SUBMISSION TO THE PARLIAMENT'S STANDING COMMITTEE ON INDUSTRY, INNOVATION, SCIENCE AND RESOURCES' INQUIRY INTO

DEVELOPING AUSTRALIA'S SPACE INDUSTRY

February 2021

TABLE OF CONTENTS

Introduction

The global space economy

In 2020, the global space economy was valued at around AU$471 billion[1]. That figure is expected to grow to almost AU$1.5 trillion over the next 20 years[2]. In fact, the growth trajectory of the space economy has continued despite the COVID-19 pandemic, with governments maintaining their investments in the thriving space sector. According to Euroconsult's latest assessment, manned spaceflight has now superseded Earth observation as the biggest budget priority for government spending in space.

Numerous challenges are faced by governments and industry in the pursuit of space endeavours, not the least of which is building business cases for where to place both public and private investments.

Figure 1 shows the relative size and dispersal of world government expenditures for space programs.

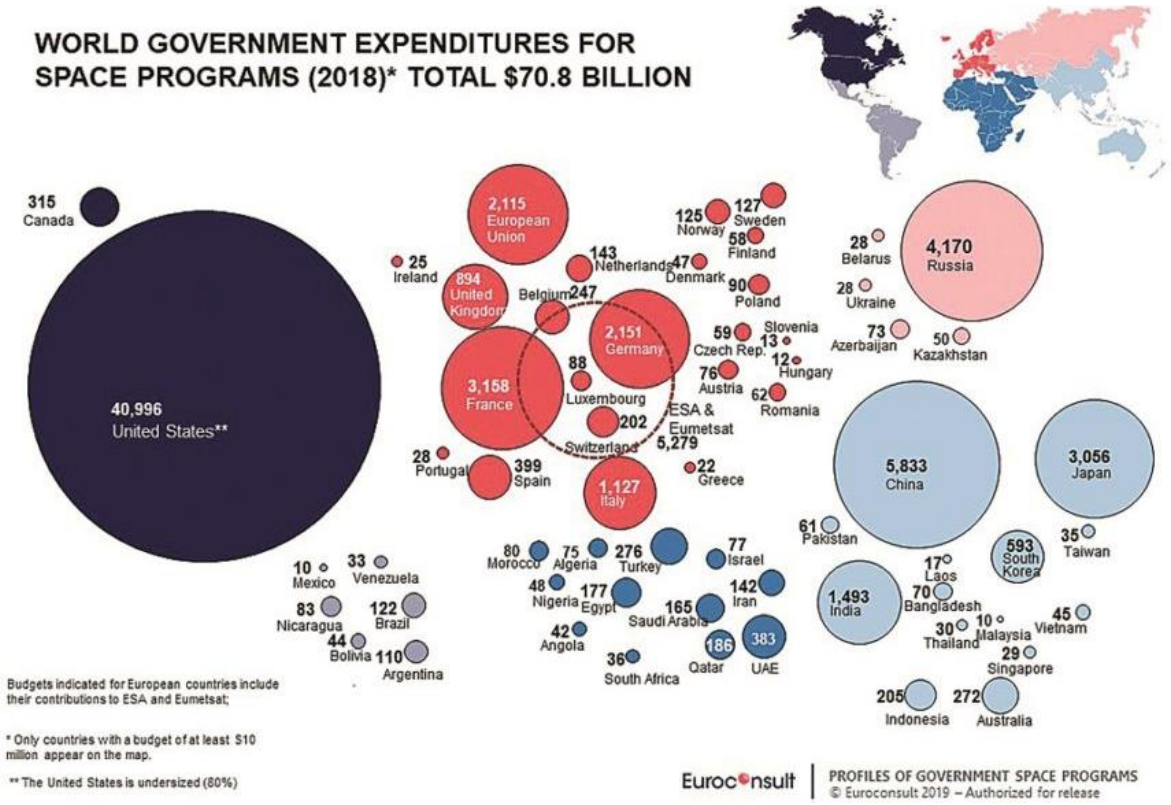


Figure 1 – World government expenditure for space programs in 2018

In 2020, the US Government's National Aeronautical and Space Administration (NASA) had a budget of about AU$28 billion for its activities, including the Space Launch System, Lunar Gateway, commercial launch capabilities (to enable easier access to the moon), and lunar landers.

Australia is a relative latecomer in establishing a coordinating space agency, with several nations holding a significant head start on the comparatively new Australian Space Agency (ASA). However, Australia has a long history of involvement in the space industry and can be proud of its achievements to date. The nation can trace its space pedigree back to the 1940s when Australian scientists from the

[1] https://digital-platform.euroconsult-ec.com/product/space-economy-report-new-edition/
[2] https://www.morganstanley.com/ideas/investing-in-space

Council for Scientific and Industrial Research's (the precursor to the CSIRO) Division of Radiophysics made key discoveries in solar activity through radio astronomy observations. Since then, Australia has played a key role in space endeavours through niche contributions to missions, technologies, and research and development (such as the Parkes radio telescope that tracked NASA's Mariner 2 Spacecraft as it flew past Venus in 1961 and received signals from Apollo 11 during its moon landing mission in 1969), as well as through world-leading expertise. Three Australian astronauts have also ventured into space, further marking the nation's ascension in the ranks of space-faring countries.

Boeing's local partnerships and investment in Australia

Boeing's presence in Australia is the company's largest footprint outside the United States, with more than 3,800 employees across the country. With the broadest portfolio in Australian aerospace, Boeing has invested heavily in upskilling Australian professionals and building an extensive local supply chain to support our work in advanced manufacturing of commercial aircraft composite components, defence systems design and development, modelling and simulation, research and development, support and training, and unmanned systems.

Our team has also successfully established partnerships with universities, government organisations, and science and technology groups to build local knowledge, explore new technologies, and mentor the next generation of Australian aerospace professionals.

A hallmark of Boeing's partnerships in Australia is its 30-plus year relationship with the Commonwealth Scientific and Industrial Research Organisation (CSIRO), representing 190 joint projects and more than AU$170 million in combined investment in aerospace development. A key research partner for Boeing in Australia, CSIRO has been awarded a Boeing Supplier of the Year four times (2010, 2016, 2017, and 2018). Building on this relationship, Boeing and CSIRO signed a Joint Research Agreement in 2019, committing to a combined investment of US$35 million for research and development over five years (including several space-specific programs). This agreement has seen the creation of 20 new research programs to form the largest research portfolio in the history of the Boeing and CSIRO relationship. It includes research programs in the areas of Space Situational Awareness (SSA), Space Manufacturing and Materials, and On-Orbit Image Processing and Analytics.

In addition, Boeing routinely undertakes activities in Australia to support its global space business. Examples of these space R&D and commercial activities are highlighted throughout this submission and detailed in Annex A. We believe continuation and expansion of our investment in Australia will help reach the ambitions expressed in the Inquiry's Terms of Reference.

1. Executive summary and recommendations

As Australia looks to advance its presence in the global space industry, there are already a number of locally-based small, medium and large enterprises that are successfully contributing to – and indeed creating significant impacts on – space activities. Having played a key role in space endeavours since the earliest days of the United States' space program, Boeing is well placed to comment on opportunities to advance Australia's space industry.

Space industry opportunities

As seen in other space-faring nations, whole-of-government coordination and direction can be a significant lever to induce businesses to invest in the space sector. Civilian and military space needs should be considered together, rather than as separate lines of effort, and the Australian Space Agency (ASA) can help bring that alignment. With coordination from government, and a focus on the right technologies such as mission systems and integration, we can accelerate Australia's success in space by drawing on the skills and expertise of the passionate specialists that make up the Australian

aerospace community.

Australia's advantages

Australia has a number of natural advantages in space science and technology, including our geographic features and physical placement in the southern hemisphere, recognised excellence in research and training, significant expertise in technology and aerospace, and strong international partnerships. These factors make Australia an attractive option for supporting international ventures in the space sector and offer distinct advantages in building a local space industry.

Development of space satellites, technology and equipment

Some areas in which Australia holds particular expertise and already has a strong record of achievement (with potential for growth) include mission systems, additive manufacturing, and space launch.

International collaboration, engagement and missions

An opportunity exists for the Government to take a lead role in the space sector by facilitating international and national collaborations. There is also a role to be played by industry, especially at the Prime level. Ideally, the entire ecosystem should be working together to progress local space activities. For example, as a Prime that already holds a substantial portion of space industry work, Boeing can act as a conduit between Australian suppliers and major space customers (including governments and commercial organisations). We recognise that Australia doesn't have to provide all the components of space activity, especially to begin with, but can continue to supply coordinated niche contributions that will help the country "punch above its weight" on the global stage.

Commercialisation of research and development, including flow-on benefits to other sectors

We have seen first-hand the expertise and potential inherent in Australian industry. Our local R&D organisation, Boeing Research and Technology-Australia, has created longstanding partnerships with Australian universities, CSIRO, and other research organisations to realise critical intellectual property developments that will help keep Australia at the forefront of future space activities in the commercial and defence sectors. Several projects in particular have positioned Australia well for future commercialisation of research and development in the areas of virtual reality/artificial reality training and simulation, remote spacecraft operation, antimicrobial surfaces and habitations, and hypersonics. These are just a few examples of what can be achieved by leveraging local talent and investing in Australian industry. By further encouraging and supporting businesses to partner with Australian organisations, the Government could see Australian industry move to the forefront of global space science and R&D, and realise a corresponding increase in economic return and jobs creation.

Future research capacity, workforce development and job creation

Collaboration and connection between academic institutions and industry will be vital in developing the professional space industry workforce of the future. There are a number of programs, both in Australia and around the world that can serve as models for creating industry-education collaboration. An example is Boeing's support for the next generation of the space workforce in schools and higher education. On an ongoing basis, we provide top-up industry scholarships to a number of university PhD students engaged on topics relevant to spaceflight, many of which are in areas of technology crucial to Australia's goals of developing sovereign space capability. The key is strong partnerships and an understanding between Australian industry (particularly Primes), the Government, and education institutions as to where the needs are and how to provide access to the latest global best practice.

Boeing endorses the Government's AI Action Plan and Technology Roadmap, and urges the Government to continue to encourage education and training in advanced software development,

artificial intelligence, and machine learning as critical skills areas for the high value jobs of the future.

Boeing's experience

Boeing has been at the forefront of manned and unmanned space exploration since we started sending machines beyond earth's atmosphere in 1960. Collectively, our organisation holds more than six decades of knowledge in space-related research, development, testing, and mission assurance, making Boeing an authority on the subject and an ideal advisor to Australia's space industry journey. Our partnerships with Australian research and development organisations, innovative small to medium-sized enterprises (SMEs), and the Australian Space Agency have given us extensive insight into the current landscape of the Australian space sector and affirmed our commitment to building a thriving local industry.

Details of Boeing's global and Australian space sector achievements are provided in Annex A.

Recommendations

Boeing makes the following recommendations to the Inquiry Committee:

1. The Australian Government should ensure military, institutional, and commercial space markets are considered as a contiguous whole, rather than as separate endeavours.
2. The Australian Government should develop a set of national space industry development priorities that allow industry to better target investments across all agencies and programs.
3. The Australian Government should facilitate development of a national Space Industry Plan that addresses the entirety of Australia's space interests. This could be achieved by integrating the Sovereign Space Industry Capability Priorities of all applicable portfolios into a national Space Industry Plan.
4. Government agencies commissioning space activities should consider the wider socio-economic benefits to Australia that will potentially arise from their considerable investment in space programs.
5. The Australian Government should consider prioritising the development of space mission systems, especially AI-enabled processing, storage, and decision support systems, as sovereign industrial capabilities that take full advantage of Australia's skills and experience.
6. Government agencies should facilitate technology transfer into Australia from overseas by actively supporting space technology transfer proposals and licence requests by industry.
7. Primes seeking to bid on major space programs should demonstrate their commitment to supporting Australian industry and a track record of meaningful investment in Australia's space capabilities.
8. The Australian Government should recognise the need for industry to better exploit IP generated as a result of Government-funded space collaborations. This should include consideration of a model where IP defaults to those industry partners best placed to deliver long-term value to the Australian space industry.

2. Space industry opportunities

The global space market is generally typified by high entry costs and an extremely competitive and unforgiving commercial environment. It is serviced by a number of established players, most of whom see Australia as an open, fair, and attractive market. The Australian space industry has struggled to gain traction for a number of reasons – these include Australia's relative geographic isolation from the main industry players, historically limited commercial and government spending in space, our small

national presence in space, and (likely) our limited historical and cultural connections with the space domain.

Australia now seeks to establish itself in the global space market to address the growing Australian and international need for space-related products and services. To succeed in this market, Australia's space industry will need to be lean, efficient and focused on sustainable growth, recognising the realities of the current international market and aligning with the future growth vectors in the global space industry.

Whole-of-Government approach

Like many other nations, government programs tend to dominate the space market in Australia. In particular, Defence investment during the period 2021–2030 will (at least initially) outpace commercial and other government spending. While Defence has a number of unique technological requirements, military mission needs in general (security, capability assurance, resilience, etc.) are well aligned with non-Defence users. Without compromising Defence requirements, it may be possible to better leverage the significant Defence investment to kick-start elements of Australia's commercial industry. Tighter cross-coupling of Defence investment with civilian industry development priorities will help to streamline industry focus by avoiding the evolution of separate industrial capabilities for Government agencies and commercial applications.

Recommendation 1: The Australian Government should ensure military, institutional and commercial space markets are considered as a contiguous whole, rather than as separate endeavours.
Recommendation 2: The Australian Government should Develop a set of national space industry development priorities that allows industry to better target investments across all agencies and programs.
Recommendation 3: The Australian Government should facilitate development of a plan that addresses the entirety of Australia's space interests. This could be achieved by integrating the Sovereign Space Industry Capability Priorities of all applicable portfolios into a national Space Industry Plan.

Space industry risk

Confronted by the technological, competitive and financial barriers to entry, Australian industry is naturally wary of accepting risk in the development of space-related products or capabilities. Apart from niche players, space is not a traditional target for Australian industry, especially when other markets (agriculture, mining, education, aerospace, etc.) offer easier entry with more assured returns. By its very nature, Government investment in space programs, especially by Defence, can be used to reduce technical, production, and programmatic risk that would otherwise stall any move by industry to lead the development of innovative Space capabilities. History has shown that in many cases, government investment in space programs has stimulated commercial innovation and market access. For example, NASA tracks the significant socio-economic benefits that accrue from its investments in space technology[3], such as innovations in solar power generation, battery technology, robotics, air travel, mining technology, medical imaging, and many other areas. Following this principle, a useful starting point for Australia may be for Defence to challenge industry to show how Government funded projects will help to stimulate product, service and industry development activities in other domains.

[3] https://www.nasa.gov/sites/default/files/files/SEINSI.pdf

Recommendation 4: Government agencies commissioning space activities should consider the wider socio-economic benefits to Australia that will potentially arise from their considerable investment in space programs.

Mission system focus

The space industry is traditionally characterised by the development of space vehicles, launch capabilities, and manufacturing of space-rated hardware (including complex sensors and communications equipment). These markets, however, are already mature and well-served by the incumbents who compete on cost and capability. Australia's strength lies more in its understanding of the application and end use of space domain capabilities – alternatively described as the "Space Mission". Mission systems, data analysis, secure communications, and decision support systems are just some of these critical enabling capabilities. These are areas where Australia's deep understanding of missions such as earth sciences, remote sensing, communications, and precision navigation, will give it a competitive advantage. Australia would benefit by considering a shift in focus to space mission management and information systems. These may include:

- Development of sophisticated ground-based operational mission systems
- Application of advanced automation, artificial intelligence, and signal processing to the complex task of managing space vehicles and missions
- Development of systems that can store and process the enormous amounts of data generated by remote sensing satellites.

Recommendation 5: The Australian Government should consider prioritising the development of space mission systems, especially AI-enabled processing, storage and decision support systems, as sovereign industrial capabilities that take full advantage of Australia's skills and experience.

3. Australia's advantages

Australia has a number of natural advantages in space science and technology, including our geographic features and physical placement in the southern hemisphere, recognised excellence in research and training, significant expertise in technology and aerospace, and strong international partnerships. These advantages and the opportunities they present have been well documented in recent reports[4].

Essentially, Australia's position as the only continent between the Indian and Pacific Oceans and projecting outwards with visibility of one-third of the sky means that ground system support at Australian longitudes and latitudes is required for any remote mission, space station, or colony to maintain continuous communication with Earth. Australia's proximity to the equator is conducive to rocket launch and its vast, clear-skied desert landscapes are attractive for astronomy and ground-based space communications infrastructure.

Australia also offers a strong education and R&D base with local expertise in space technologies. This is used in the integration and application of space-sourced data across multiple industries and

[4] Bryce Space and Technology. (2016). *Global Space Industry Dynamics, Research Paper for Australian Government, Department of Industry, Innovation and Science*
ACIL Allen Consulting. (2017). *Australian Space Industry Capability, A Review.*
CSIRO. (2018). *Space, A Roadmap for unlocking future growth opportunities for Australia.*
Expert Reference Group. (2018). *Review of Australia's Space Industry Capability*

underpins small Australian companies targeting the space industry.

Boeing acknowledges and recognises these advantages as opportunities to grow and enhance Australia's space market potential.

Advanced software development capabilities, artificial intelligence and machine learning

Increasing digitisation of space ground segments and collection and analysis of data will result in new applications and services that can be delivered virtually around the world. Advanced software development, artificial intelligence, and machine learning capabilities will only further the process, with demand for skills in these areas increasing across multiple industries. Currently, Australian universities only supply a quarter of the forecast demand for ICT graduates each year (CSIRO Data 61, 2019). Boeing endorses the Government's AI Action Plan and Technology Roadmap, and urges the Government to continue to encourage education and training in advanced software development, artificial intelligence, and machine learning as critical skills areas for the high value jobs of the future.

Capabilities in niche emerging technologies, including quantum computing and encryption

There are a number of potential future applications of quantum technology in space, including sensors and precision instruments, communications, simulation, computing, and networks. These are potentially niche, high-value opportunities. Australia was a pioneer in quantum technology. Boeing supports the CSIRO approach to growing Australia's quantum technology industry and other initiatives across the country, and the Government's continued support for the commercialisation of quantum technologies for high value applications globally.

Progressive regulatory environment

Australia is unlikely to have sufficient domestic demand to support a sustainable commercial space launch industry. The country does, however, have the potential to attract international customers for equatorial and polar launch, particularly if it implements a contemporary regulatory framework as it did in its world-leading regulation of unmanned aircraft systems in 2001. Australia has already established solid regulatory foundations for the nascent space sector.

While not advocating any specific Australian space launch initiative or program, Boeing believes that the development of a suitable regulatory framework would facilitate the future establishment of a sustainable space launch industry in Australia. Such a framework would need to draw on the recent experience of countries such as the UK and New Zealand to encourage the establishment of a commercially viable Australian sovereign space launch capability, while still accommodating Australia's international obligations.

4. ASA collaboration

On 26 March 2019, Boeing and the ASA signed a Statement of Strategic Intent and Cooperation, acknowledging that the Agency and Boeing share the common objectives of enhancing the capability and competitiveness of Australian industry and of promoting investment in space capabilities and high tech jobs of the future for Australians.

The statement outlined Boeing's goal to be a space industry leader in Australia, just as it is globally, and identified a number of priority research and development programs being pursued in collaboration with CSIRO and university partners. In line with the intent of the statement, our R&D investment is heavily focused on establishing new business opportunities and high tech jobs growth in Australia through the development of satellites, technology, and equipment such as those highlighted in the projects outlined below.

Some emerging areas of collaboration with ASA under the Statement of Strategic Intent include:

- **Capability roadmaps and industry assessments** – Boeing has actively engaged with the ASA to provide feedback on capability roadmaps through participation in technical advisory workshops. We have also held discussions with the ASA around Australian testing facilities and capability that can support and develop the Australian space industry, including formal input into a national survey assessing current industry capability.
- **Anticontamination technology** – Over the past four years, Boeing Research and Technology-Australia has been developing an antimicrobial technology for space missions that could help ensure the health crews and protect spacecraft systems from bacteria – and ultimately may help prevent interplanetary contamination from Earth-borne or another planet's microbes. This project has been discussed with the ASA as work progressed. It is currently a research payload in orbit on the ISS and was developed with the University of Queensland as a Boeing partner. This work is in line with the Space Health and Life Sciences area highlighted by the ASA as a field in which Australia possesses unique expertise.
- **Software development** – Boeing Research and Technology-Australia has developed software currently used in the United States for rocket tests and satellite launches. In line with the ASA's support for a sovereign launch capacity, this software is now being explored for space technology developmental partnerships with Australian universities and start-ups.

The initiatives listed above should make it clear to the Inquiry Committee that ongoing support for the ASA to continue fostering industry and research collaborations is a critical role for the Agency. This is equally as true for Primes and larger organisations (such as Boeing and CSIRO) as it is for SMEs.

As a result of our local depth and breadth of investment in space-related technology projects, Boeing Research and Technology-Australia was awarded R&D Business of the Year in the 2020 Space Connect Australian Space Awards. Our R&D in Australia is world-class and our collaborations with ASA, CSIRO and the University of Queensland in particular will lead to new business opportunities for Boeing Australia, helping to grow local industry and secure new high tech in-country jobs.

5. Inquiry terms of reference

5.1. Development of space satellites, technology and equipment

The traditional view of technology associated with the space domain focuses on the satellite bus and hardware itself, as well as the launch vehicle. There are still some advances to be made in the satellite bus (such as new propulsion technologies and a move to smaller, lower-cost buses), however we believe the major technology advances that Australia is positioned to take advantage of are in the areas of space payloads and ground systems.

Mission systems

In the Defence environment, Australia has excelled in focusing on the operational mission and how to integrate platforms, components, and support systems to achieve an operational effect. If we apply this lens to the space domain, we believe the following technology areas to be key opportunities of interest for Australia:

- Development of highly resilient multi-mission ground systems
- Development of sophisticated operational mission systems supporting complex user needs
- Automation of space mission management
- Development of techniques that address the enormous data storage and analysis problem that typifies civilian and military space-based remote sensing and intelligence, surveillance and

reconnaissance (ISR) missions

- AI-enabled processing systems that automate demanding and time-consuming operator activities
- Development of precision test and evaluation capabilities to ensure end-to-end performance of space-based systems.

The common thread in this list is that these opportunities all involve development and integration of complex systems that come with significant development risk. To mature Australia's capability in these areas, the Government must be prepared to embrace the perceived (and in some cases real) risk that comes from undertaking these sorts of programs, rather than leveraging products and services from other countries. From a Boeing perspective, this level of support from the Australian Government will be complemented by an intentional and focused knowledge transfer approach, where world-leading space domain expertise within The Boeing Company is shared with Boeing Australia employees.

Additive manufacturing

We have identified systems integration, mission ground systems, data capture, and analysis as key focus areas, however we do believe there are opportunities for Australian industry in supporting space vehicles and launch. For example, Boeing has an additive manufacturing capability in Australia and continues to actively explore ways in which it can be applied to space. Australia is well placed to exploit additive manufacturing opportunities, as they are achieved through leveraging technology to maintain competitiveness, rather than trying to compete with more labour intensive manufacturing techniques with relatively higher costs.

Space launch

A sovereign space launch capability is an area that has the potential to not only create an enduring national space capability, valuable in both defence and commercial applications, but provide tangible business opportunities for Australia to be used as a launch location of choice for our region. The capability would also create a very powerful symbol of Australia's commitment to space, and inspire a sense of excitement and passion for space in Australians. The challenge for sovereign launch, especially moving from small launch vehicles and payloads into the larger vehicles that support medium and geosynchronous orbits, is the investment in launch infrastructure. Taken on a program-by-program view, this investment will likely prove cost-prohibitive and of limited competitiveness in a market already well served by the established players. However, when viewed across the portfolio of programs and interests in both the defence and commercial sectors, and combined with other intangible benefits, the business case for a sovereign launch capability may well prove compelling.

5.2. International collaboration, engagement and missions

To a great extent, most space-related technology development, production, manufacturing, and innovation resides overseas. The most appropriate longer-term strategy is to create the means to transfer these capabilities, through collaboration and international engagement, from overseas companies and agencies to Australia where it can be used to develop new systems and capabilities. Until Australia has a self-sustaining space industry, it will be heavily dependent on international partnerships and collaboration, especially when it comes to sharing data, coordinating R&D, and aligning priorities. These international partnerships can be led by government and/or industry and all participants have a responsibility to collaborate in good faith to achieve the end result of developing a vibrant internationally competitive Australian space industry.

The Government has an essential role in facilitating international and national collaboration at all levels. Firstly, Australian government institutions involved in space research should be encouraged to more freely share information and collaborate with industry, especially when industry is considering

investing in the development of space-related products or services. Secondly, Government departments (such as Defence) may be able to better leverage their international relationships to facilitate local industry access to sensitive space technologies.

Foreign governments protect sensitive space system information using a complex system of licences and authorisations. The Australian Government is often called upon to confirm the end-use of technology in supporting Australia's national interests, effectively legitimising the request. Withholding that support (potentially in the interests of avoiding a perceived bias in favour of the requestor) can impede technology transfer to support industry. The Australian Government can assist local industry by supporting technology licence requests, lobbying foreign governments to release technology to Australian industry, and supporting collaborative or co-development programs.

Recommendation 6: Government agencies should facilitate technology transfer into Australia from overseas by actively supporting space technology transfer proposals and licence requests by industry.

Australian Primes aspiring to a role in the space industry have a responsibility to partner with smaller Australian companies to help nurture and develop the SME base. Primes should also demonstrate a willingness to both develop SMEs and assist them to access international opportunities. SMEs that have little experience in the difficult global space market should be given assistance, guidance, and direct support by Primes in commercialising their intellectual property (IP) or marketing their products. This is best achieved when multi-national Primes extend and integrate their global space businesses into Australia, rather than conducting business in Australia from overseas. It is an important distinction, as it involves Primes actively including Australian businesses in their global (not just Australian) supply chains, integrating R&D activities to include work undertaken in Australia, and collaborating meaningfully with Australian businesses and research organisations.

Recommendation 7: Primes seeking to bid on major space programs should demonstrate their commitment to supporting Australian industry and a track record of meaningful investment in Australia's space capabilities.

Intellectual property

The end-ownership of IP is often a major concern of larger Primes when considering collaborating with Australian companies or Government agencies. A Prime will tend to invest where it sees a return or competitive advantage, so the ownership of IP needs to be carefully managed to avoid restrictive or onerous ownership and/or licensing arrangements being seen as a disincentive to international collaboration. With the current pace of innovation and technology development, space-related IP tends to be relatively perishable in the marketplace, meaning it needs to be commercialised quickly.

Furthermore, the business value of IP tends to be linked to its suitability for inclusion in major international proposals or its ability to displace a more expensive incumbent solution. Australia has valuable niche capabilities in areas including remote sensing, on-board processing, quantum encryption, and others. However, to translate these types of capabilities into a complete system generally involves investment and risk, often borne by the Prime. When core IP is held at risk, it is a strong disincentive for its inclusion in a proposal by the Prime. As Australia seeks to significantly expand its space industry, fuel innovation, and drive exports, there may be an opportunity to consider taking a more permissive approach to the management of space-related IP generated through collaboration and international partnerships.

Recommendation 8: Government should recognise the need for industry to better exploit IP generated as a result of Government-funded space collaborations. This would include consideration of a model where IP defaults to those industry partners best placed to deliver long-term value to the Australian space industry.

5.3. Commercialisation of research and development, including flow-on benefits to other industry sectors

In recent years, Boeing has supported a number of space-related research projects with CSIRO, leveraging its significant and longstanding experience in radio astronomy, remote sensing, and advanced materials for extreme environments. Each project is aimed at advancing some of the critical IP elements that will put Australia in good stead for future advanced satellite design and operations across the commercial and defence sectors. The key research areas identified in the ASA/Boeing Statement of Strategic Intent and Cooperation included Space Situational Awareness (SSA), Space Manufacturing and Materials, and On-Orbit Image Processing and Analytics.

Space virtual reality/artificial reality training and simulation

Through its relationships with NASA and Boeing Houston, Boeing Research and Technology-Australia has created several fully interactive simulation environments for R&D and training. They use local Australian technical and human factor expertise and are primarily focused on solving problems in:

- Ground-based simulation training
- Training in orbit
- Physical spacecraft design, circumventing the need for physical mock-ups.

These are only initial use cases for the capability that has been developed locally – requirements will continue to be driven by our partners at NASA, as well as through industry opportunities. The training environment will continue to be developed internally and through partnerships with universities, allowing it to support more of the design pipeline and train a broader spectrum of critical skills for industry, astronauts, and ground operators.

Broader commercialisation will be achieved by:

- Continuing partnerships with NASA and Government
- Leveraging partnerships with Australian universities and start-ups to reach a “critical mass”
- Providing training
- Perform the role of subject matter expert in the field.

Remote spacecraft operation

Due to the complex nature of modern manufacturing and payload testing, Boeing Research and Technology-Australia has developed and deployed a secure, real-time communications capability that allows for remote inspection, review, and qualification of the manufacturing process. It has proven a critical tool at several supported events, including remote launch operations at El Segundo Mission Control Centre and distributed testing at NASA’s Michoud facility. The capability provides broad application across:

- Satellite launch
- Rocket launch

- Distributed testing
- Ground to orbit communication.

Discussions are already underway with SME and university partners on how this capability can be further used by Australian start-ups in the space industry to drive effectiveness. It will continue to be developed internally and under Australian university partnerships.

Antimicrobial surfaces for space systems and habitations

Boeing Research and Technology-Australia and the University of Queensland are developing an antimicrobial polymer to improve the health and safety of space missions and habitats. The polymer is currently in-orbit on the International Space Station for testing.

5.4. Future research capacity, workforce development and job creation

Future research capacity

On an ongoing basis, Boeing is providing top-up industry scholarships to a number of university PhD students engaged on topics relevant to spaceflight (simulation, manufacturing, risk assessment and mitigation for human health during spaceflight, and autonomy). Many of these are in areas of technology crucial to Australia's goals of developing sovereign launch capability, space situational awareness, communications, autonomy for spacecraft and possible off-earth mining, and long-duration interplanetary human missions.

Boeing's core contributions in terms of research capacity includes software, human factors, and advanced manufacturing in partnerships with Australian universities and start-ups.

Space industry workforce development

Boeing is developing a strong STEM workforce through innovative partnerships and programs across the globe. Through initiatives such as FIRST Robotics, the Australian Space Design Competition, and placing National Engineers Week interns on space projects, Boeing Space and Launch employees have committed themselves to inspiring the next generation of innovators, technology leaders, and change makers – on Earth and beyond.

The Boeing-sponsored Genes in Space competition is a STEM contest that challenges students in grades seven through 12 to design DNA analysis experiments for the International Space Station (ISS) US National Lab. Genes in Space winners give a presentation on their research and are invited to watch their experiments launch on ISS resupply missions.

Boeing partners with the ISS US National Lab on the MassChallenge start-up accelerator's Technology in Space competition. Winning companies receive funding and the opportunity to have their research conducted on the station.

Jobs creation

In its 2020 *State of Space* publication, the ASA reported that in the financial year 2018–19, the Australian space sector employed approximately 13,200 people, up 14% from 2016–17. Over the same period, the number of businesses involved in space industry work grew almost 10% to 766[5].

If industry is to drive investment in space (and meet the Government's objective of growing the space sector by 20,000 people over the period 2018 to 2030[6]), it needs to see a path to commercial return.

[5] https://www.industry.gov.au/sites/default/files/2020-12/state-of-space-report-2019-20.pdf, p.18

[6] https://www.industry.gov.au/data-and-publications/australian-civil-space-strategy-2019-2028/strategic-vision-for-the-australian-space-sector

Boeing understands there are many advantages to placing work in Australia, such as the strong education sector, an accomplished and skilled base of small to medium enterprises, social and economic stability, and its diverse geographical features, including proximity to the booming Asia Pacific region. But even Boeing, with its relatively large Australian workforce and longstanding commitment to the country, has to make constant judgements on whether to place work here or elsewhere due to a range of competing factors. Many nations that invest very heavily into space endeavours also insist their money is spent locally to build a local workforce and create local jobs.

Boeing believes that integrating military and civilian project and job creation pipelines will ensure future opportunities for Australia to capitalise on the many advantages the nation has for participation in the global space industry.

By partnering with a space Prime such as Boeing, with its long history of local collaboration and development, Australia can leverage itself into more projects that, in turn, will develop expertise, job creation, and further investment.

5.5. Other related matters

Boeing has supported several industry events, including the Austrade Space Forum and the 2020 CSIRO Space 2.0 workshop. We have also conducted an industry training event for suppliers in responding to bids and engaging Prime contractors. These workshops were aimed at enabling Australian suppliers to enter into the global space supply chain and Boeing's local space supply chain as part of current space campaigns. Through this process, more than 100 Australian suppliers have been engaged to explore opportunities to work with Boeing in the space domain, either in Australia or overseas. At the end of 2020, Australian export opportunities supporting Boeing's global space supply chain covered 30 suppliers across 13 categories.

Role of Primes in developing Australia’s space industry

Prime companies have an important role to play in the development of the space industry in Australia. Primes can help accelerate industry development by transferring skills and knowledge developed through decades of space operations in the United States and Europe.

Australia has proven aerospace capabilities, however the learning curve is significant when it comes to the additional requirements of working in the space sector. This learning curve – covering areas such as manufacturing, certification, and operations – can be flattened by involving Primes with a high level of expertise. Primes can send skilled international space experts to work alongside their Australian counterparts and they can invest in R&D with Australian research organisations and specialist SMEs to develop local IP and grow technical and research capability. Primes need a pipeline of talent and will invest in education programs for space at the secondary and tertiary level, offering a variety of learning opportunities (such as Boeing’s FutureU Program and Space Camp sponsorship) to attract and grow talent. Primes will benefit from this approach, as will the entire Australian space industry. Young people who have gone through such programs are attractive hires for Primes, SMEs and research organisations.

The Australian space market is small; while it is growing, it will be difficult to maintain scale. As with other industries, Australian space companies will seek to export their capabilities. Breaking into the global space market will be challenging for many smaller organisations, and Primes can assist by including Australian SMEs in their global supply chains.

By their nature, Primes will focus on markets and opportunities that have the potential for viable financial returns that present manageable risks, and that can accommodate the overhead of protracted and resource-intensive procurement process responses. Primes will assist Australian industry to focus on sustainable opportunities.

6. Conclusion

With the formation of the Australian Space Agency, and through strong partnerships between industry, the Government, education institutions, research organisations, and other interested parties, Australia has substantial opportunity to capitalise on its long experience in contributing to space activities. However, there are actions that the country should take to ensure it maintains its growth towards greater participation in the global space ecosystem. Chief among them is continuing the tight partnership with space Primes which can leverage Australia's advantages as opportunities arise. With its strong history and presence in Australia, and a record of partnership with Australia's research and development community, as well as small and medium-sized enterprises, Boeing stands ready to further assist the nation to reach its full potential in the space industry.

ANNEX A – BOEING'S SPACE PORTFOLIO

For more than 60 years, Boeing has partnered with governments, industry and academia to lead the world's endeavours in space. From putting humans on the moon and exploring the reaches of our solar system, through to the latest defence and commercial satellites, the International Space Station (ISS), and looking ahead to the future of human space exploration, Boeing is at the cutting edge of space technologies and systems.

Today, Boeing's Space and Launch business unit covers a broad portfolio of innovative platforms and capabilities. We're designing and building the future of safe, assured space exploration and commercial access while simultaneously leading the digital transition of the satellite industry for government and commercial customers around the globe. Partnered with NASA, Boeing continues to support the ISS, now in its 20th year of human habitation. We're also supporting NASA's next Moon to Mars efforts via our heavy lift Space Launch System (SLS) rocket and our resusable CST-100 Starliner spacecraft. Our satellite business continues to support commercial and government satellite programs with the US military's most modern communications satellite, WGS-11+.

Here in Australia, Boeing and the Australian Government have an established partnership. As part of a collaborative research and development portfolio, Boeing and the CSIRO have been furthering technology (including space technology) for more than 30 years. Boeing Research and Technology-Australia has partnered with the CSIRO, the Defence Science and Technology Group, academia, and small businesses to lead research into areas including space situational awareness, satellite on-board processing and machine learning, and antimicrobial materials, with the latest antimicrobial research project having launched to the ISS in December 2020.

Boeing's venture capital business unit HorizonX has invested in Adelaide-based Internet of Things (IoT) start-up Myriotta and recently partnered with Sydney-based artificial intelligence and machine learning company Saber Astronautics to develop technology that predicts the impact of unexpected events and space weather on spacecraft. Boeing Australia plans to use this technology, as well as collaboration with Australian small businesses such as Clearbox, to support the Australian Defence Force's next-generation Satellite Communication (SATCOM) system, known as JP9102.

We have established an Office of Australian Industry Capability leadership position within Boeing to further opportunities for other Australian small businesses in both local ADF programs as well as more broadly within our global supply chain.

Collectively, the experience of Boeing in the US, globally, and in Australia continues to benefit the Australian space sector through the transfer of knowledge and expertise to local industry, the creation of local jobs, and the establishment of export opportunities for Australian small businesses. In March 2019, this commitment to building the Australian space sector was reflected in a Statement of Strategic Intent and Cooperation, signed by Boeing and the Australian Space Agency (ASA). The ASA's efforts to foster industry and research collaborations is a critical role for the Agency that will continue to shape industry's support for the Australian Government's development of sovereign space capabilities.

1. SPACE PROGRAMS GLOBALLY[7]

1.1. HUMAN SPACE EXPLORATION

Boeing built and sustains the **International Space Station (ISS) –** now in its 20th year of human

[7] Several Boeing programs have been omitted from this paper out of respect for customer and program communication schedules.

habitation – to enable research that benefits the future space economy, deep-space exploration and life on Earth. We will provide NASA with critical crew launch capabilities with the reusable **CST-100 Starliner** spacecraft, and deliver heavy-lift, human-rated propulsion to deep space with **NASA's Space Launch System (SLS)** rocket. We provide the core and upper stages and avionics suite for the evolvable SLS rocket, which will launch missions to cislunar space, the Moon's surface, Mars, and beyond. In support of these and other missions, Boeing-built **Tracking and Data Relay Satellites (TDRSs)** provide high-bandwidth communications between Earth-orbiting spacecraft and facilities on the ground.

1.2. BOEING GOVERNMENT AND COMMERCIAL SATELLITE SERVICES

Boeing is the industry leader for next-generation satellite technology and manufacturing practices, and designs and builds advanced space and communications systems for military, commercial and scientific uses. Our company pioneered the industry's most advanced, software-defined digital payload, all-electric propulsion and 3D manufacturing capabilities for spacecraft that can operate in the geosynchronous, medium-Earth or low-Earth orbit.

Boeing's government satellite programs include the **Wideband Global SATCOM (WGS)** constellation, including the US military's most modern communications satellite, **WGS-11+**. Boeing also supported the US Air Force in establishing WGS international partnerships, including the MOU that enabled the Commonwealth to fund the acquisition of WGS-6 in exchange for global access to the system. Boeing is one of three contractors developing a satellite payload prototype and resilient satellite communications architecture for the US Space Force's **Evolved Strategic SATCOM (ESS)** program. Other secure MILSATCOM programs include extremely high-frequency payloads, and the **Protected Tactical Enterprise Service (PTES)** and **Protected Tactical SATCOM (PTS)** programs, which deliver survivable, secure and resilient communications to the US military and its allies. In addition, Boeing is the manufacturer of Intelsat's IS-22 satellite, including the UHF hosted payload providing narrowband SATCOM service to the Commonwealth.

Boeing is the Prime contractor for "America's Spaceplane," the **X-37B** – winner of the 2019 Collier Trophy for the year's most outstanding accomplishments in astronautics and aeronautics – used by the US Air Force and US Space Force to explore reusable space vehicle technologies, as well as experimentation, risk reduction and concept of operations development.

Current Boeing commercial satellite programs include **Viasat-3**, which will launch in 2022, and will comprise three ultra-high-capacity satellite platforms and complementary ground network infrastructure. **O3b mPOWER** is SES's 11-satellite Medium Earth Orbit (MEO) constellation based on the company's 702X platform, which will deliver internet access to three billion people around the world, beginning in 2021. Boeing's 702X is the next generation of highly flexible, software-defined satellites, featuring our most advanced digital processor to form, steer and shape more than 5,000 beams and adapt coverage in real time or over time. Boeing is also building two **C-Band** satellites for SES that will allow US broadcasters to deliver TV and radio service to nearly 120 million homes.

1.3. LAUNCH SERVICES

Since 2006, **United Launch Alliance (ULA)** – a joint venture between Boeing and Lockheed Martin – has successfully launched more than 135 missions aboard its Atlas and Delta rocket families, including satellites and other critical payloads that provide Earth observation capabilities, enable global communications, support classified defence programs, unlock the mysteries of our solar system, and support life-saving technology.

Later in 2021, ULA's human-rated Atlas V rocket will launch astronauts and cargo aboard Boeing's CST-100 Starliner to the International Space Station.

1.4. SPECTROLAB

Spectrolab, a wholly-owned Boeing subsidiary, is the world's leading merchant supplier of the highest-efficiency multi-junction solar cells for spacecraft power systems, with proven reliability drawn from 60 years of space heritage. Spectrolab's state-of-the-art space solar cells and panels power satellites in Earth's orbit, as well as the International Space Station.

1.5. MILLENNIUM SPACE SYSTEMS

Boeing subsidiary Millennium Space Systems, acquired in 2018, provides agile, flight-proven small-satellite solutions. It has developed high-performance satellites and space systems for exacting missions ranging from 50kg to more than 6,000kg.

2. OUR WORK IN AUSTRALIA

Noting the breadth of space capability, Boeing needs to diversify its global supply chain to ensure it can keep up with the supply and demand of its products. With this in mind, we are actively engaging with more than a hundred Australian companies to assess their capabilities to be included in current programs and to be further developed in Australia.

Boeing’s goal is to be a leader in Australia’s space industry, just as it is globally. In support of this, Boeing Australia will build on its legacy in the Australian space industry by continuing to make strategic research and development investments that support the Australian Space Agency and the Australian Defence Force in their efforts to expand space-based and space-enabled capabilities.

Of note, Boeing has a 30 year research and development partnership with Australia’s Commonwealth Science and Industrial Research Organisation (CSIRO), and Boeing has invested more than AU$170 million in CSIRO R&D projects. Currently, Boeing is investing jointly with the CSIRO, focused on the key space-related technology areas detailed below.

2.1. SPACE SITUATIONAL AWARENESS PROJECT

Standard radar ground antennas have limited size and signal reception performance for communication and detection of small/distant objects. This project will use the Australian Square Kilometre Array Pathfinder (ASKAP) radio astronomy antenna array to demonstrate highly accurate detection and tracking of near-earth objects and satellites, and develop auto focus/correction and tracking algorithms for small moving objects using the antenna array. This technology may be of interest for future ADF programs such as the Space Domain Awareness capability (JP9360).

2.2. SATELLITE ON-BOARD PROCESSING PROJECT

Earth observation satellites (EOS) have data processing, battery, and data downlink limitations for the data they collect. This project aims to demonstrate software capabilities that can process Earth observation data on-board to create useable images and information, reducing the volume of data that must be sent through downlinks. This capability will be needed to enable the new generation of hyper-spectral sensors that produce data volumes several orders of magnitude higher than current sensors.

2.3. DATA ANALYTICS AND NETWORK OPTIMISATION

In 2020, Boeing’s venture and investment team at HorizonX sponsored a research project with Boeing's Australian data analytics team. This project looked at software defined networks, machine learning and artificial intelligence for network optimisation. The project examined network structures,

carried out a trade study on network optimisation methodologies, and produced a working demonstration, both on simulated and live data. The technology is aimed to be applied to both terrestrial and satellite networks for both Defence and commercial customers.

2.4. ON-ORBIT MANUFACTURING STUDY

HorizonX engaged CSIRO Futures in November 2018 to conduct an exploratory high-level review into current and potential applications for on-orbit manufacturing. The report aimed to identify emerging technologies, products, and ideas in a rapidly evolving industry in order to identify and negate risks and opportunities to Boeing's core business.

2.5. VIRTUAL REALITY – TRAINING AND ENGINEERING CAPABILITY

Boeing Research & Technology-Australia's mixed reality team developed the virtual reality astronaut training capability for Boeing's CST-100 in support of Boeing's Space and Launch capability in Houston. This capability demonstrated the skills and experience in the mixed reality team that has resulted in additional work in the engineering design for Boeing's Human Landing System and Gateway design work. The work has developed company-wide expertise in Australia in the use of virtual reality for simulation and engineering design, now used across Boeing Commercial Aircraft and Boeing Defence and Space.

2.6. LUNAR EXPLORATION TECHNOLOGIES

Partnering with Boeing Space & Launch, the local commercial and defence business units are collaborating on a proposal for key lunar surface infrastructure and systems for NASA's Program Artemis (https://www.nasa.gov/specials/artemis/).

Under a work-share arrangement with Space & Launch, Boeing Australia is leading the engagement with Australian research partners, such as CSIRO, to define key lunar standards. This includes a proposal to design and build lunar hardware in-country, continuing Australia's involvement with exploration of the moon since 600 million people watched Neil Armstrong via television signals famously received via the Parkes radio telescope.

If selected for the demonstration phase it will include prototype production and demonstration of the equipment (expected in 2023–2025 timeframe), with subsequent production to be confirmed.

2.7. OTHER AUSTRALIAN SPACE INVESTMENTS

Myriota

Boeing invested in Adelaide-based company Myriota, an Internet of Things (IoT) start-up seeking to revolutionise satellite communications by providing low-cost access to high-value data in remote locations via satellites the size of shoeboxes in orbit 500km above Earth. Boeing continues to work and guide Myriota in the development of this technology. Myriota has recently been announced as a participant in the South Australian Government's project to send a locally manufactured small satellite into space.

Australian Signals Directorate – SATCOM Support contract

Details of this program are classified. In general terms, however, Boeing's contract for the provision of maintenance and support services (M&SS) for the Australian Signals Directorate is concerned with the availability and continuity of a critical Defence communications system and its associated supporting infrastructure at strategically important Defence sites.

Australian Defence Force Satellite Communication Program (JP9102)

The Australian Defence SATCOM System (ASDSS) will enable the joint command and control of deployed joint task forces through resilient and responsive communications, beyond the range and capacity of other communications systems. This AU$4.6 billion satellite communications program will provide the Australian Government with the ability to kickstart the Australian space economy by working closely with established Australian Primes to build capability in Australia.

Boeing is currently working with several Australian companies to deliver a sovereign SATCOM solution to Defence, and has already signed two agreements with local suppliers to deliver this next generation capability – Clearbox Systems and Saber Astronautics.

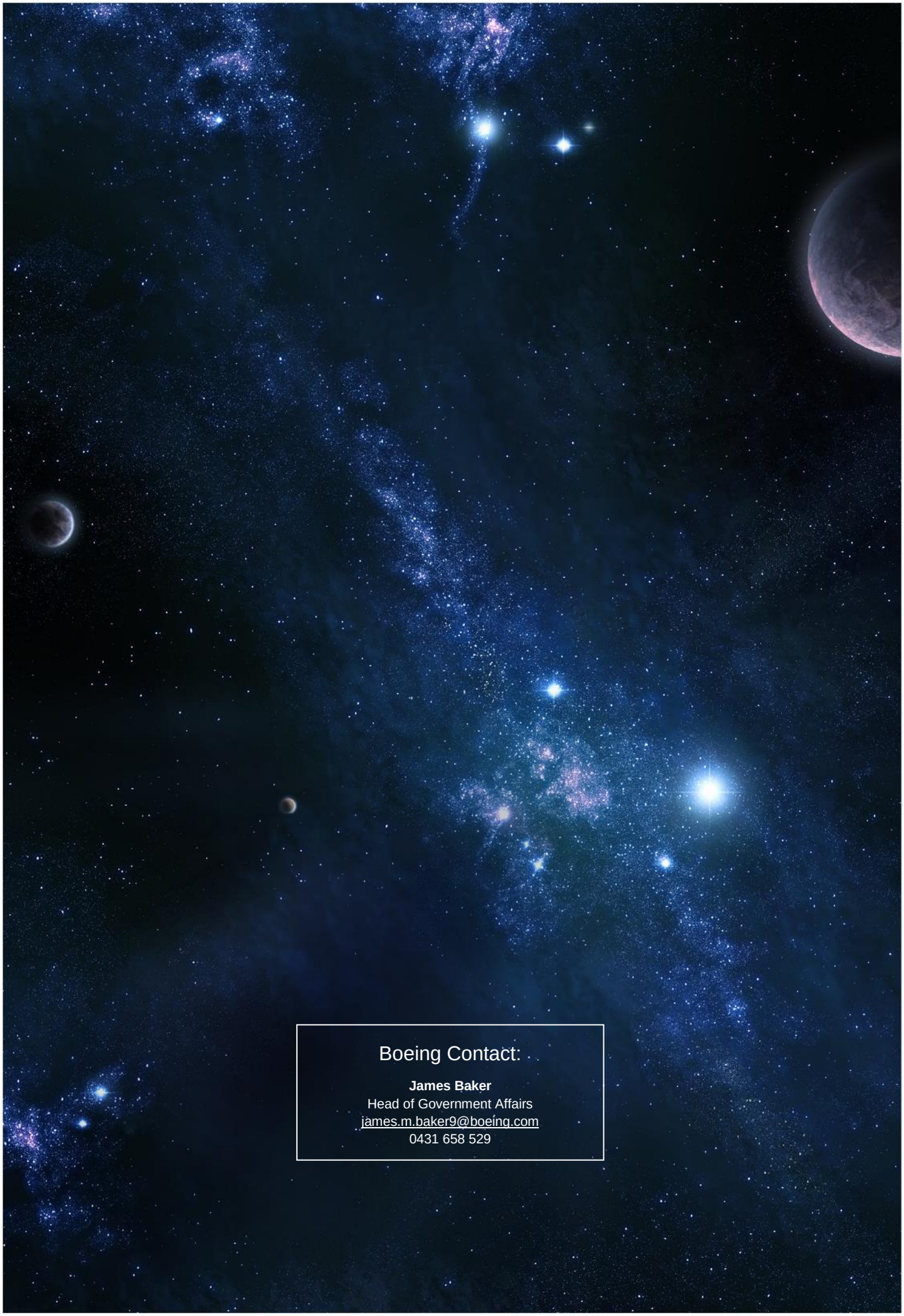
Boeing Defence Australia (BDA) and Clearbox Systems have signed a collaboration agreement for the development of a solution for the Australian Defence Force's (ADF) next-generation satellite communication (SATCOM) system, known as JP9102. Boeing is looking to combine its global satellite communications skills and local development capabilities with Clearbox's SATCOM software development and integration capabilities. The two businesses will collaborate to design a strong solution for JP9102 that provides a low-risk, sovereign solution to the ADF for a flexible, resilient and agile SATCOM system

Using advanced artificial intelligence (AI) and machine learning, Boeing HorizonX and local Australian company Saber are developing technology to predict the impact of unexpected events and erratic space weather on spacecraft, enabling operators to quickly address issues when they are encountered. This capability has been proven on smaller, less complex spacecraft, and Boeing's investment will enable Saber to investigate the technology's application to Boeing 702 Geostationary (GEO) satellites. The technology is a key capability for JP 9102, the Australian Defence SATCOM System, which requires the use of machine learning to increase the speed, quality and agility of the conduct of SATCOM operations as compared with legacy systems.

Under Defence project JP9102 Boeing Australia is also supporting the Commonwealth of Australia by developing new approaches to modelling and simulation which comprise construction of complex, multi-domain, and joint force scenarios to understand the implications of a contested, degraded, and operationally limited space environment.

Other space-related Australian Defence contracts

Within its Defence business, Boeing first delivered satellite-on-the-move capability on the Royal Australian Air Force's (RAAF) C-17A Globemaster III in 2015. Boeing has since delivered upgrades to the RAAF's E-7A Wedgetail fleet to fit a wideband SATCOM terminal, building on its key enabling function of connectivity to the Headquarters Joint Operational Command. In addition, Boeing is delivering Australian-integrated satellite communications terminals certified for use on the Wideband Global Satellite (WGS) under its Land 2072 Phase 2B Currawong Battlespace Communications System program, and historically developed the IS-22, and WGS satellites currently in service with the ADF today.



Boeing Contact:

James Baker
Head of Government Affairs
james.m.baker9@boeing.com
0431 658 529