STATE DEVELOPMENT, NATURAL RESOURCES AND AGRICULTURAL INDUSTRY DEVELOPMENT COMMITTEE

Inquiry into job creation opportunities in Queensland arising from the establishment of an Australian Space Industry

Information Paper No. 1: What is the Space Industry?

November 2018

Background

'Space' as we know it has changed. It is no longer an activity dominated by huge rockets, massive NASA projects or the lure of moon walks. Space is a new economic frontier, with activity driven by innovative enterprises.

The new 'spaceman' is not a white-suited astronaut: it is a ground-based start-up entrepreneur. This commercialisation of the space economy is called Space 2.0.

Internationally the space industry is worth US$345 billion each year, but only 0.8% is contributed by the Australian space sector.[1]

The Australian space sector currently produces annual revenues of $3-4 billion and employs between 9,500 and 11,500 people from its 0.8% share of the global space economy.[2] The Australian Space Agency wants to triple the size of the space industry to $12 billion by 2030 and create up to 20,000 new jobs.[3]

What is Space?

Space begins at the Kármán line (or Karman line), an altitude 100 km above sea level and the point at which earth's atmosphere becomes too thin for aeronautical purposes.[4]

The Space Economy is Here

The space economy is a wide economic sector built around the generation and consumption of data gathered by a new generation of satellites. It feeds directly into the phones and devices we hold and is a sector driven as much by business opportunity as by military needs.

Photo taken at SDNRAIDC site visit - Mount Stromlo Observatory

The Organisation for Economic Co-operation and Development defines the **space economy** as:

> *The space economy is the full range of activities and use of resources that create and provide value and benefits to human beings in the course of* ***exploring, understanding, managing and utilising space****. Hence, it includes all* ***public and private actors*** *involved in developing, providing and using space-enabled products and services, ranging from* ***research and development****, the* ***manufacture and use of space infrastructure*** *(ground stations, launch vehicles and satellites) to* ***space enabled applications*** *(navigation equipment, satellite phones, meteorological services, etc.) and the* ***scientific knowledge*** *generated by such activities.*[5]

Space Industry

The distinguishing feature of Space 2.0 is that much of the activity is firmly based on Earth. It includes:

- **Manufacturing:** for example, the design or manufacture of launch vehicles, satellites and spacecraft, control centres, the supply of relevant materials or components, scientific and engineering support and research.
- **Operations**: for example, the launch and operation of satellites and spacecraft, including launch services and ground segment operations.
- **Applications**: for example, broadcasting, fixed and mobile satellite communications services, processing satellite data, location-based services and GPS.
- **Ancillary services**: for example, support services for launch and satellite services, financial and legal services, software and IT services, market research, consultancy and business development.[6]

Traditionally, the space industry that services the space economy has been thought of as the launch of rockets into space.

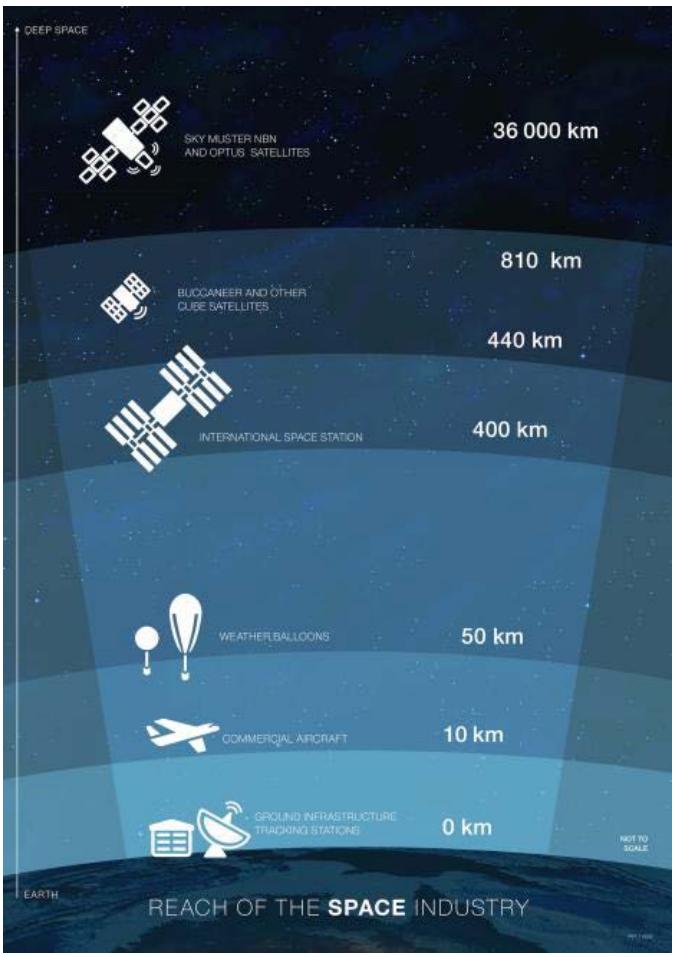
In Space 2.0, the launch is only one component of the industry. There is a broad supply chain that is being filled by a range of companies, with expertise in advanced manufacturing, aeronautics, engineering, electrical componentry and software development.

As Mr Anthony Murfett, Deputy Head of the Australian Space Agency, said:

> *'…technology is smaller, technology is cheaper and the cost of launch is reducing, which means that with space activities what was once the realm of government only is now a place where commercial providers can make commercial realities through space, whether that be through very small satellites, the use of space data or provisioning commercial launch.'*[7]

Space 2.0

A new approach to the space industry based on low cost systems and innovation, with an emphasis on commercial sector leadership, rather than government-run space programs.[8]



Source: Australian Government, *Review of Australia's Space Industry Capability: Report from the Expert Reference Group for the Review*, 2018, p. 11.

Three priority areas where Australia has existing space industry capability include:

1. Space services
2. Space tracking
3. Space exploration[9]

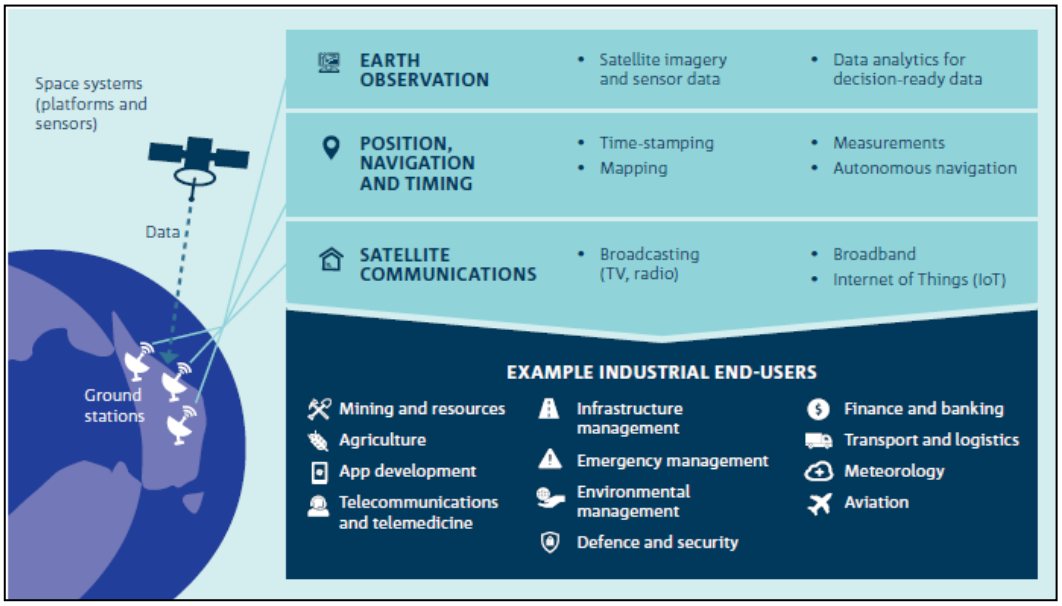
Space services

Space services refers to earth observation, communications and position navigation and timing - essentially, what satellites can see or gauge happening on Earth, and creating the data we consume.

Earth observation, or remote sensing, which is any activity which collects information about the Earth, its atmosphere and oceans from satellite, aircraft and also remotely piloted systems.[10]

Communications, which is communications received from satellites, typically geostationary satellites which are located 30,000 to 36,000 kilometres away from the earth's surface.[11]

Position navigation and timing, which is the ability to determine position, location and timing through global navigation satellite systems and when used with map data and other information, is commonly referred to as GPS.[12]



Source: CSIRO, Space: A Roadmap, p 7

The CSIRO has highlighted that space-derived services have the potential to improve the Australian way of life through the provision of more accurate:

- satellite navigation and TV services
- internet access enabling telemedicine services for rural communities, and
- nation-wide weather forecasts and disaster monitoring.[13]

'For every dollar that you spend on a space activity you probably can get a return of $4 on the added value of the data if it is earth-observing data or geophysical GPS data. Then there is the spin-out to the community in general. It is a value chain of how the value flows back to a country.'[14]

Users of space services

Space-derived data and services are increasingly being used by Australian businesses and government to improve productivity, innovation and inform strategic decision making. The Queensland Government is a significant user of satellite data. While the Department of Natural Resources, Mines and Energy has been the lead adopter to monitor land use, space imagery is used by 14 Queensland government agencies and a number of large councils.[15]

Developing new value-added services derived from this data could result in significant economic benefits to existing and new end-users.[16]

There are multiple industries relevant to the space services sector. They can be end-users of the data obtained from earth observation, position navigation and timing, and satellite communications.[17]

For example, in the **agricultural** sector data obtained from satellites and location monitoring can be used to track cattle in the fenceless management of livestock. Satellite imagery can also be used for crop management and horticulture (e.g. to monitor growth over particular seasons), water resource management and precision farming.[18] Queensland based companies deliver maps and information direct to the grower, via a website or directly to their phone.[19]

It is estimated that the value of Australian satellite imagery-enabled precision farming for broad acre cropping could reach $221 million annually by 2025 (up from $17 million in 2015).[20]

Queensland already has a presence in the space services sector. Queensland is home to a growing group of next-generation SMEs as well as international and national companies involved in earth observation, data collection and analysis.[21] Queensland also has a strong research sector in the field of space services, particularly earth observation:

- The University of Queensland's School of Earth and Environmental Sciences is one of Australia's leading faculties in earth observation analytics and also houses the Remote Sensing Research Centre.[22]
- The University of Queensland, Queensland University of Technology, Griffith University, and sections of James Cook University and the University of the Sunshine Coast, are recognised nationally and internationally as leaders in analytic development application of earth observation data.[23]

The CSIRO also has significant earth observation expertise located in Queensland, including at the Ecosciences Precinct in Dutton Park, the University of Queensland and regional areas such as Townsville, where it has a site where it performs calibration and validation for international earth observation satellites.[24] CSIRO also coordinates the Queensland Centre for Advanced Technologies, based at Pullenvale.

As the space services sector grows, there is a need for more ground stations to receive and process satellite imagery.[25]

Space Tracking

Space tracking refers to space situational awareness, spacecraft tracking, telemetry and control as well as deep space communications – looking mostly from Earth on what is up there.[26]

Space situational awareness involves the use of both ground and space based systems to track objects in space.[27] This includes the monitoring of space debris ('space junk') and near earth objects like asteroids.

Space junk: Natural space debris that occurs in the solar systems, such as asteroids and comets, but also artificial objects – such as disused satellites, rocket stages and related debris.

The tracking of objects in space allows for operators, both government and commercial, to predict movement and avoid collision of space objects. Collision of space objects has cascading effects, including increasing the vulnerability of space-assets. As more space activity occurs, the space environment will become increasingly congested with space debris, driving the need to develop measures to protect space infrastructure from collision.[28]

Space tracking is important for Defence purposes, but is increasingly being recognised as relevant to the commercial sector.[29]

> *'When we get into orbit there is a lot orbiting up there, so it means that we need to pay attention to what is orbiting around the Earth. Again, because of Australia's position we can see a lot of the sky and we have facilities around Australia that play a role in monitoring orbiting objects. That was once very much in the Defence realm of activities but, again, we now have more commercial providers that are launching their own satellites which means that they need data about what is orbiting around the Earth. There are opportunities for commercial provision of those types of technologies or commercial entities providing those types of technologies to Defence, which monitors those activities.'*[30]

Space tracking needs commercial operators who can use technology and advanced manufacturing techniques to reduce the creation of space debris, for example, by building satellites that are serviceable in orbit.[31]

Space tracking also involves the tracking of spacecraft through **deep space communications**. CSIRO operates the Canberra Deep Space Communication Complex on behalf of NASA, which has been delivering spacecraft communications from Australia for more than 50 years.[32]

The **Deep Space Network (DSN)** consists of three deep-space communications facilities placed globally approximately 120 degrees apart: Canberra in Australia, Goldstone in California and Madrid in Spain.

As the Earth rotates, this placement permits constant observation of spacecraft and makes the DSN the largest and most sensitive scientific telecommunications system in the world.[33]

Space tracking requires ground stations to receive and process spatial data. Australia is well placed with its position in the southern hemisphere, low light and radio noise interference.[34]

Photo of DSS-43 taken at SDNRAIDC site visit to Canberra Deep Space Communication Complex.

Space Exploration

Space exploration refers to autonomous systems and remote asset management, robotics, as well as launch and propulsion – essentially, the creating and launching of the equipment that goes into space.[35]

Robotics and autonomous systems

Australia already has approximately 1,100 robotics companies and niche experience in the computer vision and robotics field.[36]

Canada provides a useful illustration of the development of the robotics industry through its development of the 'Canadarm':

> The Canadarm: [Canada]…
>
> *'invested in space back in the 1970s and developed an industry consortium that created a robotic technology called the Canadarm. It is essentially a robotic arm that is used on the International Space Station to be able to transport goods in and out of the space station. That required such a national effort to be able to develop this technology and then to see it actually in use in space…it now appears on the $5 bill for Canada.'*

Queensland's research and development organisations, including universities, private sector providers and academia, are well positioned to grow and transform the Australian space exploration industry.[37]

Launch and propulsion

Launch and propulsion is traditionally the most visible part of the space economy, but it is still a huge component of the Space 2.0 economy. It includes the launch site, the launch vehicle and power and propulsion (e.g. fuel and catalyst design).[38]

Launch sites

Significantly more launch sites are needed and this is a large focus of the industry. Different satellites require different orbits and therefore different launch systems.

Equatorial orbit: orbits that travel around the equator
Polar orbit: orbits that go from North to South poles

Generally, launch sites closer to the equator suit equatorial orbits and launch sites further away from the equator suit polar orbits.[39]

Australia already has two commercial companies developing launch sites. 'Equatorial Launch Australia' is planning an Arnhem Space Centre in the Northern Territory that will focus on equatorial low earth orbit.[40]

'Southern Launch' in South Australia, is developing capabilities in the Great Australian Bight for polar launches.[41]

In New Zealand, 'Rocket Lab' provides an integrated model with launch site and vehicle.[42]

Regional Queensland is home to a commercial suborbital launch site, which allows industry to develop, test and operate systems and launch vehicles.[43]

In early 2019, the Queensland government will release its findings into a feasibility study on possible sites in Queensland for a satellite park and a launch facility, taking into consideration environmental, economic and infrastructure requirements.[44]

Launch vehicles

Launch vehicles carry the payload (for example, satellites or spacecraft) into space.

Historically, international companies and governments have made launch vehicles for large satellites (such as the Space Shuttle Discovery operated by NASA which deployed the first Optus Satellite).

Traditional space exploration is time and resource intensive. Under Space 2.0, there will be a need to have launch vehicles for small satellites which are cost-effective and agile.[45]

Small satellites

These new generation satellites are the engines of the space economy. Already, the commercial and research sectors are recognising the significant opportunities for small satellite launches now and in the future. Small satellites are typically less than 200 kilograms and have the ability to provide high quality imagery and supply high-quality broadband.

> *'A 2017 survey predicted that 6,200 small satellites will be launched between 2017 and 2026. The estimated cost of the launch of those 6,200 small satellites is US$13.6 billion… Australia has the potential to tap into that US$13.6 billion market.'*[46]

CubeSats

CubeSats are a type of nanosatellite with a dimension of 10cm x 10cm x 10xcm and a mass from 1kg to 10kg. Multiple cubes can be configured to construct larger CubeSats. This type of earth-observing satellite is new technology at a lower cost.

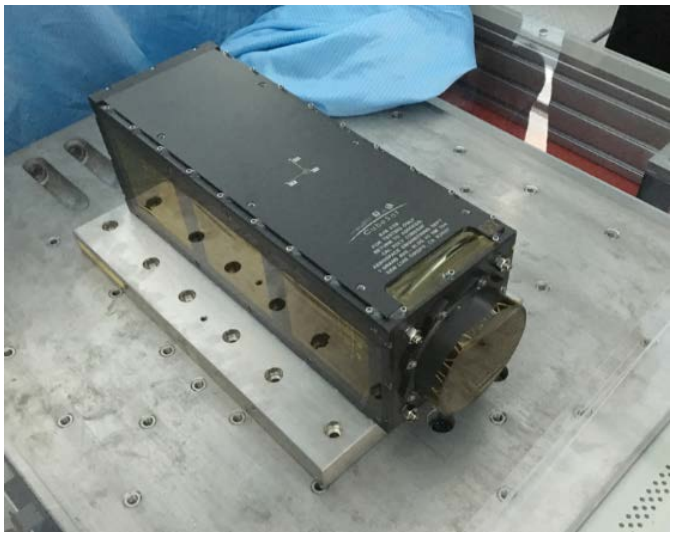


Photo of CubeSat from the SDNRAID Committee site visit to the Canberra Deep Space Communication Complex, 20 November 2018.

The development of the launch vehicle industry is in its infancy in Australia, but there are companies in Queensland that are engaged in the sector - for example, Gilmour Space Technologies, Hypersonix, and Black Sky Aerospace.[47]

Gilmour Space Technologies has acquired $24 million in venture capital and develops launch capabilities based in Queensland.[48]

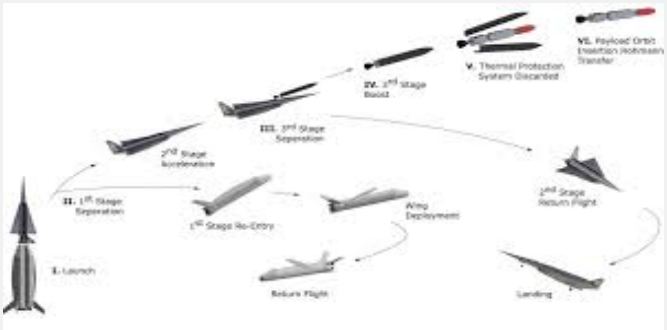
Black Sky Aerospace is another Queensland-based company whose services include launch vehicles and propulsion systems. Black Sky Aerospace operates the only commercial suborbital launch site in Queensland, which allows the company and its partners to develop, test and operate systems and vehicles.[49]

Photo taken at SDNRAIDC site visit - Black Sky Aerospace Launch, Tarawera, 21 November 2018.

Re-useable launch systems

Queensland start-up company Hypersonix are working with local SMEs to develop a re-usable small satellite launch system:

> '*With the SPARTAN system, we call the fly-back first-stage rocket booster the Boomerang, because it flies back to base and lands right next to where it was launched. The hypersonic stage that is powered by a UQ designed scramjet—which, by the way, can heat up to 1,500 degrees Celsius on the way to space, before returning to base—is the second stage of the system. The only part of the system that is expendable is the small upper stage*'.[50]



Source: Submission 13, p 7.

Scramjet engines are hyper-sonic air-breathing engines that use the oxygen in the air to combust with fuel to generate thrust. These engines only have to carry fuel (rather than oxygen and fuel) which means that they are more efficient and can carry more payload.[51]

Aviation and Space – Biomedics

Biomedics is a growing sector of the space economy.

For example, Boeing Research and Technology Centre in Brisbane has partnered with UQ to develop antimicrobial technology for aircraft to mitigate the possibility of a pandemic/minimise the spread of germs, but can also be used to address crew health in spacecraft:

> *'With the International Space Station's missions to Mars, you would be enclosed for a very long period. The growth of biofilms is a real problem up there. It is not so much virus in that case but fungus and bacteria. Astronauts are immunosuppressed, so they are very vulnerable to catching infections. On top of that, microbes actually grow faster in space and mutate more in space, so it is a real deadly cocktail in that regard. The technology for space that we are extracting from this university locally is to address crew health'.*[52]

The Australian Space Agency

On 14 May 2018, the Commonwealth Government committed $41 million in funding over four years for the establishment of the new Australian Space Agency to ensure Australia has a long-term plan to grow its domestic space industry.[53]

The Agency commenced operations on 1 July 2018. Under its broad mandate, the Agency has six primary responsibilities:

- providing national policy and strategic advice on the civil space sector
- coordinating Australia's domestic civil space sector activities
- supporting the growth of Australia's space industry and the use of space across the broader economy
- leading international civil space engagement
- administering space activities legislation and delivering on our international obligations, and
- inspiring the Australian community and the next generation of space entrepreneurs. [54]

The Agency seeks to support a national approach to triple the size of the space industry to $12 billion by 2030 and create up to 20,000 new jobs. [55]

The Australian Space Agency advocates a 'Team Australia' approach, where every level of government, industry and research works collaboratively with one another to develop Australia's space economy.[56]

The Regulation of Space

The Australia Space Agency is responsible for Space regulation in Australia, which includes authorising Australian space activities and international arrangements affecting space regulation.

The Agency recently conducted a review of the *Space Activities Act 1998* and the Space Activities Amendment (Launches and Returns) Bill 2018 has now been introduced into the Australian Parliament. The Bill should make it easier for companies to innovate in the space economy. The Bill will:

- include licensing arrangements for launches from aircraft in flight
- streamline the approvals process for launches and returns
- balance safety and risk of potential damage with the national interest in a changing environment
- adjust insurance requirements to appropriate risk levels and international norms
- reduce barriers to participation for small Australian space industry companies
- increase non-compliance penalties to reflect the seriousness of damage to people and property, and
- introduce safeguards for high power rocket activities.[57]

Australia is also a signatory to a variety of space-related international treaties. These treaties cover topics such as: space exploration and the use of outer space, activities on the moon and liability for damage caused by space objects. [58]

Although the Australian Space Agency is the responsible regulatory and policy body in Australia, 'as the Australian space industry expands so will the associated legal work and this, too, will attract jobs and commerce to Queensland.'[59] There is potential for strong employment opportunities in the interpretation of international treaties regarding the use of space resources and the regulation of space traffic management.[60]

Next Steps for the Inquiry

The State Development, Natural Resources and Agricultural Industry Development Committee will release its second information paper at the end of January 2019. This paper will outline what the space industry requires.

The Committee will table its final report in 2019.

ENDNOTES

[1] Australian Space Agency, Welcome to the Australian Space Agency, available: https://www.industry.gov.au/data-and-publications/welcome-to-the-australian-space-agency
[2] Submission 8, p 2.
[3] Mr Anthony Murfett, Australian Space Agency, public hearing transcript, Brisbane, 16 November 2018, p 3.
[4] Australian Government, *Review of Australia's Space Industry Capability: Report from the Expert Reference Group for the Review*, 2018, p 11.
[5] OECD, *Handbook on measuring the space economy,* Paris: OECD, 2012; OECD, *Space economy at a glance*, Paris: OECD, 2014.
[6] London Economics, Size & Health of the UK Space Industry 2016 – Summary report, 2016.
[7] Mr Anthony Murfett, Australian Space Agency, public hearing transcript, Brisbane, 16 November 2018, p 2.
[8] Australian Strategic Policy Institute, Australia's Future in Space, February 2018, p 5.
[9] Ms Denise Johnston, DSDMIP, public briefing transcript, Brisbane, 15 October 2018, p 2.
[10] Professor Stuart Phinn, public hearing transcript, St Lucia, 19 October 2018, p 27.
[11] Dr David Williams, CSIRO, Public hearing transcript, St Lucia, 19 October 2018, p 34.
[12] US Department of Transport, What is Position, Navigation and Timing? Available at: https://www.transportation.gov/pnt/what-positioning-navigation-and-timing-pnt
[13] CSIRO, Space: A Roadmap for unlocking future growth opportunities for Australia, 2018, p 7.
[14] Dr David Williams, CSIRO, Public hearing transcript, St Lucia, 19 October 2018, p 12.
[15] Mr Steve Jacoby, DNRME, public briefing transcript, Brisbane, 15 October 2018, p 11.
[16] CSIRO, Space: *A Roadmap for unlocking future growth opportunities for Australia, 2018,* p 7.
[17] CSIRO, Space: A Roadmap for unlocking future growth opportunities for Australia, 2018, p 4.
[18] Professor Stuart Phinn, public hearing transcript, St Lucia, 19 October 2018, p 28; and Mr Steve Jacoby, DNRME, public briefing transcript, Brisbane, 15 October 2018, p 10.
[19] Professor Stuart Phinn, public hearing transcript, St Lucia, 19 October 2018, p 28.
[20] CSIRO, Space: *A Roadmap for unlocking future growth opportunities for Australia, 2018*, p 7; ACIL ALLEN, *The value of earth observations from Space to Australia, 2015*, CRC for Spatial Information.
[21] Ms Johnston, DSDMIP, public briefing transcript, Brisbane, 15 October 2018, p 2.
[22] Ms Johnston, DSDMIP, public briefing transcript, Brisbane, 15 October 2018, p 2.
[23] Submission 6.
[24] Submission 5.
[25] Professor Stuart Phinn, public briefing transcript, St Lucia, 19 October 2018, p 28.
[26] Ms Johnston, DSDMIP. public briefing transcript, Brisbane, 15 October 2018, p 2.
[27] Professor Stuart Phinn, public briefing transcript, St Lucia, 19 October 2018, p 34.
[28] CSIRO, Space: A Roadmap for unlocking future growth opportunities for Australia, 2018, p12-13.
[29] Mr Anthony Murfett, Australian Space Agency, public hearing transcript, Brisbane, 16 November 2018, p 10.
[30] Mr Anthony Murfett, Australian Space Agency, public hearing transcript, Brisbane, 16 November 2018, p 4.
[31] Mr Peter Kinne, DigitalGlobe, public hearing transcript, Brisbane, 16 November 2018, p 30.
[32] Submission 5, p 8.
[33] Canberra Deep Space Communication Complex, Our Voyage of Exploration, available: https://www.cdscc.nasa.gov/Pages/welcome.html
[34] CSIRO, Space: *A Roadmap for unlocking future growth opportunities for Australia, 2018,* p 13.
[35] Ms Denise Johnston, DSDMIP, public hearing transcript, Brisbane, 15 October 2018, p 2.
[36] Dr Sue Keay, Australian Centre for Robotic Vision, public hearing transcript, Brisbane, 16 November 2018, p 45.
[37] Ms Denise Johnston, DSDMIP, public hearing transcript, Brisbane, 15 October 2018, pp 2-3.
[38] CSIRO, Space: *A Roadmap for unlocking future growth opportunities for Australia, 2018,* p17.
[39] Professor Michael Smart, public hearing transcript, St Lucia, 19 October 2018, p 3.
[40] Submission 19, p 2.
[41] Mr Blake Nikolic, Black Sky Aerospace, public hearing transcript, Brisbane, 16 November 2018, p 21.
[42] Professor Michael Smart, public hearing transcript, St Lucia, 19 October 2018, p 2; Mr Lau Saili, DSDMIP, public briefing transcript, Brisbane, 15 October 2018, p 8.
[43] Mr Blake Nikolic, Black Sky Aerospace, public hearing transcript, Brisbane, 16 November 2018, p 22.
[44] Ms Denise Johnston, DSDMIP, public briefing transcript, Brisbane, 15 October 2018, p 4.
[45] Mr Adam Gilmour, Gilmour Space Technologies, public hearing transcript, Brisbane, 16 November 2018, p 17.
[46] Professor Michael Smart, public hearing transcript, St Lucia, 19 October 2018, p 2.
[47] Ms Denise Johnston, public briefing transcript, Brisbane, 15 October 2018, pp 2-3.
[48] Mr Adam Gilmour, Gilmour Space Technologies, public hearing transcript, Brisbane, 16 November 2018, p 13.

[49] Mr Blake Nikolic, Black Sky Aerospace, public hearing transcript, Brisbane, 16 November 2018, p 21.
[50] Professor Michael Smart, public hearing transcript, St Lucia, 19 October 2018, pp2-3.
[51] Professor Michael Smart, public hearing transcript, St Lucia, 19 October 2018, p 5.
[52] Dr Jason Armstrong, Boeing Research and Technology Australia, public hearing transcript, St Lucia, 19 October 2018, p 56.
[53] Submission 8, p 2.
[54] Submission 21, pp 1-2.
[55] Submission 21, pp 1-2.
[56] Ms Denise Johnston, DSDMIP, public briefing transcript, Brisbane, 15 October 2018, p 2.
[57] Australian Space Agency, Space regulation, 6 November 2018, https://www.industry.gov.au/regulation-and-standards/space-regulation
[58] For example: 1967 United Nation (UN) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies; 1968 UN Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space; 1972 UN Convention on International Liability for Damage Caused by Space Objects; 1975 UN Convention on Registration of Objects Launched into Outer Space; and 1979 UN Agreement Governing the Activities of States on the Moon and other Celestial Bodies.
[59] Mr Duncan Blake, International Aerospace Law & Policy Group, public hearing transcript, Brisbane, 16 November 2018, p 40.
[60] Submission 9 and Mr Duncan Blake, International Aerospace Law & Policy Group, public hearing transcript, Brisbane, 16 November 2018, p 41.

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Further information on this inquiry can be found at:
https://www.parliament.qld.gov.au/work-of-committees/committees/SDNRAIDC/inquiries/current-inquiries/10SPACE
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