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The Victorian space industry

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Terminology and abbreviations

AAS	Australian Academy of Science
ASA	Australian Space Agency
AV	Agriculture Victoria
BOM	Bureau of Meteorology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEA	Digital Earth Australia
digital twin	A virtual model that is designed to accurately reflect a physical object. For example, Digital Twin Victoria is a virtually mapped 2D and 3D representation of Victoria.
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
ESA	European Space Agency
GA	Geoscience Australia
GNSS	Global Navigation Satellite System
ground station	Infrastructure on Earth designed to collect and stream remote sensing data from satellites to a range of users
NASA	National Aeronautics and Space Administration (US)
polar orbit	Satellite orbiting path running north–south crossing roughly over Earth’s poles
R&D	Research and development
satellite	An object sent into space that may serve a range of purposes while in orbit: collect and relay information, communications etc.
SKA Low Telescope	Square Kilometre Array Low Telescope
SMEs	Small and medium enterprises

1 | Executive Summary

This paper provides an overview of the Victorian space industry, in the context of both the Australian and international space sectors. It also examines the breadth of the space industry in Victoria and its applications. A number of current issues are driving research and innovation within the space industry. However, opportunities for growth are also coupled with a number of challenges to established players and new entrants. This paper has been produced for National Science Week 2023.¹

¹ For a summary of the Australian space technology sector, see also the Parliamentary Library's Research Note from September 2022, [Space Technology in Australia](#).

See also the webinar [Space technology: Niche opportunities and the skills needed](#), which was hosted in May 2023 by the Victorian Parliamentary Library & Information Service in conjunction with the Australian Academy of Technological Sciences and Engineering (ATSE) Victorian Division.

2 | What is the space industry?

While mention of the space industry often recalls the historic feats of industry giants like NASA and SpaceX, a diverse range of activities are driving rapid industry expansion across the globe. Government-backed space programs are now commonplace around the world, and are accompanied by a burgeoning private sector, a globalised supply chain, decreasing entry costs and a willingness to coordinate launch resources and research and development.

Access to space-derived benefits is also becoming easier; CEO of SpaceBase—a consultancy working on ‘democratising’ space—Emeline Paat-Dahlstrom, says, ‘All you need is a computer and wi-fi’, given the breadth of space infrastructure in orbit and data being received on Earth.²

Australia’s space industry is small but straddles a broad mix of endeavours both looking out to space and looking back down to Earth. According to a KPMG report commissioned for the American Chamber of Commerce in Australia (AmCham), the sector employs 15,247 people as of 2022, which is forecast to rise to 25,000 by 2028–29.³

The Australian Space Agency (ASA), formed by the federal government in 2018, is the country’s chief space industry body. Far from having ambitions to develop a space program comparable to NASA or the European Space Agency (ESA), the ASA is ‘industry-focused’, aiming at ‘transforming, inspiring and creating a competitive environment for the space sector to grow, and advancing Australia’s competitiveness and role as a responsible actor in civil space’.⁴

Space-related activity is regulated through the federal *Space (Launches and Returns) Act 2018* (Cth) and a series of rules and codes.⁵ Australia is also a signatory to the United Nations’ Outer Space Treaty, which emphasises the freedom of nations to explore space without discrimination.⁶

The ASA broadly defines the sector as ‘a set of space-related activities along the space value chain’ and ‘part of the broader space economy’.⁷ These include:

- **manufacturing and core inputs**—integration of ground-based facilities; space segment manufacturing
- **space operations**—launch activities; objects in space; use and management of satellites
- **space applications**—creation of products and services from space-derived resources; improvement of other parts of the economy through application of space technologies and data
- **enablers**—regulation; infrastructure and capabilities; research, development and engineering; specialised support services.⁸

Beyond these more direct elements, the *OECD Handbook on Measuring the Space Economy* describes the space economy as encompassing ‘the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of

² StartSpace HQ (State Library of Victoria) (2023) ‘[Inventors & Innovators: SpaceTech](#)’, *YouTube*, 14 June.

³ KPMG Australia (2023) *A Prosperous Future: Space [Space industry opportunities for Australia and the United States]*, KPMG Australia, 5 April, p. 30.

⁴ K. Burgess (2018) ‘[Not NASA: New Australian space agency more ‘nimble’, ‘industry-focused’](#)’, *Canberra Times*, 4 October; Australian Space Agency (2019), *Advancing Space: Australian Civil Space Strategy 2019–2028*, Canberra, Commonwealth of Australia, April, p. 5.

⁵ Garma Festival (2022) ‘[2022 Garma Key Forum - Preparing the Space Generation](#), Enrico Palermo, Australian Space Agency’, *YouTube*, 1 August; Australian Government (Unknown) ‘[Regulating Australian space activities](#)’, Department of Industry, Science and Resources website. Last accessed 13 June 2023.

⁶ United Nations Office for Outer Space Affairs (1967) *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies [Outer Space Treaty]*, UNOOSA website, 27 January.

⁷ Australian Government (2020) ‘[Definition of the Australian space sector](#)’, Department of Industry, Science and Resources website, 1 June.

⁸ *ibid.*

exploring, understanding, managing and utilising space’.⁹ James Brown, the CEO of the privately organised Space Industry Association of Australia, states:

Nearly every industry in Australia is currently reliant on space. Our transport, shipping, resources, and forestry industries rely on space-based navigation from GPS. Every electronic financial transaction in Australia is dependent on atomic clocks on satellites in space. Defence relies on satellite intelligence. Regional communities are connected by satellite communications.¹⁰

In these activities, Australia is also supported internationally, with established connections to many major space agencies overseas, including NASA, the ESA and others in Japan, the United Kingdom, Canada, France, Germany and Korea, giving access to data and data exchange.¹¹

Understanding upstream and downstream

The components of the space sector and economy can be thought of in terms of elements ranging from ‘upstream’ to ‘downstream’.

The upstream sector covers what the ASA refers to space operations as well as the manufacturing and core inputs that support those activities. These involve investment in technologies directly related to manufacturing, launch capabilities and space infrastructure, such as satellite, defence and earth observation technology.

The Australian private sector has been involved in this area for more than 35 years. Optus has launched ten satellites since 1985 to upkeep its telecommunications coverage and currently operates a fleet of five.¹² Other prominent examples include the newly established SmartSat Cooperative Research Centre (CRC) and the ASA’s Moon to Mars initiative, undertaken in collaboration with NASA. See page 13, ‘Upstream investment’, for more detail.

The downstream sector encompasses the earth-bound operation and application of these upstream technologies in a range of industries.¹³ This includes ‘the bulk of the subsequent data infrastructure, value-added content and analytics, and the ‘last yard’ delivery channels to customers and end users economy-wide’.¹⁴ These end users and beneficiaries span a number of industries.

While space infrastructure already plays a key role in enabling a range of everyday services—internet, the Internet of Things, navigation, radio astronomy, telecommunications and weather monitoring—satellite data is also supporting activities in sectors including emergency management (bushfires, floods), agriculture and farming (irrigation, drought management, water and landscape health), and climate change mitigation.

Australia’s ground station infrastructure provides a crucial mediating role between the upstream and downstream sectors, receiving and retransmitting data for both Australian and international interests. Global Navigation Satellite System (GNSS) networks are integral to a number of these activities, including communications, weather monitoring and monitoring services for polar-orbiting satellites.

Australia’s geospatial positioning framework consists of a number of ground station networks providing data to local data-gathering programs, such as: the Australian Regional GNSS Network (providing a geodetic framework for Australia’s spatial data infrastructure); the South Pacific Regional GNSS Network (which monitors the Earth’s crust in the Pacific

⁹ OECD Space Forum (2012) *OECD Handbook on Measuring the Space Economy*, Paris, Organisation for Economic Co-operation and Development, p. 20.

¹⁰ Space Industry Association of Australia (2023) *SIAA Submission to National Reconstruction Fund Inquiry*, media release, 24 February.

¹¹ ACIL Allen Consulting (2017), *Australian space industry capability*, report to the Department of Industry, Innovation and Science (Cth), Canberra, ACIL Allen, p. 11.

¹² Optus (2023) ‘*The Optus Satellite Fleet*’, Optus website.

¹³ KPMG Australia (2023) op. cit., p. 21.

¹⁴ P. Woodgate, P. Kerr, W. Barrett, J. Dean, G. Cockerton, K. Ikin, A. Kealy, R. Keenan, G. Kernich, P. Nikoloff, A. Wheeler and M. White (2023), *2030 Space+Spatial Industry Growth Roadmap*, March 2023, p. 5.

region amid climate sea level concerns); and the more recently arrived AuScope GNSS Network (looking into the Australian continent's geological make-up).¹⁵

Forward planning in the space sector

The federal government's *Australian Civil Space Strategy 2019–2028* sets out a plan to grow the sector and capitalise on its breadth of activities. It has set out a number of National Civil Space Priority Areas, around which the ASA hopes to help develop the Australian industry:

- positioning, navigation and timing
- Earth observation
- communication technologies and services
- space situational awareness and debris monitoring
- leapfrog research and development
- robotics and automation on Earth and in space, and
- access to space.¹⁶

Australia's geographic location on Earth provides it with a strategic advantage in many of these aspirations.¹⁷ Covering a large area in the Southern Hemisphere, the federal government believes it is in an advantageous position to 'leverage international space missions and commercial launch activities', just as it did in 2022 when NASA launched three rockets into sub-orbit from Arnhem Land.¹⁸

A 2017 review conducted by ACIL Allen into Australia's space capability and competitiveness within the global space economy even argues the country's location and well-established ground infrastructure are big strengths:

[Australia] has well positioned ground stations across a 4,000 km baseline able to observe a large number of satellites, space debris and weather. It also has suitable locations for ground station calibration and validation with clear skies, low noise and low light interference. Australia is well positioned for satellite communications and control operations. Its location also gives access to a large number of satellites for Earth Observations from Space and GNSS.¹⁹

The Australian Trade and Investment Commission, accordingly, promotes the civil space strategy's goal of developing Australia's space industry to be worth \$12 billion by 2030.²⁰ It focuses on a range of initiatives that include robotics, small satellites, aerospace medicine and remote health.²¹ Decreases in entry costs to the industry are further incentivising investment in the sector for smaller enterprises. The cost of manufacture and launch of satellites, for instance, is now a fraction of the cost of a few years ago.²² According to Dr Sarah Pearce, director of the Square Kilometre Array (SKA) Low Telescope, 17,000 satellites are due to be launched in the next decade, quadruple the number from the previous decade.²³

¹⁵ Australian Government (2023) '[Global Navigation Satellite System Networks](#)', Geoscience Australia website, 7 June.

¹⁶ Australian Space Agency (2019) op. cit., p. 5; Commonwealth of Australia (Australian Communications and Media Authority) (2021) [Market study: Australian space sector](#), ACMA, Melbourne, p. 1.

¹⁷ Commonwealth of Australia (Australian Communications and Media Authority) (2021) op. cit., p. 3.

¹⁸ Australian Space Agency (2019), [Advancing Space: Australian Civil Space Strategy 2019–2028](#), Canberra, Commonwealth of Australia, April, p. 6; Australian Associated Press (AAP) (2022), '[First of three Nasa rockets to take off from Northern Territory space centre](#)', *The Guardian*, 26 June.

¹⁹ ACIL Allen Consulting (2017) op. cit., p. ii.

²⁰ Note that this goal originated in the 2019–28 strategy, which was established before COVID-19 and the subsequent change in federal government. See page 17, 'Industry uncertainty', for more detail.

²¹ Australian Government (Unknown) '[Space: Australia's Space Industry](#)', Australian Trade and Investment Commission website.

²² Morgan Stanley (2020), '[Space: Investing in the final frontier](#)', Morgan Stanley website, 24 July.

²³ Parliamentary Library & Information Service and Australian Academy of Technological Sciences and Engineering (ATSE) (2023), '[Space technology: Niche opportunities and the skills needed](#)', Youtube, 18 May.

The industry does, however, face challenges. Space sector revenues have been ‘mixed’ in the wake of COVID-19, and businesses are commonly seen to have low net profits due to high depreciation and interest costs.²⁴ A crowding of Earth’s orbit with space infrastructure brings an increased risk posed by space debris.²⁵

Further, an uptake in space technologies for a range of purposes also comes amid a complex geopolitical climate, with a recent KPMG report commissioned for AmCham emphasising the fragmentation of space industry participation as a source of tension between nations. In this context, the federal Minister for Industry and Science, the Hon. Ed Husic, has asserted Australia’s commitment to the United Nations Open Ended Working Group on Reducing Space Threats.²⁶

²⁴ Commonwealth of Australia (Australian Communications and Media Authority) (2021) op. cit., p.3.

²⁵ NASA (2021) ‘[Space Debris and Human Spacecraft](#)’, NASA website, 27 May; B. Alderson (2023), ‘[Space junk is causing clutter around the Earth, but a small cube could help cut back on trash](#)’, *ABC News*, 13 June.

²⁶ E. Husic (Minister for Industry and Science), R. Marles (Deputy Prime Minister and Minister for Defence) and P. Wong (Minister for Foreign Affairs) (2022) [Australia advances responsible action in space](#), media release, 27 October.

3 | The Victorian space industry

Compared to more advanced programs in other jurisdictions, Victoria's space industry is in its infancy. However, Victoria hosts a growing number of space-related and space-enabled activities.

The Victorian Government reiterated as recently as February 2023 that it wants this industry presence to increase, with Minister for Industry and Innovation the Hon. Ben Carroll citing supply chains, research and engineering expertise as key pillars for the state's growing involvement.²⁷ These attributes now inform an expanding list of upstream and downstream projects.

Historical interest in space

The people living on the land area of Victoria have long had connections to space. First Nations peoples' astronomical traditions help them to understand their lands and waters. Indigenous stargazers have understood the night sky in terms of constellations for millennia, just as western traditions introduced to Australia in recent centuries have done.

The Wergaia language group in north-western Victoria, for instance, names a star as 'Marpeankurrk'.²⁸ A selection of these constellations now make up the logo of the ASA, in recognition of those whom Enrico Palermo, head of the ASA, calls the 'world's oldest astronomers'.²⁹

Later, in the 19th Century with the European colony of Victoria taking shape, Melbourne would become home to the 'first ever large, fully steerable telescope designed to see beyond our galaxy'.³⁰ Built in Dublin in 1868 and installed at Melbourne Observatory in 1869, the 'Great Melbourne Telescope' was relocated to Canberra in 1944 before being damaged by bushfires in 2003.³¹ It is currently undergoing restoration back in Melbourne in a joint effort between the Astronomical Society of Victoria and Scienceworks.³²

Victorian ingenuity was also represented during the height of the Space Race, when a group of University of Melbourne students—inspired by the passage of Russian satellite Sputnik over Australia in the late 1960s—built their own satellite with an assortment of household items such as nail varnish, bedsprings and a rifle.³³ The team were later able, with the help of the Menzies government, to send up the *Australis-Oscar 5* satellite on NASA's Delta 76 rocket in early 1970, becoming Victoria's first satellite in space.

Sector size, scope and strategy

While Victoria's space sector hopes to expand, it operates within a national strategic framework overseen by the ASA and remains guided by a suite of National Civil Space Priority Areas.

Various estimates exist of the sector's size and scope. The Victorian Department of Jobs, Precincts and Regions estimated in 2021 that 2,300 Victorians were employed in 250 space-related businesses, including Lockheed Martin, Marand, Cablex, ESSWeathertech, FrontierSI, Thales, Boeing and BAE Systems. Collectively the industry was generating approximately

²⁷ D. Andrews, Premier of Victoria (2023) *Space Tech – The New Frontier In Victorian Manufacturing*, media release, 28 February.

²⁸ K. Banks (2020) 'Our Indigenous astronomical traditions', Department of Industry, Science and Resources website, 29 May.

²⁹ Garma Festival (2022) op. cit.

³⁰ Museums Victoria (2023) 'Great Melbourne Telescope Restoration', Scienceworks website.

³¹ Research School of Astronomy and Astrophysics (ANU School of Science) (2023) 'Great Melbourne Telescope', Australian National University website, 25 December.

³² G. Mulcaster (2012) 'Great Melbourne Telescope to see night again', *The Age*, 21 February.

³³ A. Gorman (2016) *The Satellite: The improbable true story of Australia's first spacecraft*, media resource.

\$400 million in space-related revenue annually.³⁴ On a national scale, Victoria is underrepresented in its share of the space industry compared to other states (see Figure 1), in part because the eastern states are not well suited to some core space activities that require less built-up landscapes.³⁵

Victoria's upstream space industry activities also provide benefits and applications that overlap with several sectors. The *Made in Victoria 2030: Manufacturing Statement* identified the space industry within a 'Defence, aerospace and space' grouping worth \$8.4 billion combined, supporting \$350 million in exports, employing 24,300 people and accounting for 2.2 per cent of gross state product (GSP). The statement outlines goals for the space industry as part of a wider manufacturing strategy and the ambition to 'become a leader in the global space industry'.³⁶

Figure 1: Distribution of space sector organisations vs population, percentage of national total³⁷



Source: IBIS, KPMG Analysis, 2023

Victoria's defence focus is in step with the Australian Government's commitments to developing defence capabilities and sovereign space infrastructure. This is reflected in initiatives such as the SmartSat CRC initiative, which many of Victoria's research institutions are participating in. Federal defence ambitions are also evident in Lockheed Martin's recent decision to establish in Melbourne its operational base for developing the JP9102 national defence contract.³⁸

While Victoria may not be well-placed to take on core space activities such as astronautics (technology relating to space travel), the state nonetheless hosts valuable existing infrastructure and expertise. The Bureau of Meteorology's (BOM) Crib Point earth station, which was established as far back as 1991, is a good example of Victoria's geographical advantage in servicing a range of national and international interests. Originally a turn-

³⁴ Victorian Government (2021) *Victorian Space Industries Snapshot 2021*, Melbourne, Department of Jobs, Precincts and Regions, 22 October.

³⁵ KPMG Australia (2023) op. cit., p. 33.

³⁶ Victorian Government (2022) *Made in Victoria 2030: Manufacturing Statement*, Melbourne, Department of Jobs, Precincts and Regions, p. 3.

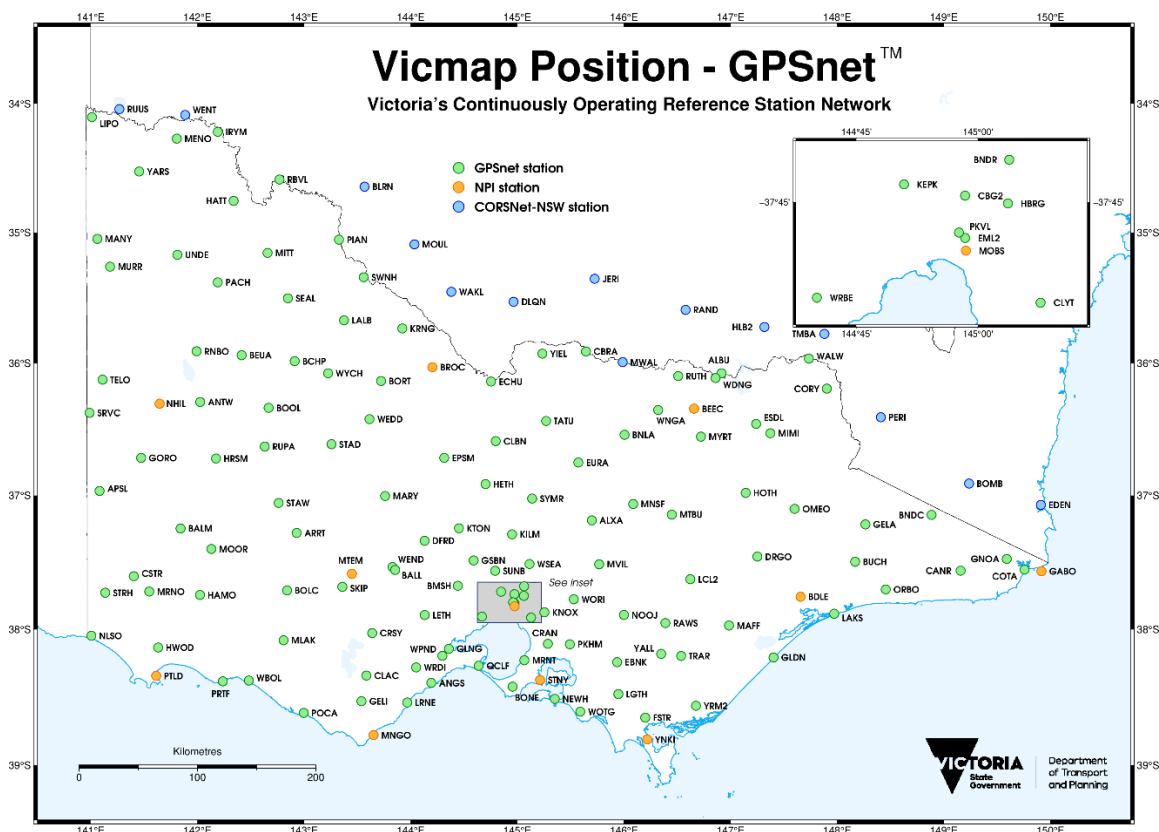
³⁷ KPMG Australia (2023) op. cit., p. 33.

³⁸ D. Andrews, Premier of Victoria (2023) *Space Tech – The New Frontier In Victorian Manufacturing*, media release, 28 February.

around ranging station for Chinese geostationary meteorological satellites, its remit has since expanded to receiving and retransmitting meteorological data from American, European and Japanese weather satellites.³⁹

Victoria also maintains a large network of GNSS ground stations (see Figure 2), known as GPSnet. Consisting of more than 120 stations as of 2021, they collect positioning data from the Global Positioning System (GPS), among other inputs, and enable Victoria's positioning system through regular data streams from orbiting satellites.⁴⁰

Figure 2: Victorian GNSS locations⁴¹



The downstream applications of these investments are evident in a broad range of industries. Some of this potential is underpinned by the Surveyor-General of Victoria's Geodesy division, which continuously maintains Victoria's positioning and navigation infrastructure, including its network of GNSS stations.

The Department of Transport and Planning's Vicmap and Digital Twin Victoria databases are also continually updated with satellite data inputs and used in a range of activities by farmers, agricultural scientists, urban planners, climate scientists and foresters.⁴²

Growth of the space industry

Since the ASA's establishment, the Victorian Government has conveyed that it wants the state to become a more significant player in the space economy. In 2018, it launched *Victoria: The Place for Space*,⁴³ a pitch to attract the headquarters of the ASA. While it was

³⁹ Bureau of Meteorology (BOM) (2012) 'Crib Point Satellite Earth Station: celebrating 20 years of service', BOM website, last updated 6 August 2018.

⁴⁰ Victorian Government (2021), 'Positioning', Department of Transport and Planning website, 10 March.

⁴¹ Victorian Government (2023) 'Vicmap Position—GPSnet', Vicmap Position website.

⁴² Victorian Government (2022) 'Geodesy', Department of Land and Transport website, 16 September; (2023) 'What's available', Department of Land and Transport website, 15 February; (2023) *Digital Twin Victoria*, last accessed 26 June 2023.

⁴³ T. McCann (2018) 'Victoria: The Place for Space', Moonshot Space Co. website, 23 October.

ultimately unsuccessful, at the time Victoria's Lead Scientist Amanda Caples highlighted the opportunities created by the state's 'research, engineering and advanced manufacturing in the areas of aerospace, satellite communications, cybersecurity and spatial information for both the civil and defence industries'.⁴⁴

Troy McCann, CEO of the space-focused entrepreneurship incubator Moonshot Space Co., also rated Melbourne's potential for growth highly, saying it was already 'one of the strongest cities in the world for spatial information and geographical information system (GIS) research and development'.⁴⁵

Data analytics is being employed in a number of contexts. Victoria's primary industries benefit from a strong spatial information sector and continue to look for ways to apply satellite imagery in activities normally associated with laborious data gathering practices. According to Emeline Paat-Dahlstrom, there may also be other 'low-hanging fruit' for aspiring entrants to the Victorian industry. She told a forum on space technology organised by the State Library of Victoria:

It used to be so expensive to get data and then it was also very expensive to use data analysis software to analyse the data, but today there is open-source data now coming from governments and there are open-source platforms that can analyse the data, so I think that is something that with very little capital people can gravitate to and look for where the opportunities are.⁴⁶

A number of industry collaborations in Victoria aim to build relationships among industry participants, including business and research institutions. In July 2022, the Victorian Government opened a tender for a service provider to deliver a 'Victorian Defence and Space Industry Network', which could 'promote Victorian defence and space industry capabilities' and identify opportunities for Victorian companies to participate in global supply chains.⁴⁷

According to an *Innovation Aus* report, it would 'act as a conduit for information from Victoria's supply chain companies to the Victorian government'.⁴⁸ This comes after RMIT launched its Space Industry Hub in March 2022 to provide, as Dr Amanda Caples explained, 'a forum for industry to explore satellite data technology in a safe space ... to develop new and improved products and services'.⁴⁹

Applications

Applications of space activities are already evident in a range of areas. The Victorian Government's geospatial data portfolio, Vicmap, has been part of the state's mapping system since 1975.⁵⁰ As Victoria's chief repository for 'land-related data', it is regularly updated with satellite data from a range of international satellites through the state's GNSS stations.

Data from orbiting satellite networks contributes to a number of earthbound industries and research initiatives. This is particularly true of climate science, with over 50 per cent of climate change variables able to be monitored only via satellites.⁵¹ Virtual twin services, such as Digital Twin Victoria and Digital Earth Australia (DEA),⁵² reflect a broader trend of using space infrastructure and positioning technology to understand natural and built

⁴⁴ D. Andrews, Premier of Victoria (2018) *Victoria Ideal Home For New Space Agency*, media release, 11 June.

⁴⁵ T. McCann (2018), 'A Federation for Australia's Space Industry', *Medium*, 17 May.

⁴⁶ StartSpace HQ (State Library of Victoria) (2023) op. cit.

⁴⁷ Victorian Government (2022) 'Display Tender FY22-759', Buying for Victoria website, last updated 9 August 2022.

⁴⁸ D. Sadler (2022) 'Victoria to create space and defence industry network', *InnovationAus*, 27 July.

⁴⁹ RMIT University (2022) *Looking up: RMIT launches Space Industry Hub*, media release, 24 March.

⁵⁰ Victorian Government (2023) 'About Vicmap', Department of Land and Transport website, 31 May.

⁵¹ A. Chaturvedi (2020) 'How satellite imagery is crucial for monitoring climate change', *Geospatial World*, 30 January.

⁵² Australian Government (2023) 'Baseline satellite data', Digital Earth Australia (Geoscience Australia) website.

environments, helping governments and businesses to plan for the future in areas of environmental management, agriculture and infrastructure planning.⁵³

Scope for further development of these capabilities is also outlined in the Victorian Government's *Strategy for Victoria's positioning system 2021–2025*, which touts earth monitoring, construction, water management, agriculture, mining, mapping and location-based services as areas that could be improved with precise positioning.⁵⁴ Victoria is also particularly active in seeking to harness the benefits of space technology for emergency response, especially as climate change is expected to bring more intense—and more frequent—extreme weather events.⁵⁵

The following sections detail some current initiatives involving Victorians within the space industry and some of the benefits derived from space activities.

Upstream investment

In April 2019, the SmartSat CRC received a combined \$190 million in private and federal funding—at the time ‘the biggest investment in space industry R&D in Australian history’—to develop **satellite technology** in aid of Australian ‘connectivity, navigation and monitoring capability’.⁵⁶ The project aims to strengthen Australia’s sovereign capability in areas of communications and connectivity; earth observation from space; and positioning, navigation and timing.⁵⁷

Described as a ‘consortium of industry and research organisations developing game-changing space technologies’, it draws on expertise from around Australia, with the Victorian node to be hosted at RMIT’s Space Industry Hub.⁵⁸ The project also counts a number of Victorian universities, including La Trobe University and Deakin University, as backers.

Victorian research institutions are also seeking a better understanding of space and dark matter through research being conducted over a kilometre underground at the **Stawell Underground Physics Laboratory**. Dark matter accounts for ‘85 per cent of the cosmos and binds the universe together’,⁵⁹ with Professor Alan Duffy, Director of the Space Technology and Industry Institute, explaining that an understanding of it ‘would reveal more of the universe than all of our collective efforts to date’.⁶⁰

The lab, which attracted funding from both federal and Victorian governments, is a collaboration between Swinburne University, the University of Melbourne, the Australian National University, the University of Adelaide and the Australian Nuclear Science and Technology Organisation.

Upstream investment has also seen large international space industry bodies branch into the Australian market through Victoria. The EPE and Lunar Outpost Consortium has been granted \$4 million as part of the **Moon to Mars Trailblazer program**—an ASA collaboration with NASA—and is setting up operations in Melbourne. The project aims to design the ‘early-stage prototypes of a semi-autonomous rover’ for the Moon, which would collect samples of regolith—a loose, mixed-material substance that covers solid rock—with the aim of

⁵³ J. Coykendall, A. Brady, K. Hardin and A. Hussain (2023) ‘[Riding the exponential growth in space](#)’, *Deloitte Insights*, 22 March.

⁵⁴ Department of Environment, Land, Water and Planning (2020) *Strategy for Victoria's positioning system: 2021–2025*, Melbourne, DELWP.

⁵⁵ CSIRO (Unknown) ‘[What are the impacts of extreme weather and climate events?](#)’, CSIRO website.

⁵⁶ La Trobe University (2019) *Research centre to boost space economy*, media release, 16 April.

⁵⁷ SmartSat Cooperative Research Centre (2023) *Build Australia's Space Industry*, promotional material, Adelaide, SmartSat CRC; RMIT University (2021) *Space Industry Hub set to launch Victorian expertise into global markets*, media release, 23 June.

⁵⁸ RMIT University (2021) *ibid*.

⁵⁹ R. Ward and L. Abbott (2022) ‘[“Nobel Prize for sure”: Hunt for dark matter goes underground in Stawell](#)’, *The Age*, 19 August.

⁶⁰ Swinburne University (2022) *Underground lab plunges researchers into the dark (matter)*, media release, 22 August.

extracting oxygen and developing a ‘sustainable human presence on the Moon’ as well as ‘supporting future missions to Mars’.⁶¹

It also hopes to advance carbon-neutral mining technology and Australian robotics capability.⁶² Partners include Victorian research institutions such as RMIT University’s Space Industry Hub and the University of Melbourne’s Melbourne Space Laboratory.⁶³

International collaboration

Satellites are providing a range of opportunities for research collaborations between Victorian and international entities.

Cubesats, for example—small satellites that can be easily stacked for launch—offer an affordable research tool for research and government institutions looking to test materials in the harsh environment of space, place scientific instruments in space to conduct measurements, carry cameras for earth observation and educate students.⁶⁴ The first three from Australia were launched in 2017, and the SpiRIT (Space Industry–Responsive–Intelligent–Thermal) nanosatellite is one more initiative in this vein.⁶⁵

The Melbourne Space Laboratory project is funded through the federal International Space Investment—Expand Capability Grants program and involves designing a cubesat to host an X-ray detector developed by the Italian Space Agency and Italian National Institute of Astrophysics.⁶⁶ Expected to be launched into low-Earth orbit during 2023, it amounts to ‘the first Australian-made spacecraft to host a foreign space agency payload’, but also doubles as a testing ground for plans to develop the SkyHopper space telescope project.⁶⁷

La Trobe University also has a history of international collaboration in this sector, having designed a high-resolution camera called the DLR Earth Sensing Imaging Spectrometer (DESI) in partnership with the German Aerospace Center (DLR) to ‘monitor bushfires, natural disasters and environmental changes’.⁶⁸ According to La Trobe University’s Dr Peter Moar, the camera, which launched on Space X’s Falcon 9 rocket in July 2018 and is now installed on the International Space Station, was ‘one of the first of its kind in the world’.⁶⁹ Data will be received by the School of Engineering and Mathematical Sciences at La Trobe University and Melbourne-based ESS Weathertech.⁷⁰

Emergency response

Satellite data informs much of our understanding of the land, climate and weather, with frequently updated satellite imagery providing a range of data to emergency management agencies. According to Dr Danielle Wright, a Remote Sensing Analyst in the Country Fire Authority (CFA) Research and Development team, the CFA has trialled satellite imagery in its

⁶¹ E. Husic, Minister for Industry and Science (2023) *Head of NASA visit to Australia highlights space partnership*, media release, 20 March; M. Davis (2022), ‘Australia on a path to the moon with NASA’s Artemis program’, *The Strategist*, 17 November.

⁶² K. Cowing and Lunar Outpost (2023) *EPE & Lunar Outpost Oceania Consortium Selected to Participate in the Australian Space Agency’s Moon to Mars Trailblazer Initiative*, SpaceRef, media release, 20 March; E. Husic, Minister for Industry and Science (2023) op. cit.

⁶³ K. Cowing and Lunar Outpost (2023) *EPE & Lunar Outpost Oceania Consortium Selected to Participate in the Australian Space Agency’s Moon to Mars Trailblazer Initiative*, op. cit.

⁶⁴ Government of Canada (2022) ‘CubeSats in a nutshell’, Canadian Space Agency website, 6 May.

⁶⁵ A. Dempster (2017) ‘Australia’s back in the satellite business with a new launch’, *The Conversation*, 18 April; University of Melbourne (2023) ‘SpiRIT’, University of Melbourne website.

⁶⁶ Australian Government (2020) ‘International Space Investment Expand Capability Grants supported projects’, Business.gov.au website, 26 June.

⁶⁷ University of Melbourne (Unknown) ‘SkyHopper’, University of Melbourne website.

⁶⁸ La Trobe University (2018) *Game-changer camera launched into space*, media release, 29 June.

⁶⁹ *ibid.*

⁷⁰ Invest Victoria (2018) *La Trobe University is on Falcon 9 to the International Space Station*, media release, 6 July.

response methods for around 30 years, and these methods continue to inform the state's suite of emergency management agencies.⁷¹

The Victorian Government's response to the Royal Commission into National Natural Disaster Arrangements lists a variety of satellite inputs available to authorities, including data from the BOM and a range of NASA, ESA and Japanese satellites, together with hotspot data and additional positioning data for lightning strikes.⁷²

Geoscience Australia (GA) can also play an assisting role in activating the *International Charter: Space and Major Disasters* in times of bushfire or flood, granting local emergency services access to tools such as satellite imagery, rapid mapping, exposure mapping, early warnings and monitoring through the European Union's Copernicus Emergency Management Service.⁷³

DEA Waterbodies is a recent addition to this arsenal.⁷⁴ Using satellite imagery to map water bodies from the air and reduce what is typically a laborious exercise of 'ground-truthing' to keep up-to-date records of water resources across the state, this platform may be able to aid aerial firefighting vehicles in quickly sourcing water without being restricted to the 5-kilometre radius of a pilot's field of vision.⁷⁵

Waterbodies director Dr Claire Krause hoped to expand the tool's capacity by adding inputs from the Sentinel program, meaning data arriving 'every three-to-five days'.⁷⁶ A recent report by Natural Hazards Research Australia also details work undertaken by FrontierSI and a collection of end users (including the CFA) in February 2023 to optimise the platform through value-adding data such as 'the surface area of water in the waterbody and the most recent date that water was observed'.⁷⁷

Figure 3: DEA Waterbodies map of Australia⁷⁸



⁷¹ Australian Government (2021) '[Finding water to fight fire](#)', Digital Earth Australia (Geoscience Australia) website, 1 February.

⁷² Department of Justice and Community Safety (2020) '[Victoria's State Response to Notices to Give: Royal Commission into National Natural Disaster Arrangements](#)', *Royal Commission into National Natural Disaster Arrangements*, July, Melbourne, p. 58.

⁷³ European Space Agency (2021) '[Sentinels activated for NSW floods](#)', Digital Earth Australia (Geoscience Australia) website, 7 April; European Union (2023) '[Copernicus Emergency Management Service](#)', Copernicus website.

⁷⁴ Australian Government (2023) '[DEA Waterbodies](#)', Digital Earth Australia (Geoscience Australia), 24 March.

⁷⁵ Australian Government (2021) '[Finding water to fight fire](#)', op. cit.

⁷⁶ *ibid.*

⁷⁷ C. Adams, M. Seehaber, F. Yuan and R. Sharma (2023) '[Identifying water sources for aerial firefighting](#)', Natural Hazards Research Australia, May.

⁷⁸ Australian Government (2023) '[DEA Waterbodies](#)', op. cit.

Water management

The implementation of DEA Waterbodies in an emergency management role is an example of one use springing from another, according to Dr Krause, given the platform's original aim was to map crop boundaries.⁷⁹ The intended field of application is now much broader, providing 'insights into drought, regional-scale development, water management practices, and water spatial variability',⁸⁰ which has implications for water health and sustainability goals:

National-scale reporting on water availability is a critical metric for the United Nations Sustainable Development Goal (SDG) six: clean water and sanitation. DEA Waterbodies provides a mechanism for reporting against SDGs by providing snapshots in time of the amount and spatial locations of surface water across Australia.⁸¹

On a national scale, these goals are being advanced through CSIRO and the SmartSat CRC through the Aquawatch initiative—an 'integrated ground-to-space water quality monitoring system'.⁸² SKA Low Telescope director Dr Pearce describes this as 'a merging of satellite data and sensors in rivers and streams with data analysis and artificial intelligence'.⁸³

Locally Agriculture Victoria (AV) is also informing water management research and advice with satellite data, specifically in irrigation. IrriSAT is offered as a satellite-informed decision support system that can help farmers with water allocation and land assessment, a traditionally labour-intensive process which relies on 'in-ground probes, visual inspection and fixed irrigation scheduling'.⁸⁴

Further, the Smarter Irrigation for Profit: Phase II initiative—a partnership of agricultural industries, research organisations and farmer groups—has collaborated with the University of Melbourne and AV, among others, on a range of projects, including investigation of the use of satellite technology to allocate irrigation water.⁸⁵

One recent study has trialled a satellite-based irrigation management approach on a farm near Tatura, finding that such an approach might be adopted for various circumstances but conceding that, at present, there would be 'different benefits and challenges when implemented on farms with less developed infrastructure'.⁸⁶

⁷⁹ Australian Government (2021) 'Finding water to fight fire', op. cit.

⁸⁰ Dr C. Krause, V. Newey, M. J. Alger, L. Lymburner (2021) 'Mapping and Monitoring the Multi-Decadal Dynamics of Australia's Open Waterbodies Using Landsat', *Remote Sensing*, 2021, 13(8), 1437.

⁸¹ *ibid.*

⁸² CSIRO (2023) 'AquaWatch Australia', CSIRO website, 19 June.

⁸³ Parliamentary Library & Information Service and Australian Academy of Technological Sciences and Engineering (ATSE) (2023) op. cit.

⁸⁴ Smarter Irrigation for Profit Phase II and Agriculture Victoria (2022) *Investing in satellite technology to save irrigation water in northern Victoria*, Smarter Irrigation for Profit Phase II, July; CSIRO (Unknown), 'IrriSAT – Environmental Informatics', CSIRO website; Agriculture Victoria (2020) 'Online training brings irrigator savings', Agriculture Victoria website.

⁸⁵ Smarter Irrigation for Profit Phase II and Agriculture Victoria (2022) op. cit.

⁸⁶ *ibid.*, p. 1.

4 | Challenges and opportunities

There are many challenges for the growth of a small space industry, but these also come with considerable opportunity. The following section overviews some of the key issues facing the space industry. Many of them are not unique to Victoria but may require local solutions.

Industry uncertainty

According to an Australian space research and industry community survey compiled in June 2020 for the Australian Academy of Science's *Australia in Space: A Decadal Plan for Australian Space Science* report, impediments to the industry were varied:

The most common concerns regarding ongoing employment in the sector were 'lack of funding' (38%), 'instability of employment' (22%), and 'poor career prospects' (13%). ... The negativity concerning employment relates specifically to Australia ...⁸⁷

That perceived negativity has persisted in the wake of the 2023 federal budget, which saw the discontinuation of a number of space-oriented projects. Some of these projects did not align 'with the Albanese government's priorities' and its ideas of 'value for money for the taxpayer'.⁸⁸ In response, James Brown, CEO of the Space Industry Association of Australia, said more certainty was needed and that the industry needed to know what the new federal government's 'plan for space is'.⁸⁹ Brown had already said in February 2023 that Australia was 'crawling in the global space economy whilst our friends and competitors are sprinting'.⁹⁰

Numbers indicate that the Australian Government's financial commitment to the space industry is small in the context of comparable economies, representing just 0.004 per cent of GDP.⁹¹ The *Space+Spatial Industry Growth Roadmap*—developed by a number of space industry bodies, including Earth Observation Australia, FrontierSI and SmartSat CRC—shows that, on this measure, Australia spent 'less in 2021 than Belgium, a nation with an economy less than one third the size of Australia's'.⁹²

Further, a KPMG analysis of different countries' space industry exports to the US—the world's largest spender in this area—found that Australia ranks 22nd in that list, suggesting 'Australia does not have current strengths in the manufacturing of space-related goods'.⁹³

This may in part be due to Australia's focus on developing industry connections, rather than financing direct inputs. However, the roadmap stated, further, that government procurement processes were potentially undermining Australia's strategic goals in this area, with procurement money 'directed towards imported space products' and ending up 'supporting the strategic space industries of other nations'.⁹⁴

Recruitment and retention

One area in which ASA head Enrico Palermo sees promise is the number of universities around Australia offering comprehensive space programs, including many in Melbourne.⁹⁵ Addressing the youth assembled at the 2022 Garma Festival, he touted the possibilities that

⁸⁷ National Committee for Space and Radio Science (2021) *Australia in space: A decadal plan for Australian space science [Companion document: expert working group reports]*, Acton, Australian Academy of Science, p. 8.

⁸⁸ A. Dalton (2023) 'Plan for Australian spaceports axed as federal budget cuts run deep', *The Sydney Morning Herald*, 10 May; T. Shepherd (2023) 'Australia's first national space mission up in the air after federal budget cuts', *Guardian Australia*, 11 May.

⁸⁹ T. Shepherd (2023) *ibid.*

⁹⁰ Space Industry Association of Australia (2023) *op. cit.*

⁹¹ KPMG Australia (2023) *op. cit.*, p. 23.

⁹² P. Woodgate et al (2023), *op. cit.*, p. 5.

⁹³ KPMG Australia (2023) *op. cit.*, p. 23.

⁹⁴ P. Woodgate et al (2023), *op. cit.*, p. 5.

⁹⁵ Garma Festival (2022) *op. cit.*

educational opportunity could have for a local workforce: ‘It is entirely plausible now to have a fulsome career in space in Australia, whether it is launching rockets, developing rovers that go to the moon, developing advanced technologies and satellites—those are things you are going to be able to do in your careers’.⁹⁶

Experts such as Swinburne University’s Professor Alan Duffy also say that Victoria’s small space industry footprint has upside in having the chance to develop an industry from the ground up, noting that Australia can do so without the costly obligation of repairing and supporting ‘legacy systems’.⁹⁷ However, Duffy stresses the need to innovate and invest in STEM training pathways to remain competitive in the global space sector, saying, ‘You can’t reap the greatest benefits from it, unless you have been instrumentally involved in its development’.⁹⁸

Part of that involvement requires establishing a diverse range of pathways into the industry. Emeline Paat-Dahlstrom explains that the space industry is just like any other industry in its need for marketers, lawyers and the like, regardless of space expertise.⁹⁹ However, STEM specialities are especially sought-after. The ASA’s submission to the federal Inquiry into Developing Australia’s Space Industry—conducted by the lower house’s Standing Committee on Industry, Innovation, Science and Resources in early 2021—listed a number of professions that need to be developed locally to sustain a growing industry, including the following:

- engineering and technicians
- mathematicians, data scientists and computational scientists
- software developers and software engineers
- researchers
- supporting services.¹⁰⁰

An educational focus on STEM is evident across the education system, with early exposure generated through the Victorian Space Science Education Centre, situated at Strathmore Secondary College and one of six specialist Victorian STEM educational facilities around the state.

Attempts to build connections between businesses, stakeholders and project organisers are also part of a more cohesive industry-wide growth strategy. The SmartSat Cooperative Research Centre is one part of this on a national scale. Locally, the CRC’s Victorian host, the RMIT Space Industry Hub, also aims to leverage ‘the state’s strong capabilities in advanced manufacturing’.¹⁰¹ There has been no further news at the time of writing on the Victorian Government’s tender for a ‘Victorian defence and space industry network service provider’.¹⁰²

Diversity within the sector

Workforce participation figures suggest a lack of diversity is ‘holding back’ the potential of our state’s space industry. As of October 2021, only one in five employees in the space industry were women.¹⁰³

Retaining these employees is also a challenge, due to a number of factors illustrated by the *Australia in Space* plan: as of May 2020, 22 per cent of women planned to leave the workforce, a 17 per cent wage gap existed across all sectors of the space industry (particularly for women

⁹⁶ *ibid.*

⁹⁷ Parliamentary Library & Information Service and Australian Academy of Technological Sciences and Engineering (ATSE) (2023) *op. cit.*

⁹⁸ *ibid.*

⁹⁹ StartSpace HQ (State Library of Victoria) (2023) *op. cit.*

¹⁰⁰ Australian Space Agency (2021) [Submission to the Standing Committee on Industry, Innovation, Science and Resources](#), Inquiry into Developing Australia’s Space Industry, January, Canberra, The Committee, p. 9.

¹⁰¹ RMIT University (2021) [Victorian government announces \\$44.6 million investment in RMIT](#), media release, 22 June; RMIT University (2021) [Space Industry Hub set to launch Victorian expertise into global markets](#), *op. cit.*

¹⁰² Victorian Government (2022) ‘Display Tender FY22-759’, *op. cit.*

¹⁰³ United Nations (2021) ‘Only around 1 in 5 space industry workers are women’, *UN News*, 4 October.

with postgraduate STEM qualifications), ‘one in five women had reported sexual harassment at least once in their careers’, and women were more likely to be underemployed or juggling childcare. COVID-19 and the consequent job losses were also factors.¹⁰⁴

First Nations involvement in the space industry is also a key focus, posing challenges and opportunities in terms of participation, utilisation of cultural knowledge and protection of land on which space activities are taking place.¹⁰⁵ Enrico Palermo, head of the ASA, spoke at the Garma Festival about the need to take into account First Nations peoples’ ‘long heritage and understanding of space’ and ‘do things responsibly as a nation to protect Country, which includes the sky’.¹⁰⁶

Initiatives such as the National Indigenous Space Academy, established by Monash University, look to address a shortfall in representation.¹⁰⁷ Palermo raised the possibility of leveraging ‘space technologies and data to protect Country’, which he said was increasingly challenging.¹⁰⁸

This issue was also a focus of the ‘Diversity at the Frontier: Gender Equality in Space Conference’ in April 2023. An insights paper authored by the conference’s convenors, drawing on the event’s discussions, highlighted a need to foreground First Nations ‘experiences, needs and desires in the space sector’, together with minimising barriers to full engagement with the sector to avoid ‘repeating critical mistakes of the past’.¹⁰⁹

That same conference identified further problems in the sector. It found that ‘exclusion and discrimination are common’, ‘Diversity is an overlooked opportunity’, ‘The space sector has a branding issue’ in its inability to attract more diverse participants and ‘Collaboration and inclusion among stakeholders should be centred’.¹¹⁰ It also recognised an opportunity to ‘get things right at the start’, given the relative youth of the industry in Australia compared to more established space programs around the world.

The insights paper’s recommendations included the following:

- more research on representation and experiences of diversity
- mainstreamed inclusion, diversity, belonging, accessibility and equity initiatives and policies in space sector and government initiatives
- an obligation on public and private sector industry participants to ensure economic benefits from the industry are equitably spread in society.¹¹¹

COVID-19 and what comes next

In 2018 before COVID-19, CSIRO’s report, *Space: A roadmap for unlocking future growth opportunities for Australia*—with the endorsement of the newly formed ASA—laid out a number of areas where Australia and its states and territories might grow in the global space industry, citing an aim to triple the size of the space industry by 2030.¹¹²

With the disruption of COVID-19, the ASA in early 2021 was still optimistic that space industry organisations would prove resilient with the help of federal relief funding. It cited in its submission to the federal inquiry into the space industry that IBISWorld predictions

¹⁰⁴ National Committee for Space and Radio Science (2021) op. cit., p. 53.

¹⁰⁵ E. Stephenson and C. Steer (2023) ‘[Just 1 in 5 employees in the space industry are women. This lack of diversity is holding us back](#)’, *The Conversation*, 16 May.

¹⁰⁶ Garma Festival (2022) op. cit.

¹⁰⁷ Monash University (2023) ‘[National Indigenous Space Academy](#)’, Monash University website.

¹⁰⁸ Garma Festival (2022) op. cit.

¹⁰⁹ E. Stephenson, C. Steer, M. Nash, J. Hayes, S. Furman, I. Vacaflorres, K. Dhillon & N. Hartanto (2023) *Diversity at the Frontier: Gender Equality in Space Conference [Insights paper]*, Canberra, Global Women’s Institute for Women’s Leadership and ANU InSpace, p. 10.

¹¹⁰ *ibid.*, pp. 4–5.

¹¹¹ *ibid.*, pp. 5–6.

¹¹² CSIRO (2018) *Space: A Roadmap for unlocking future growth opportunities for Australia*, Canberra, CSIRO, p. ii.

showed satellite communications and the astronautics industry in Australia growing by 1.1 per cent in 2020–21 and then at 8.3 per cent annually over the five years to 2025–26.¹¹³

The Australian Academy of Science (AAS) has put a caveat, however, on any predictions of long-term growth in the ‘uncertain post-COVID world’, saying that the focus should lie instead in developing ‘a space ecosystem which fosters new opportunities and initiatives and provides sustainable growth leading eventually to a sovereign space capability not reliant on government support packages’.¹¹⁴ The AAS also sees COVID-19 posing not just an economic challenge but a skills challenge, due to a decrease in ‘skilled migration, higher education and research activity, career prospects’ as well as ‘possible redirection of investment from the space sector to other economic and social priorities’.¹¹⁵

The pandemic created challenging conditions for many in the space sector. An OECD report published in August 2020 (before the breadth of COVID-19’s impact could be established in full) found that a significant percentage of the space sector was vulnerable to its impacts.¹¹⁶ Upstream projects, such as the ASA’s Moon to Mars initiative, have flow-on effects for small and medium enterprises (SMEs), with grants being awarded to Victorian businesses such as Cornflux (thermal technology specialist) and NextAero (space propulsion specialist) to allow them to add Australian capability and supply in the global supply chain.¹¹⁷

However, a reliance on government to fund the industry’s pipeline of major projects that engage SMEs through the supply chain means that SMEs, which make up the bulk of the commercial space industry, could leave the industry at risk of contracting when funding programs are discontinued, as they were in recent times.¹¹⁸ The OECD also sees fewer SMEs participating in the industry, together with decreasing but still-prohibitive entry costs, being detrimental to technical innovation, with there being too much financial risk for SMEs to innovate through what the report calls ‘creative destruction’.¹¹⁹

Indications of space investment becoming more mainstream through traditional investors in the last few years, according to SpaceBase’s Emeline Paat-Dahlstrom, might start to offset this dependence.¹²⁰ The AAS has also emphasised the value of a strong research and development reputation, stating that ‘because the space R&D sector focuses on new ideas and technologies and encourages STEM engagement, it presents an important post-COVID growth opportunity’.¹²¹

The CSIRO roadmap cited opportunities where Australia already holds a geographical advantage over other countries—earth observation, position, navigation and timing, satellite communications and space object tracking—and where our existing expertise can advance space exploration.¹²²

Morgan Stanley also indicates there has been a dramatic decrease in costs for things such as satellite manufacturing, brought about by the broader availability of materials and advanced research and development.¹²³ As a result, smallsats are now a particular growth area that SmartSat CRC and Melbourne Space Laboratory, among others, are looking to take advantage of locally. In addition to their data-gathering potential, Euroconsult’s Alexandre Najjar says they are ‘a significant capability building opportunity’ for new entrants.¹²⁴

¹¹³ Australian Space Agency (2021) [Submission to the Standing Committee on Industry, Innovation, Science and Resources](#), op. cit., p. 10.

¹¹⁴ National Committee for Space and Radio Science (2021) op. cit., p. 122.

¹¹⁵ *ibid.*

¹¹⁶ OECD (2020) [The impacts of COVID-19 on the space industry](#), Paris, OECD, August, p. 4.

¹¹⁷ Australian Government (2022) [‘Moon to Mars Supply Chain Capability Improvement Grants—grant recipients’](#), Business.gov.au website, 1 February.

¹¹⁸ OECD (2020), op. cit., p. 3.

¹¹⁹ *ibid.*

¹²⁰ StartSpace HQ (State Library of Victoria) (2023) op. cit.

¹²¹ National Committee for Space and Radio Science (2021) op. cit., p. 122.

¹²² CSIRO (2018) op. cit.

¹²³ Morgan Stanley (2020) op. cit.; Commonwealth of Australia (Australian Communications and Media Authority) (2021) op. cit., p. 7.

¹²⁴ Euroconsult (2022) [One ton of smallsats to be launched per day on average over the next decade, yet challenges remain](#), media release, 13 July.

Figures

- Figure 1 Distribution of space sector organisations vs population, percentage of national total
- Figure 2 Victorian GNSS ground station locations
- Figure 3 DEA Waterbodies map of Australia

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