ENGINEERS
AUSTRALIA

Growing and Sustaining Australia's Space Engineering Capability and Competency

Policy Advice Paper

This report has been developed through Engineers Australia's member-delivered policy and advocacy initiative.

Contents

About Engineers Australia

Engineering is the essential link between thinking and doing. Between idea, and implementation. It's our means for positive, sustainable change, with an influence on every aspect of modern society. Engineers are the enablers of productivity because they convert smart ideas into new products, processes and services.

As Australia's national body for engineering, we are the voice and champion of our 120,000-plus members. We provide them with the resources, connections, and growth they need to do ethical, competent and high-value work in our communities.

A mission-based, not-for-profit professional association, Engineers Australia is constituted by Royal Charter to advance the science and practice of engineering for the benefit of the community. We back today's problem-solvers, so they can shape a better tomorrow.

Engineers are passionate participants in public discourse, contributing to important community and policy discussions that impact the economy and society. Engineers Australia's policy agenda is focused on engineering:

- a sustainable future
- a skilled future, and
- an innovative future.

National Committee on Space Engineering

Space engineering is complex, multi-discipline systems engineering for the space domain, including terrestrial support systems. It evolved from aircraft engineering and uses many of the same construction methods and reliability philosophies.

Space engineering covers all space-related activities including ground operations, earth orbiting bodies, deep space missions, astronomical systems and instruments. Engineers from all disciplines work in space engineering along with a wide range of other professions.

The National Committee on Space Engineering (NCSpE) is a committee of Engineers Australia's Electrical College and aims to be the voice of the space engineering profession in Australia. The NCSpE has access to dozens of leading Australian and international space engineers who are available for expert advice, speaking commitments, and events.

NCSpE also facilitates professional development events for the industry.

Additionally, the NCSpE supports a variety of programs and awards including STEM outreach which aims to inspire the next generation of space engineers.

The NCSpE, make comments and recommendations based upon decades of aggregated international and Australian experience in the space domain, expressed with a deep love for the nation and belief that a viable space industry can only be achieved with a proactive, focussed and carefully detailed plan that builds the pyramid of supply underpinning the nascent cohort of integrators.

This Policy Advice Paper was led by Mr Roger Franzen and Professor Peter Moar with Ms Anntonette Dailey and the assistance of the NSCpE over 2023.

Executive Summary

Space impacts every part of life. From weather, disaster management, banking, communications and positioning like GPS – a modern and future world depends on space capability. Across the world, space has become a warfighting domain, meaning that national security is deeply intertwined with sovereign space capability.

However, Australia has been standing idle for 40 years while the rest of the developed world has been making progress, evolving their own capabilities, capacity, and workforce. In 2018, Australia was one of the last of the OECD countries to establish a space agency and has a lot to do to catch up. However, coming into a new, more mature commercial stage of the global space environment has its advantages, should Australia capitalise on it urgently. Space technology is an essential element to solving significant global problems. After the experiences of the 2019-20 bushfires, pandemic and growing climate change impacts, there is a new sense of national urgency to establish a sovereign capability – there is no time left to let the market 'catch up' and a far more proactive and interventionist stimulation strategy is necessary. This is essential for Australia's manufacturing prowess and capability into the future. Without sovereign capability, Australia relies on its allies for information that may not be their priority.

The Engineers Australia (EA) National Committee for Space Engineering (NCSpE), made up of highly experienced engineers and technologists, has developed this advice paper to outline the key interventions required to build the pyramid of capability and capacity that will support the sovereign peak integrators. These organisations, commercial and research, will deliver appropriate civilian and military sovereign space resilience. Key interventions required include:

- Development of space satellites, technology and equipment to 'catch up' and build flight heritage and experience.
- International collaboration, engagement and missions.
- Commercialisation of industrial research and development (R&D) with flow-on benefit to adjacent industries.
- Workforce development and job creation in space technology and policy.

Funding alone will not solve the establishment of an internationally trusted Australian space industry. It will require a structured plan to build the necessary human and physical resources that form the capability and capacity supply pyramid. Australia will not be able to replace all imported space capabilities, but the planning process should account for an appropriate level of import replacement, sovereign capability, and resilience.

Engineers Australia has a role to play and can assist with the definition of standards-based development, vocational and professional space engineering course development, and accreditation. It can also be a source of expert advice on education and accreditation of government acquisition agencies involved with acquiring space infrastructure.

As the benefits and impact of space go well beyond a niche sector and across jurisdictional boundaries – space has a grounding impact on the nation's manufacturing acumen – the Australian Government in conjunction with states and territories need to act urgently.

Summary of recommendations

The NCSpE calls on the Australian Government and state and territory jurisdictions to urgently address these key recommendations.

1. Develop a structured plan to build the necessary human and physical resources that form the space capability and capacity supply pyramid.

2. Support the release of gradually more complex capacity and capability building sovereign space missions.

3. Mandate existing international space engineering standards in all government space asset procurements.

4. Subsidise some or all of the costs of space simulation testing for the coming decade.

5. Challenge the SmartSatCRC with nationally beneficial priorities in industry, agriculture, environment and climate management.

6. Support government agencies to become informed customers for space procurements, including by calling upon established and experienced space companies to assist agencies with procurement specification and management.

7. Support Australian space sector researchers, SMEs and start-ups with access to business 'angels' with space experience and expertise.

8. Adjust research translation and commercialisation funding support to be more applicable to the development of space-based technologies and experimental missions.

9. Establish a national training institute for space.

10. Drive diversity and inclusion in the emerging space workforce.

1. Context

Since the early 1980s, many Australian entities and organisations have tried to stimulate interest in the establishment of Australian space manufacturing capability. Those efforts brought many successes, most now forgotten, but sustainable industry was not one of them[1]. This unsustainability was due to several reasons, but a lack of Government direction and support was a major factor. The Australian Government did not focus on growing Australian capability. Australia's readiness to purchase technology from other nations meant that whatever capability and capacity was generated from the success, 'withered on the vine' and many or most of the participants of that time are now near or past retirement age and development facilities decommissioned.

In 2017, the International Astronautical Congress was held in Adelaide, South Australia and it provided a positive catalytic effect for Australia's fledgling space industry. At that conference, the Australian Government announced the intention to form the Australian Space Agency (the Agency). In July 2018, the Agency was formally established with a modest budget of $41 million over four years. However, when the Agency's industry growth objectives were declared, the extent of the challenge became clear. Over the following five years, funding increased to respond to obvious shortfalls with regards to supply chains and technological readiness through the $150 million Moon to Mars Program, International Space Investment initiative and Space Infrastructure Fund.

In 2022, over $1.1 billion over ten years was announced for space sovereign capability and was then re-allocated in 2023, following a change of government[2]. The Agency continues with a modest budget targeting mainly policy and regulatory requirements, with no new investment funding beyond its existing programs.

The Agency is charged with the objective of creating a further 20,000 jobs and some $12 billion of revenue within 10 years (by 2030) by developing the Australian space industry[3]. This target was based on a 2016 economic baseline which had the industry valued at 10,000 jobs and revenue of $3.9 billion. Two years later, the workforce had increased to 16,900 and the revenue was only marginally higher[4].

The Australian space customer with the largest space budget is the Australian Defence Force (ADF), and it has only $7 billion over the same period, the majority of which cannot be spent within Australia because the sovereign industry does not have the capability and capacity to supply all requirements in the required timeframe. Irrespective, the Agency's target of $12 billion means that revenues must also come from the international marketplace and to realise them, Australian industry must become at least equivalent to the international providers, admittedly, in a smaller range of supply. Therein lies the real challenge for Australia – to reel in 40 years of relative inactivity in international space supply chains.

Space continues to be seen as important for Australian defence capabilities, but it is not equally seen in the civilian sector. Both the 2023 *Defence Strategic Review*[5] and *AUKUS Agreement* (Pillar 2)[6] continued to highlight space as a critical element of Australia's defence. However as outlined below, this funding is unlikely to be fully delivered in Australia. The *Australian Civil Space Strategy* has not been updated since it was first published in early 2019 and there are no references to space as a priority in the National Reconstruction Fund or critical technology roadmaps such as the Robotics and Artificial Intelligence strategies released by the Department of Industry, Science and Resources in 2023. This presents challenges for space policy.

2. The challenge

As a developed nation, Australia's economy is today more deeply dependent upon space-based services than ever before. As a modern defence force, the ADF is also deeply dependent upon military space services and capabilities. All Australians, whether knowingly or not, are affected by this unequivocal and inexorable dependency. Like water from the tap, we do not ask where space services come from until they stop. But with this dependency comes a vulnerability to the continuity of supply.

As with any manufacturing supply chain, there is a pyramid of manufacturing suppliers that support the peak integrators. The space industry has a fragile pyramid without all the support mechanisms. But it is important to get the pyramid right. The consequences of losing 'the pyramid' became evident with the closure of the car industry in Australia. The loss included aggregate 'know how' of the car manufacturing processes which could have been easily translated to higher-order technologies. Space manufacturing capability continues to be subverted before it can be established fully.

The Australian space manufacturing capacity is today so small that it simply could not respond to all of the space capability needs of the ADF let alone the civil and global marketplace. Aspirations and good wishes alone will not build a space industry capable of providing sufficiently responsive capability and capacity.

Australian scientists, engineers and technologists are great innovators and always find clever solutions to new problems. However, the path from laboratory idea to reliable, repeatable space application is always difficult. Whilst developing for space is easier today than it was 40 years ago, it still requires rigorous and disciplined engineering processes to achieve successful space missions. Today, much is made of 'New Space' and 'Space 2.0', slogans that are used to justify "failing fast" and "learning by doing!" Industry should be wary of such fallacies as shown by the "faster-better-cheaper" era, an ideal of the 1990s and early 2000s within NASA that is no longer applauded internationally. Diligent engineering to international standards helps to ensure success and an understanding of change when failures occur.

From its earliest days, space engineering has been an evolutionary process that has used the best and most appropriate technologies of the day to solve the problems as we understood them. Technologies have come a long way in the 60 plus years of evolution, but today, we are still using the best and most appropriate technologies of the day. What has not changed are the challenges presented by the hostile environment that launch ascent and the space domain itself present to the engineered solutions.

Holistic, targeted training in the necessary processes and practices already learned by the developed space faring nations is needed in Australia. This includes complex project management, structured system engineering and preparing design, integration, and testing infrastructure. Competence is also required for sourcing the precision manufacturing capacity needed. These skills are not the province of start-ups.

However, perhaps the hardest problem to solve is the desperate shortage of adequately trained and informed engineers and scientists needed to resource the effort of mobilising a sovereign space industry. This shortage exists in civil government, defence, academia and industry. This problem is a direct consequence of the 40-year space vacuum in Australia combined with a lack of specified space disciplines in learning institutions.

3. Solutions

The following recommendations adopt a deliberately proactive posture. History shows that over the past decades, space acquisitions were routinely made offshore on the basis that prices were lower, and thus the Australian market demonstrated that there was insufficient revenue opportunity for a national space industry. However, this failed market approach is insufficient to capture the benefits of sovereign expenditure that builds capability, capacity and Australian jobs; resilience and security; and revenue that remains in country.

While Australia cannot, and should not, replace all imported space capabilities, a structured planning process is needed to build Australia's space capability across government, industry and the research sector, and the plan should account for an appropriate level of import replacement, sovereign capability, and resilience.

Recommendation 1: Develop a structured plan to build the necessary human and physical resources that form the space capability and capacity supply pyramid.

3.1 Development of space satellites, technology and equipment

Developing space satellites, technology and equipment to 'catch up' and build flight heritage and experience involves supporting best practice standards compatible in the international community, expanding capacity with gradually larger and more sophisticated satellites that can solve real problems, and supporting established institutions to expand their equipment for broader benefit.

Many new start-ups are currently trying to take on more than they can handle in order to play catch up and to be competitive. To assist here, Government space procurements would initially limit sovereign delivery expectations. Some of the nascent Australian space industry companies are more advanced than others and could be realistically challenged to deliver more. The proviso is that the experience and funding remain in Australia.

Government should then tender progressively more complicated space projects that can challenge Australian industry to reach international equivalence. This could involve the establishment of a

dedicated body to oversee the strategic funding of an industrial pipeline of space missions of national and international significance. Appointing a careful selection of internationally recognised experts with mastery level competency and proven mission success would guide Australia along the path to developing truly sovereign space flight heritage.

Australia is currently captivated with cubesats because of their compact size, relative low cost and ease of manufacture and launch. They are an excellent learning platform but should not be the goal in themselves. While massive improvements in electronics and communications have occurred over the past four decades, much of the performance of satellites is still a matter of physics limitation. Nationally, we should use the learned skills to also aim for larger missions, the size of which would be limited by the capacity of the nation's largest space simulation test facility. That currently exists at the Australian National University's Mt Stromlo Observatory Advanced Instrumentation and Technology Centre just outside of Canberra in the heart of Australia's capital. This facility is at a world class level for its capacity which is limited to a space object no larger than 1.5m x 1.5m x 1.5m and weighing up to 500kg. Access to space test facilities is always expensive and the Australian Government could consider subsidising some or all of the cost of such testing during the first 10 years of the Agency's industry development plans.

All Government space asset procurements should mandate existing international space engineering standards. The NCSpE can advise which standards to mandate. This obliges Australian companies to become familiar with these standards and thereby, familiar with the expectations of the international marketplace. International equivalence and acceptance will be essential to sustain the industry.

In support of mandatory standards, governments would establish training and guidance to assist with the implementation of these standards into the business processes of participating companies.

The development of new technology and equipment is currently well supported by the SmartSatCRC which is co-funded by the Australian Government. The Cooperative Research Centre (CRC) program has been very successful and has complemented the existence of such successful companies as Myriota. The SmartSatCRC has declared its role in solving the problems of Australian industry using space technology and the Australian Government should actively utilise the SmartSatCRC to support development of Australian industry-led responses to national challenges in, for example, agriculture, environment and climate management.

Recommendation 2: Support the release of gradually more complex capacity and capability building sovereign space missions.

Recommendation 3: Mandate existing international space engineering standards in all Australian Government space asset procurements.

Recommendation 4: Subsidise some or all of the costs of space simulation testing for the coming decade.

Recommendation 5: Challenge the SmartSat CRC with nationally beneficial priorities in industry, agriculture, environment and climate management.

3.2 International collaboration, engagement and missions

Australia must demonstrate its capability to contribute to international collaboration, engagement and missions. The lack of flight heritage makes Australia a 'risky' partner for nations that have already established capability. For Australia to be competitive in international supply chains, the heritage needs to be gained through sovereign development and demonstration.

Space capable nations have already long determined how to manage the risk of space technology and thereby, how to ensure mission success and reliability – although nobody is perfect. Collaboration with Australia will be viewed from that risk perspective and unless they can be assured that any products sourced from Australia will be at least as reliable as their own, international collaboration partners will be reluctant to incorporate Australian systems in their space missions. Collaboration may be limited, at least initially, just to lower risk terrestrial elements of their space missions.

The Agency has made positive progress to announce Australia's good intent by establishing Memoranda of Understanding with many international agencies and organisations. However, until Australia can demonstrate reliable, repeatable, and cost-effective space product delivery, we will be at a disadvantage in the collaboration and engagement negotiations.

As described above and in Recommendation 2, governments can support the release of gradually more complex capacity and capability building sovereign space missions. This would further support the Australian space industry to adopt international standards and practises and so professionalise with the objective of achieving international equivalence.

Critically, this will also require government procurement agencies to become informed customers themselves to be able to accurately specify the government needs and also to advise industry how best to proceed with delivery. Initially, procurement agencies will need to show tolerance for development schedules but also dissuade industry from trying to take on more than they can handle. Government may need to call upon properly space informed 'Above the Line' companies to assist them with procurement specification and management.

Recommendation 6: Support government agencies to become informed customers for space procurements, including by calling upon established and experienced space companies to assist agencies with procurement specification and management.

3.3 Commercialisation of research and development, including flow on benefits to adjacent industries

Australia must uplift its commercialisation of research and development (R&D) and capture the flow-on benefit to adjacent industries. Australia has a growing space R&D community that requires assistance to establish heritage. Already some capability has been demonstrated, but not at the pace or volume necessary.

The Australian Government has a significant power vehicle in the SmartSatCRC. As a CRC, it is specifically chartered to commercialise research and development and has a self-declared objective to flow on its benefits to all industry sectors.

As described above in Recommendation 5, the Australian Government could seek nationally beneficial priorities with which to challenge the SmartSatCRC and encourage it to engage, connect and translate research Australia wide in all states and territories. Topics already subject to research by the SmartSatCRC include water management, remote communications and the Internet of Things. While the COVID-19 pandemic constrained international and Australia wide engagement, the active coordination of innovative technological research solutions into commercially ready products is critical for future success.

The SmartSatCRC sponsors 'Business Angels' to commercially advise researchers and, if appropriate, make connections with venture capitalists. However, the availability of business angels with specific

space-sector expertise and experience is limited. This initiative could be better supported by governments to ensure that all Australian space sector researchers, SMEs and startups have access to business angels with space experience and expertise – drawing on international talent and partnerships where necessary.

Current R&D funding structures, including grants, are prohibitive to space R&D applications. Governments may seek to make the funding structures and conditions more applicable to the development of space-based technologies and experimental missions. Space is a normal research funding subject in space capable nations.

Recommendation 7: Support Australian space sector researchers, SMEs and startups with access to business angels with space experience and expertise.

Recommendation 8: Adjust research translation and commercialisation funding support to be more applicable to the development of space-based technologies and experimental missions.

3.4 Workforce development and job creation in space technology and policy

Australia lacks a sustainable and diverse space workforce. This is due to a lack of sufficient space knowledge, capability and experience locally, combined with the loss of some of its best space leaders overseas. Deliberate action is needed to harness the high interest in space jobs and translate this to space-educated citizens and future space workers. This has flow-on impact to adjacent industries, especially the manufacturing sector, and other sectors that rely on advanced STEM skills.

Despite Australia having some of the smartest minds in the world, there is still a lack of deep space engineering knowledge, especially about how most effectively to turn laboratory ideas into reliable flight systems. As described above, in space capable countries, there is already a pyramid of supply to underpin their own space industries. The pyramid includes a skilled, deployable workforce with the know-how at all levels of building space systems.

The Australian Government can provide the direction to enable the industry to take responsibility to gradually grow this skill and can take proactive action to establish a dedicated 'TAFE like' space education institute, in one or two key national locations, that can train students in the 'hands on' skills needed to build the space systems. Acknowledging that many universities offer professional tertiary skills, this proposed education facility would focus on 'hands on' skills, developing Australia's future 'space tradies'. Such training would include skills needed for critical technologies including artificial intelligent systems, robotics, propulsion, advanced materials, additive manufacturing, and the processes necessary for product assurance and all applicable international processes and standards. This could be a partnership between TAFEs and the university sector to align with current international best practice.

Encouraging students to engage in STEM courses remains a perpetual challenge. Space has always had the ability to inspire students to aspire to the harder STEM courses, yet in Australia there are few easily identifiable training pathways to a space career, and none at all in the VET sector.

Another benefit of Recommendation 2 is that engaging in highly visible and well promoted but achievable national space missions will show students that there is a future in a space career. Importantly, that the career goes beyond 'astronauts' and can be critical in solving Australia's most pressing problems like climate change, disaster recovery and farming.

A knowledge of space systems, engineering and operations is not an intuitive understanding that can be infused without specific training and education, and there is a severe shortage of this knowledge in depth in Australia[7]. This contrasts with the United States and Europe which have been active participants in the global space market for long enough that a space knowledgeable workforce is relatively easy to acquire if needed.

This is true not just for industry but also for the public officials with the responsibility for defining and acquiring national space capabilities and assets. In Australia, we have a shortage in both industry and the public sector[8]. The question becomes, how can we make good decisions about developing a good space industry if we do not know what we do not know and hence, what 'good' looks like? Experience from the NCSpE is that all space procurement elements of government bodies have shortages of this skill set, with informed personnel often existing in single numbers less than two.

Consolidating the available knowledge is essential. As per Recommendation 6, the Australian Government should aggregate what knowledge there is into informed cohorts that can support both the Agency, ADF as well as all other government procurement agencies like Bureau of Meteorology, Geoscience Australia, and the National Intelligence Community. This is unquestionably challenging.

Focusing on workforce development will also solve an inherent problem seen across almost all technical fields regarding attracting, retaining and supporting more diversity and inclusion. The broader space industry is ripe with enthusiasm to support more women, persons of colour and those of other minority groups. With a relatively young industry, there is enormous opportunity for diversity to be embedded at the start, rather than trying to retrofit at a later stage.

Recommendation 9: Establish a national industrial training institute for space.

Recommendation 10: Drive diversity and inclusion in the emerging space workforce.

4. How Engineers Australia can assist

Engineers Australia can work with industry, academia and governments to build space engineering capability in Australia. Like so many technological domains, academic qualifications are only the beginning and experience with real world application is critical.

Engineers Australia can provide:

- guidance concerning which international standards regimes to comply with
- guidance concerning the vocational curricula for TAFE courses
- guidance concerning the professional curricula for university courses
- guidance and advocacy to government agencies concerned with space acquisitions
- skills assessment of migrant engineers with space-related qualifications and experience
- STEM presentations and guidance for secondary school students, and
- continual professional development (CPD) for engineering professionals.

5. Conclusions

Over many decades, the Australian Government has adopted a 'hands off' approach for space capabilities, seeking instead to let the marketplace deliver what it needed. Without a local incentive for development, that marketplace has been exclusively based overseas.

Australia has not had a mature space industry and must catch up very fast with the international space marketplace if it has any chance of success. For the Australian space industry (especially with manufacturing) to participate in the international space supply chain, it must be able to achieve and demonstrate equivalence.

Supporting the space industry also supports Australia's manufacturing capability. An active and professional sovereign space industry has a vastly wider impact than just the space sector. Deliberate action in the space sector will have flow-on to adjacent sectors, particularly in critical technologies (AI, robotics, quantum) and manufacturing. Space continues to be used as an inspiration to the next generation and Australia needs a highly developed STEM-skilled workforce. Space can be this catalyst.

This is, however, a pivotal moment in time. Australia entering the international space industry needs to play catch up and innovate at the same time – taking the opportunities and running through the legs of giants.

If Australia wishes to develop a sovereign space capability, the Australian Government will need to be strongly proactive and interventionist, not just with the release of funds but also with support for the ground up development of education, capability and capacity and the supply pyramid that is currently missing from Australia's space arsenal. This is no different from any other space-developed nation.

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