Prime Minister announcing a really good thing: 18,500 extra people into the ADF. A really big expansion of the ADF. The only downside there is that growth is to be achieved by 2040. So, time. Time is not our friend with these processes that we have. They are the downsides.

Now, there are alternatives. I think this is the good news part of my presentation. There are some real alternatives available and the first one comes from an organisation that has a whole lot of attributes and processes that really look quite a bit like the Australian Defence Organisations and also its big partner – the Pentagon, US DOD – with its processes.

That business organisation is NASA, with their peak funding being the space race. So, why is NASA so interesting? Well, because it faced what government organisations do not often face, which is bankruptcy. Congress and the US presidents over time were not willing to supply the funding that NASA needed to keep operating to achieve its missions, using the incumbent business processes and with the incumbent providers, that it had.

That was true, whether it was building satellites, launching satellites, or rotating crew to the International Space Station, let alone doing things like returning people to the moon and taking people to Mars. So, NASA faced as close as a state agency gets (that is not being closed) to bankruptcy. The result was, that NASA was forced by that situation to take an entirely new approach, to resupply, to satellite construction and launch, and to astronaut crew rotation.

It did not do traditional procurement and traditional capability specification models and it did not do things that look like the ASDEFCON (Australian Standard of Defence Contracting) suite of contracting documents and processes. Instead, it encouraged new entrants into its market. It displaced the incumbent providers and it displaced its incumbent business processes. These new entrants did it their way, they did not do it the contracting framework way that existed beforehand and NASA needed that.

So, two examples: Blue Origin and SpaceX. SpaceX started in a whole different way, with cost as a key thing to drive down and reusability of all components and systems. Two primary design principles, quite different to the incumbent business processes. They had the necessary interfaces set by NASA, like, how did the aircrew module have to dock with the International Space Station and the precise specifications of that? Pretty much, they could do things their way and SpaceX, for example, did it by digital design and rapid deployment of resulting systems and learning through failure.

In some ways, it is a bit like Kim Jong-un's missile launch program. We hear about launches and things busting and burning but while we all chuckle about the failed launch, we know Kim and his designers are getting better through demonstrating what they can and cannot do.

SpaceX took a very similar result, and NASA now is wholly dependent on SpaceX for launches and that is because they are able to do it at a tempo and a cost that is unmatched in the market. SpaceX is now a very attractive global launch provider.

Also on the crew rotation of the International Space Station, what a good thing now that America is not dependent on Russian provision of crew rotation to the International Space Station.

But there are now two different agile approaches that have been contracted by NASA. One is Boeing with their Starlink, which is yet to actually conduct a mission but is close to its first one. And SpaceX – originally contracted for 12 missions – to replace crew on the International Space Station and has now been contracted with a further eight, because of delays in the Boeing program. Both those approaches by Boeing and SpaceX, again, broke the traditional way of providing these space capabilities to NASA and delivering at prices that are well below the previous price and ways of doing business. A study of the two said Boeing is able to do a crew rotation at about $90m per astronaut chair, whereas SpaceX can do the same thing for just $55m. So they are both significantly cheaper than the previous model – which was unaffordable – but there is still a differentiation between the two.

We also know that it is not just NASA. The NASA precedent is useful because of their similar scale enterprise to the Australian Defence Organisation with similar government constraints and rules, but they had a unique urgency because they had to continue to operate without the funding they needed if they kept going as they were.

I have some examples of success in the Australian environment as well.

The Afghan conflict: Diggerworks with soldier equipment and body armour, counter-IED development and iteration as the IED threat evolved in Afghanistan and protected mobility vehicles – the Bushmaster.

Diggerworks, counter-IEDs and the Bushmaster – all had that rapid iterative development because of the urgency of the operational environment and the fact that coalition soldiers were being killed. Australia ended up suffering far less because of this really rapid development and putting into the hands of operators the new kinds of capabilities. New developments in counter-IED and body armour – with further development of the Bushmaster – were all done with the cooperative effort between the end-user, science and technology and the companies doing the actual production. Really tight, fast cycle driven by urgency, like NASA with the urgent budget problem.

At the Air and Space Conference, how could I not mention the Loyal Wingman? From three years to first flight, now with its own special name and looking like it is breaking many of the rules in the Capability Life Cycle. And that is probably a good thing.

The last example is a loitering drone. It is launched from a 40 mm grenade launcher that is currently carried by Australian Army soldiers and it is a fairly routine item across other armies. It is developed by a little company in Victoria – DefendTex – who had the idea. It took them about 18 months from idea to first prototype; it got further developed interestingly with a small grant from Army Research. But then it did not make its way into the Capability Life Cycle or Acquisition in Australia, but it has seen service already with the British Army in Mali and I think it has also been acquired by the Dutch Army. Because it is so useful and they found a way to accelerate it into the hands of their Service men and women on operations. We have not done that yet.

Both Loyal Wingman and DefendTex are digital design and production approaches and are not well suited to the suite of contractual and other business processes that are in the CLC and the ASDEFCON suite of documents. They are different.

What is a solution if we think the NASA precedent is interesting? And some of these Australian presidents are interesting? The approach Defence has taken is to streamline the CLC and existing suite of contracts and other documentation.

The ASDEFCON Review was a very detailed and deeply consultative study by subject matter experts and produced many things. Probably a highlight was for complex acquisition. The front-end, pre-investment process that used to take four years may now be able to take three years and my point about this is these are marginal improvements around the time and motion problem and they do not really resolve the problem.

Streamlining the big machine and big business processes, will not produce the rapid result. There is still power in the complex business enterprise and producing things like Wedgetail and Collins, so it is not a matter of throwing away that machine. But, this is where I think the analogy with the airlines is helpful.

Qantas, when faced with low-cost artist start-up airlines, did what the other big airlines in the world did. It tried to refine its business offer and streamlined its costs to make itself into a more affordable offering that would compete with the low-cost airlines. But, it was hard, because it is flying large aircraft with first class cabins. So Qantas, turning that premium outfit into a low-cost operator was not possible. They needed a different machine, a new enterprise, rather than trying to streamline the current one. So they did what lots of other airlines have done, which is start their own disruptive start-up called Jetstar.

Jetstar was built from the ground up without being burdened by the legacy business processes and practices in the premium offering – the CLC – and the result is, it is really effective. A low-cost airline built from the ground up to beat that thing. I think the net result here is, while streamlining and trying to agilify this really elaborate, integrated enterprise, can produce some improvements and they should be sought, but if you want fast integration getting into the hands of users, you need to think differently and plan and operate differently – not try to work around the business processes, but start a new one.

Space Command seems to me to be an ideal opportunity. It can be its own start-up, just like Jetstar was Qantas's start-up, and deliberately not being burdened by the enterprise processes would be a really good first principle. Just like NASA, SpaceX, and small satellites are all areas where the incumbent business process that Defence uses in pursuit of complex integration is not appropriate. They are where the advances of digital design and development, and close involvement of the end user, are possible and real.

So, what is the future? Two different kinds of machine, two different kinds of restaurant. Defence currently is like a five star Michelin restaurant that can produce wonderful menus and offerings. Each ingredient lovingly hand selected, crafted slowly over time into an exquisite product – a Wedgetail or that fine meal you see before you, by skilled master chefs – and that is fantastic.

You produce heirloom capabilities that are really powerful but you do not have many and they are very expensive and they take a very long time. But, at the same time, Defence needs another kind of restaurant. What it needs is a fast food restaurant, it needs to be able to make new items quickly as a consumer demands change and it needs to pop them out at volumes that the degustation chef just cannot comprehend. There needs a whole different approach to doing that, just like you will not see a Michelin restaurant producing McDonald's fast food at scale. So, it is a case of needing both these different approaches for the heirlooms and for the rapid, fast-changing technologies and consumables of modern conflict.

To link this to AUKUS, its got a particular activity that must be done in this complex integrated way. The slow food movement – and that is the nuclear submarine project.

To try to do that in a McDonald's kind of way would have terrified our UK and US submarine enterprise partners and probably create a whole bunch of proliferation risk. So the degustation fine-dining approach of the CLC is probably underdone for the nuclear program. But the rest is all digital, like many things in the air and space domain now – cyber, AI, hypersonics, undersea beyond the nuclear submarine. That really is far more amenable to this faster set of processes and precedents that I have talked to you about.

Keynote Address: A culture of innovation

Dr Brendan Nelson

President of Boeing Australia, New Zealand, and South Pacific

Air Marshal Mel Hupfeld, Chief of the Air Force, our political leaders, uniformed personnel, members of Defence industry, ladies and gentlemen.

'People and leadership' is what I have been asked to speak about in the context of innovation and resilience. 'I have worn their blood. So many of us have worn their blood.' Those were the words of Wing Commander Sharon Brown (retired), reflecting on her service in Afghanistan as an Air Force nurse to the crowd assembled for the dawn service on Anzac Day at the Australian War Memorial in 2014.

The operational missions of the Royal Australian Air Force are prominently displayed on the Air Force Memorial on Anzac Parade in Canberra – the most symbolically powerful, man-made vista this country has to offer. That memorial, along with others, straddles Anzac Parade. At one end across the lake is the Australian Parliament where, exercised on our behalf, are our political, economic and religious freedoms. At the other end, nestled under Mount Ainslie, is the Australian War Memorial, where we reveal our character as a people. Where we honour the men and women – you, who underwrite the freedoms, which too often my generation has taken for granted.

Behind Per Ardua Ad Astra – in that memorial – the aircraft, the technology, are the props for the people, men and women who have worn the uniform of the Royal Australian Air Force, reminding us every day that there are truths by which we live that are worth fighting to defend. A sense of history is absolutely essential to an understanding of, and shaping, the future. When little else in the world makes sense, history is the guiding discipline. It can break down prejudice, it can overcome fear, it can inspire, and it can also point to new directions and where we need to go.

The German physicist and philosopher, Bernhard Philberth, wrote in revelation, 'Progress leads to chaos, if not anchored in tradition'. Tradition becomes rigid if it does not prepare the way for progress. But a perverted traditionalism and a misguided progressivism propel each other toward a deadly excess, hardly leaving any ground between them.

And therein lies the fundamental challenge of leadership. To understand, to know and live the fundamental values of the traditionalists who made your organisation what it is, who gave it what it has and that will be the basis upon which you will drive a new future, a better future for your organisation and to ensure that the progress of this, which you always have around you, both understand and respect the traditions and values upon which it is based.

We gather here in a time of unprecedented uncertainty. We are living through the most consequential, geopolitical realignment in our lifetime. Those institutions of the global world order built largely but not only by the United States after the Second World War, are being severely tested. Some of those instruments are failing the world that is, let alone the one that is coming. We are seeing a resurgence of totalitarian; authoritarianism being played out as we meet. We are living through a once-in-a-century global pandemic. Humankind faces an existential challenge in the form of a changing environment. We see immense global economic uncertainty, vast technological change, the militarisation of space and the Sino-American relationship and its tensions are taking us to a world that we have not lived in since the Franco-Prussian war or the Qin dynasty.

As Paul Kennedy, Richard Dilworth Professor of History at Yale University, observed just over a decade ago, perhaps humankind is moving to a new age. We have not had that cataclysm of the Napoleonic wars or the Second World War – God forbid – but nonetheless, humankind, as it did in the late fifteenth century, is moving now to a new age, and we are living through that.

The most fragile, yet powerful of human emotions paradoxically is hope. We all have to believe that tomorrow is going to be better than today, next week will be better than this, next year will be better than this one. And what most sustains hope is men and women reaching out in support of one another, even when gripped by fear. Leaders who are able to inspire those whom they lead, to confidently believe in a better future, to never allow them to lose sight of

from where they came and gave them, as I said, what they have and where they are going.

At the heart of the Australian War Memorial is the Hall of Memory and beneath that Byzantine inspired tomb, since 1993 has been the tomb of the unknown Australian soldier. Standing silent sentinels above him are the images in stained glass windows of 15 Australians of the First World War. And at the bottom of each window is a single word. The founder, First World War official historian who saw everything from Gallipoli to Mont St Quentin, Charles Bean, and the first Director Henry Gullet, himself a veteran, asking themselves an important question. What they asked are the qualities – the values – we saw in these men and women that we regard as being essential, not just for victory in battles, but for depth and breadth of character.

Character derives from the Greek word that means the impression left in wax by a stone seal ring. The Greeks called it the stamp of personality. Transcending everything in life: rank, power, money, intellect, talent, looks is character – informed by worthwhile intrinsic virtues.

There are depictions of two aviators amongst those 15. The first is an Air Force technician and he is holding a clamped vice. There is an electric arc. There is a flame of invention, a sword cutting the Gordian Knot. Creative and bold solutions to difficult problems. Resource to always look, within yourself, within others for every human and material resource that you might have available to you to help you achieve your objectives. On the Western side is the image of an airman of the First World War from the Australian Flying Corps – the antecedents of our Royal Australian Air Force – and above him are the accoutrements of the Knights of the Middle Ages and the word at his feet is *Chivalry*.

Because seen in those airmen were the chivalric code of those mediaeval knights, of courage. We often speak of courage, but it is that spirit that challenges doubt in us. It allows us to impose will. It protects your integrity, advances values, and ultimately, allows you to break through fear. Moral courage, physical courage.

Honour, integrity, courtesy, a sense of justice, knowing right from wrong and the importance of knowing. And Napier Waller, the muralist who designed those stained-glass windows said of this airman, the single most important one was the willingness, the preparedness to help other human beings, irrespective of the risk to yourself.

Beyond those headlines, broad brush strokes and popular images and perhaps mythology are individual stories of courage, of devotion to duty and to our country. This year we will mark the eightieth anniversary of one of *the* most courageous acts ever by a man wearing the uniform of the Royal Australian Air Force.

On 29 November 1942, Pilot Officer Rawdon Hume Middleton, a 26-year-old Australian, was piloting a Stirling

bomber from 149 Squadron. It was his twenty-ninth mission. The target was the aircraft factory, the Fiat factory at Turin. They struggled over the French Alps, very, very heavy flak over the bombsite. On the third attempt, flak hit the cabin of the aircraft, three were wounded: the wireless operator, the co-pilot, and Rawdon Middleton. He was grievously wounded, shrapnel wounds to his arms, body and legs. His jaw was shattered, and the right eye was blown from its socket. He passed out.

The aircraft was in a death dive when the co-pilot was resuscitated by one of the crew and started to try to get control of it. Middleton regained consciousness. The bleeding-out help level the aircraft out 800 feet. He then said his crew, 'I promise you I will get you back to England'. They took more flak across France, and four hours later, they saw the English coast with less than five minutes of fuel left. The crew begged Middleton to attempt a crash landing, but he regarded the risk to civilians to be too great. Instead, he levelled out and flew the aircraft alongside the English coast where the crew were ordered to bail out.

Five of them bailed out, but two – the flight engineer and the forward gunner – refused to do so. He then turned the aircraft out to sea, the other two crew members bailed out but did not survive the night in the English Channel. Rawdon's body was washed up two months later on the English coast.

The citation for his Victoria Cross – and only 118 Australians have ever been so awarded – the citation says in part, 'His devotion to duty is not surpassed in the annals of the Royal Air Force'. If you go to Lincolnshire, in England, to the international bomber command centre, you walk from the interpretive centre along the path to the large steel spire, the height of which equates to the wingspan of a four-engined Avro Lancaster bomber. Around concentric circles, which form around that spire, are inscribed the names of 55,000 British and Commonwealth airmen who died in Bomber Command during the Second World War, including 3,486 Australians.

The very last memorial plaque you will see, is a large piece of stone, and at the bottom of it are inscribed the words of a 20-year-old Australian pilot, Colin Flockhart of 619 Squadron, who was killed in Villenueve on 7 January 1945. The words come from a letter that he wrote to his family three weeks earlier in the event of his death. It says, 'I have always been proud to wear my uniform. And striven to do my best for the Service as a whole. Cheerio, keep smiling, though your hearts are breaking'.

A century on after the formation of the Royal Australian Air Force, its leadership today is manifesting resilience and innovation. Boeing in Australia, in 2016, conceived the idea of an AI powered autonomous air powered teaming system, an attritable capability with fifth-generation flight and design characteristics with a modular payload. The Royal Australian

Air Force made the decision – a courageous decision – to co-invest in the project. Not just politically, but financially.

Less than four years after conception, it has been designed, built, and flown in Australia by Australians. With more than 70 per cent of the content being Australian made and delivered. An aircraft now flying, which is also for export to like-minded countries. But it is not just the technology, it is the way that we need to increasingly approach the acquisition of technology and materiel and platforms in a rapidly deteriorating threat environment. We can no longer simply give shopping lists to Defence industry and tell them that that is what we want to acquire. We need also, as we have done with Loyal Wingmen, to co-invest in the rapid development of capability and in doing so, take that risk.

Leadership, in my experience, is not something that can be taught – but it can be learned. And it is learned through observation of, reflection upon and adoption of the leadership qualities that we see in others. And the power is in the story, whether it is Wing Commander Sharon Brown, whether it is more than Rawden Middleton VC, or a 20-year-old Colin Flockhart, different kinds of leadership. Good leaders are at ease with themselves, there is no sense of self-aggrandisement. They are motivated clearly by a sense of public duty to do the right thing. Clear-minded, ethical and decisive.

What differentiates leadership from management is vision; management is about day-to-day, week-to-week decisions, emptying an inbox, and managing people. But leadership is informed by vision, a comprehensive sense of who we are, where we come from, where we want to go, why we want to get there, and what we are all going to have to do to deliver that outcome. Amongst the many qualities, it includes making other people feel a reverence for themselves.

As Defence Minister, I remember getting in the back of a C-130 Hercules and a young man in the Air Force disrupted cams said he was just a load master. I said, 'There is no such thing as just a load master. Every single person, including you, is responsible for the safety of the men and women on this aircraft, the delivery of the mission outcome; it does not matter where you fit. Every single person has something to contribute and no one has a monopoly on innovative and creative ideas also'. It is essential to have an open mind, a mind that is open to the unfamiliar. People that are different, ideas that are different. And to build a successful environment, to surround yourselves with people that are questioning your own thinking.

The second thing is to nurture and protect the inner integrity of your own intellect, your ability to think, to articulate ideas, to challenge the ideas of others. To be interested in and interesting to the rest of the world. Too often, in any field of endeavour, people will look through a straw, with immense expertise. But completely oblivious to the context and the broader environment in which they are undertaking their work.

The third thing that is essential is character. As I said earlier, it is what makes and breaks people. The fourth thing that is important is to be imbued with the imaginative capacity to see the world through the eyes of others.

Almost all the world's suffering comes from people who make themselves the centre of their own lives and that is the case also with nations. Understanding what people think is important, of course it is. But what is much more important, is understanding how they think. Finally, in the end, in leadership, you will be remembered not for what you are, but who you are. The way you treat others.

I know the military has a hierarchy, a chain of command. But as the great seventeenth-century Prussian philosopher Immanuel Kant observed, every human being is in and on to itself. Not a means to be used by others. Respect for your own humanity will be found in the respect for the humanity of others and morality is freedom. To do the right thing, to others and for others is freedom.

Per Ardua Ad Astra, through adversity to the stars.

Closing Address

Air Marshal Mel Hupfeld
Chief of Air Force

I acknowledge the Ngunnawal people, Traditional Custodians of the land on which we meet today. I pay my respects to their Elders past, present and emerging. I extend that respect to Aboriginal and Torres Strait Islander peoples who may be present and to the custodians of the land on which our many virtual participants are located.

It has been my great privilege to welcome and host the many international delegations, distinguished guests and aviators who attended and those who joined us digitally. I extend my appreciation to all those who made this conference possible. I wish to thank the principal sponsor of this conference, Boeing, and our major sponsors, L3 Harris Integrated Mission Systems Australia, Lockheed Martin Australia and Rolls Royce Australia.

The theme of the 2022 Air and Space Power Conference resilience and innovation in air and space – echoed throughout the presentations and many thought-provoking questions were raised and discussed.

Yesterday morning I highlighted that one of the main points of this conference, alongside enabling us all to connect, was to ignite our thinking. I am confident this intent has been well achieved. There are too many highlights to reflect on them all, but I offer the following:

It was a privilege to have the Honourable Peter Dutton MP, Minister for Defence, joining us to officially announce the stand-up of Australia's Defence Space Command and the release of the Defence Space Strategy. The perspective he offered on some of the regional and global challenges we face, and the Minister's candour and clear focus was both refreshing and bracing in light of current events.

The Announcement of Space Command and the launch of the Space Power Manual and the Defence Space Strategy were greatly enriched by General Reymond's keynote address and the space focused plenary. It is fair to say Space is now well and truly front of mind; taking its rightful place as an operational domain alongside Air, Maritime, Land and Cyber – with the unified purpose of serving our national and collective interests.

Bilahari Kausokan's insights and perspectives on what he referred to as the China dilemma was a truly masterful survey of the drivers within our current geostrategic environment. I will no doubt return to the conference records to review his words again, and I encourage you all to do the same. I expect I will be enriched further with every attempt to take in all the nuanced layers he so masterfully wove.

Professor Tanya Monro's and Carl Gibson's presentations where equally rich, and as I have worked to understand all the complexity of resilience and innovation, I now have a much deeper appreciation, and I thank them for that.

A question that has arisen in my mind following Tanya's presentation is: how do we keep Science and Technology grounded but not constrained? The pendulum may need to shift here I feel, to enable us to best go after emerging opportunities at pace.

I trust the that 'Innovation Expo' evoked thoughts on the immense potential that can be realised when research and innovation from Defence, are complemented with research institutions, academia, start-ups and industry.

I would like to thank AVM (rtd) Blackburn for his excellent framing of the resilience and innovation discussion, and for his powerful honesty when reflecting on his time as DCAF with the knowledge he has today – something in that for all of us. I would also like to express pride in one of my own, I thought ACAUST's perspectives in both his presentation and discussion in Q&A were compelling; it has been a privilege to serve alongside him and I thank him for advancing my thinking.

I have no doubt that General Luyt and AVM Clark's fellow servicemen and women would be equally proud of their deep intellect and insightful appreciation of a broad array of issues facing us all – the cascading thread of people, ideas, things was a key takeaway.

Hugh Webster's compelling narrative on need for progress in Defence industry partnership was picked up this afternoon by both AVM Denny and Michael Shoebridge. The case for meaningful change has never been clearer or more urgent.

I would like to thank my fellow Domain Leads for joining me for the launch of the manuals, sharing their perspectives and to demonstrate to all how truly unified we are in purpose.

I would also like to acknowledge Brendan Nelson for his powerful message, reflecting on our proud history to drive home the enduring importance of leadership and people in success in any endeavour – not least war.

Which takes me back to my central message from yesterday: the future of air and space power is you – its current and future practitioners. Your ability to work together with all elements of military power, and instruments of national power, are the key to our effectiveness. Engaging with every opportunity to advance your thinking, at conferences such as this one, will have tangible benefits to this outcome and your much-valued service.

I encourage you to review the proceedings when able over the coming days, weeks, months; as our conversations will be available to view and revisit online at any time in the future through our Air and Space Power Centre's website.

The many activities we conducted gave us an invaluable opportunity to reconnect with each other as people with a genuine desire to strengthen our bonds of friendship, founded on a community with common values striving for common purpose to advancing our collective prosperity.

As I bring this conference to a close, I am encouraged to know that many more answers await us as we process the vast information shared and begin to apply it to build resilience and innovation in our collective effort to maintain the prosperity of our region.

We eagerly await you at our next conference.

Thank you.

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