



FRAMING THE FUTURES OF AUSTRALIA IN SPACE

**INSIGHTS FROM
KEY STAKEHOLDERS**

**WESTERN SYDNEY
UNIVERSITY**





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FRAMING THE FUTURES OF AUSTRALIA IN SPACE: INSIGHTS FROM KEY STAKEHOLDERS

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* PUBLISHED BY THE INSTITUTE FOR CULTURE AND SOCIETY

WESTERN SYDNEY UNIVERSITY

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ACKNOWLEDGEMENTS

The authors would like to extend their deepest gratitude to the 41 experts who participated in the 39 interviews with us. Without their generous time and nuanced insights this report would not have been possible.

With respect for Aboriginal cultural protocol and recognising that Western Sydney University campuses occupy their traditional unceded lands, the authors acknowledge and pay their respects to the Darug, Eora, D'harawal (Tharawal), and Wiradjuri Elders and communities.

This research was supported under the Australian Research Council's Future Fellowship scheme Australia a Space-faring Nation: Imaginaries and Practices of Space Futures (FT190100729, 2020–2024), Western Sydney University. ARC Future Fellowship Projects are funded independently and are not commissioned or filtered by industry partners or government entities. The views expressed herein are those of the authors and not those of the Australian Research Council.

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DOI: 10.26183/ffm4-5k07
URL: <https://doi.org/10.26183/ffm4-5k07>

TABLE OF CONTENTS

7 – EXECUTIVE SUMMARY

9 – KEY MESSAGES

13 – NEXT STEPS: SPACE FUTURES HORIZON SCANNING

17 – INTRODUCTION

24 – METHODOLOGY

28 – CHAPTER 1: CHARACTERISATION OF THE AUSTRALIAN SPACE SECTOR

32 – 1.1. Timeframe: Between the Sector's Newness and Its History

36 – 1.2. Key Actors: Who Is (in) the Sector?

44 – 1.3. Frameworks for Value Assessment

44 – 1.3.1. Sovereign: Australia's Particularities as a Country

48 – 1.3.2. Commercial: Australia Is "Catching Up" in an

51 – Industry-Centred Manner
1.3.3. An Elusive Shared Vision

56 – CHAPTER 2: THE AUSTRALIAN SPACE AGENCY

58 – 2.1. Timeframe: "At Long Last"

61 – 2.2. Key Actors: Expertise and Staffing of the Agency

65 – 2.3. Frameworks for Value Assessment

65 – 2.3.1. Sovereign and Commercial: Focus of the Agency

71 – 2.3.3. Inquisitive: Science and Outreach in the Agency

78 – 2.3.3. Commercial, Sovereign, Inquisitive, and Caring: Questions about Lunar Exploration

86 – CHAPTER 3: PERSPECTIVES ON KEY GLOBAL ISSUES IN SPACE

87 – 3.1. Timeframe and Key Actors: When and who is "NewSpace"?

92 – 3.2. Frameworks for Value Assessment: Democratisation and Sustainability

104 – CHAPTER 4: CULTURAL DIMENSIONS OF THE AUSTRALIAN SPACE SECTOR

107 – 4.1. Timeframe: An Australian Space Culture?

111 – 4.2. Key Actors

111 – 4.2.1. First Nations Perspectives

118 – 4.2.2. Equity and Diversity

121 – 4.3. Frameworks for Value Assessment: Public Communication and Participation

128 – CHAPTER 5: AUSTRALIA'S FUTURES IN SPACE

157 – INDUSTRY LITERATURE CONSULTED

160 – REFERENCES

Iron-rich aerosols from the 2019–2020 fires fertilized huge phytoplankton populations in the far South Pacific. Credit: Joshua Stevens / NASA Earth Observatory



EXECUTIVE SUMMARY

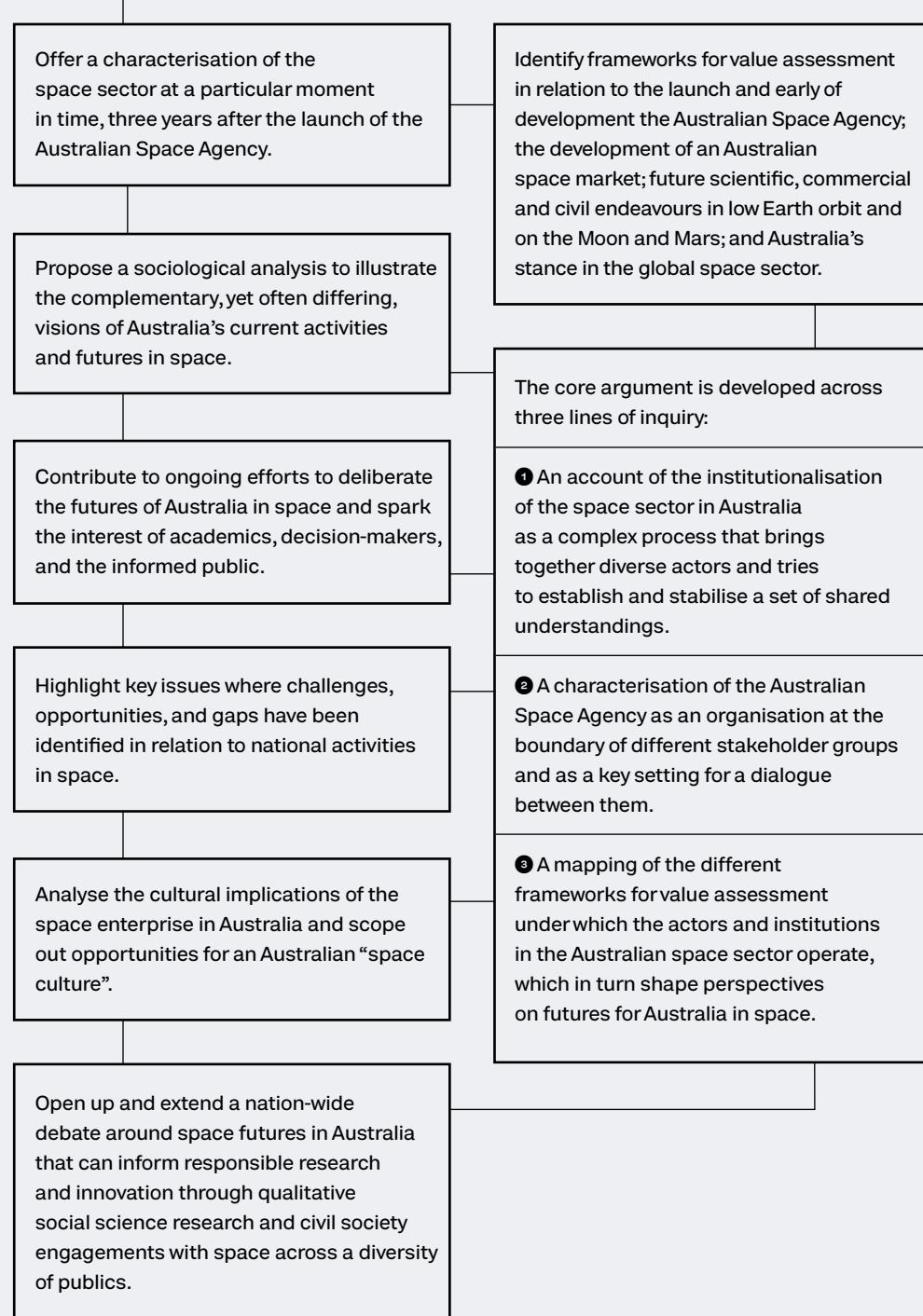
This report is a core output of the project Australia a Space-faring Nation: Imaginaries and Practices of Space Futures, funded under the Australian Research Council's Future Fellowship scheme (FT190100729) and led by Juan Francisco Salazar at Western Sydney University. This ARC project investigates the challenges, opportunities, and implications of outer space as a site of economic, political, environmental, and cultural interest for Australia.

This report presents key messages derived primarily from a set of 39 semi-structured interviews undertaken between October 2020 and May 2021 with 41 key actors in the Australian space sector. These actors represent a diverse range of perspectives from government, industry, science, law, and culture that constitute the space sector. The report explicitly aims to respond to the challenge of how to bring together the diversity that makes up the sector into a meaningful collective dialogue.

The interviews were analysed between June and December 2021 together with a selection of relevant literature consisting of key industry reports, technical documents, and relevant opinion pieces. The writing and synthesis took place between October 2021 and February 2022. Following the ethics protocols of the project, all interview transcripts were anonymised and all selected extracts from the interviews have been de-identified in the report.

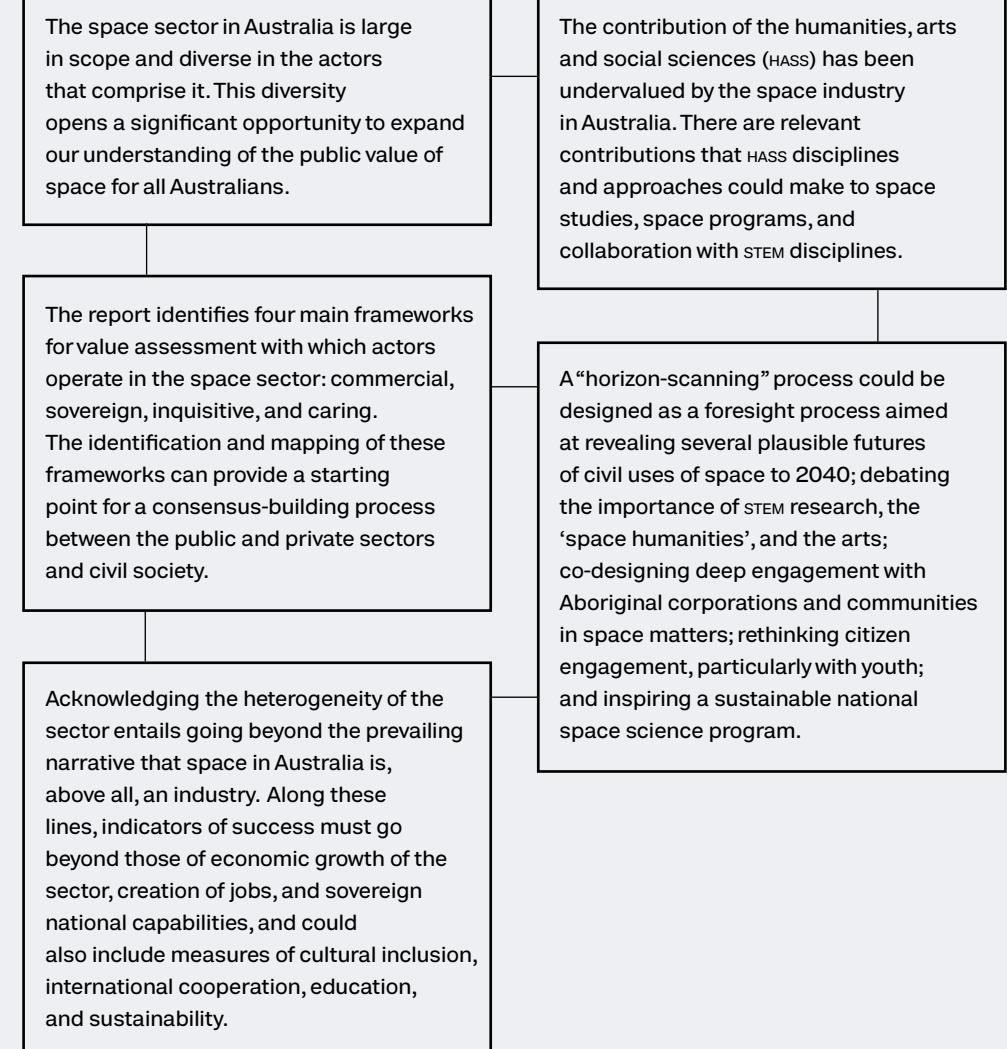
The idea that guides this report is that space is a site of political, scientific, commercial, environmental, and cultural interest for Australia. Therefore, it is not a single domain of activities, nor there is a single collective vision about it. However, more than simply stating that space carries different meanings for various actors, our goal is to characterise that diversity and to provide elements to map it with the goal of enabling conversations across those meanings.

THE PURPOSE OF THIS REPORT IS TO:



KEY MESSAGES

AN EXPANDED UNDERSTANDING OF THE AUSTRALIAN SPACE SECTOR AND ITS PUBLIC VALUE



THE AUSTRALIAN SPACE AGENCY AS A BOUNDARY ORGANISATION

Within the consensus about the importance of establishing a national space agency, there are different perspectives about the role of the Australian Space Agency (ASA). ASA has an official mandate centred on industry, but many interviewees saw shortcomings in its role regarding outreach, science, and regulation.

The report proposes that understanding ASA as a boundary organisation between numerous stakeholder groups and across jurisdictions is useful to support the agency's key role as a value creator across the entire science and innovation chain, and in facilitating interaction amongst diverse actors.

EMERGING ISSUES AROUND THE DEMOCRATISATION OF SPACE, SUSTAINABILITY IN SPACE, AND PARTICIPATION OF DIVERSE ACTORS IN THE SPACE SECTOR

There are significant convergences across a diversity of perspectives and historical accounts of the current state of the Australian space sector, which coalesce around an overarching industry-centred master narrative of NewSpace.¹

The future of Australia as a relevant actor in civil space activities depends as much on its diversity of perspectives and plurality as on its industry-centredness.

There is a range of different futures narratives at play regarding commercialisation, democratisation, and sustainability in space. But there is no nationwide collective vision across the sector, and there are differing, often conflicting, imaginaries of Australia's futures in space.

A gender- and culturally diverse workforce is imperative for the development of the Australian space sector, and fundamental to a democratic, inclusive, and sustainable sector.

IS THERE AN AUSTRALIAN SPACE CULTURE?

The Australian space sector, like any other sector, does not operate in a vacuum. It is crucial to include perspectives that examine the cultural implications of space in Australian society and the role culture plays at the intersections of a range of perspectives and imaginaries on space, including between Indigenous and non-Indigenous Australians.

There are important agreements emerging between commercial start-ups and Aboriginal corporations, particularly around the use of launching sites. It is crucial to ensure this engagement leads to opening up opportunities for the revitalisation of Aboriginal astronomical star lore and the skilling of an Aboriginal workforce and careers in STEM.

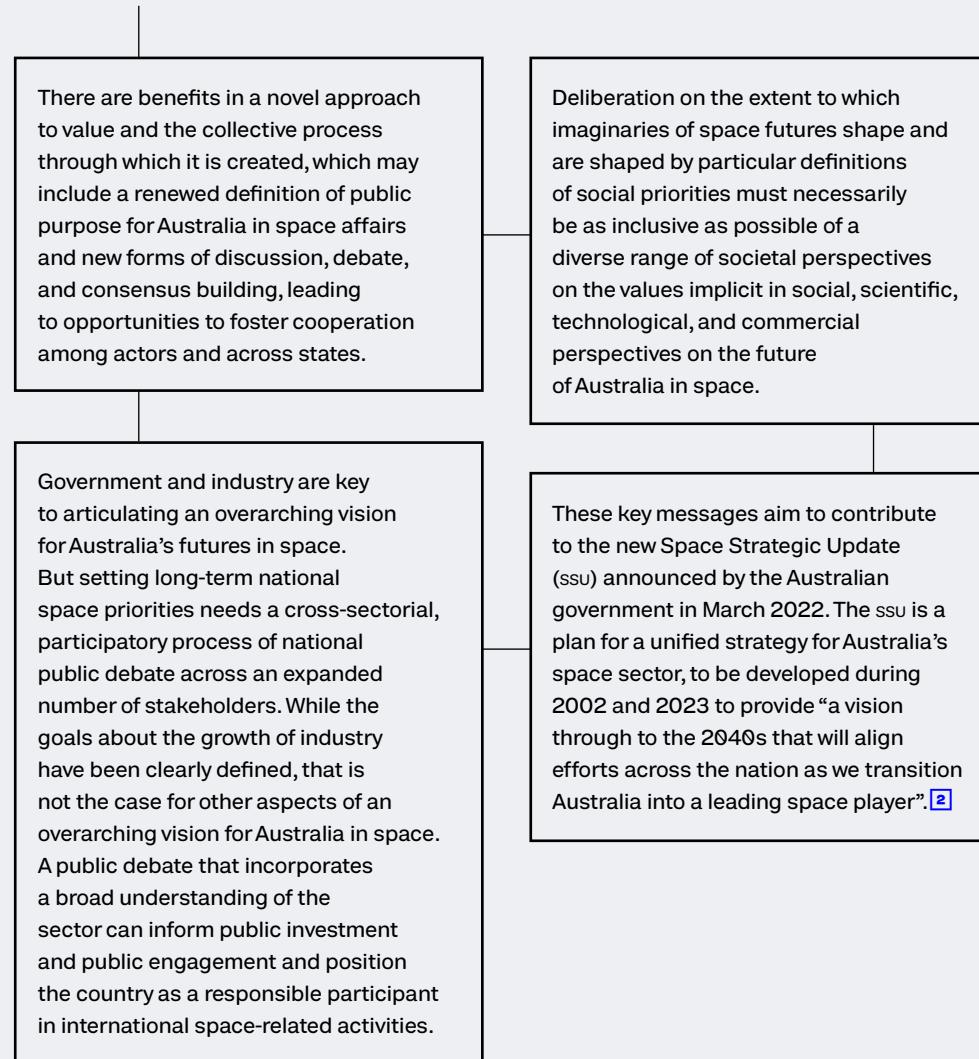
There is an uneven approach to Indigenous Australian knowledges of Sky Country and to participation by Aboriginal experts and communities in the space sector. There is an increasing awareness of, and interest in, Aboriginal astronomy, but in many cases this is understood as a comparative advantage for marketing an "Australia in Space" brand, instead of an ethical engagement with Australia's First Nations.

There is an urgent need to establish protocols for using First Nations cultural and intellectual property in the space sector. These protocols should respect local and international standards around respect, self-determination, cultural integrity, confidentiality, benefit sharing, recognition, and protection.

¹

The term NewSpace was coined in 2006 by the Space Frontier Foundation, a US non-profit space advocacy corporation that promotes entrepreneurial space activity. NewSpace has become a neologism to describe a broad range of primarily entrepreneurs and advocates who, since the 1990s, have aimed to commercialise outer space. For a critical analysis of NewSpace in the United States, see David Valentine, "Exit strategy: Profit, Cosmology, and the Future of Humans in Space." The author argues that beyond the possibilities for new forms of capital investment and profit, it is the promise of a radically transformed human social future that underwrites NewSpace discourses and activities (2012, p. 1049).

SPACE IMAGINARIES: AUSTRALIA'S FUTURES IN SPACE TO 2041



NEXT STEPS: SPACE FUTURES HORIZON SCANNING

It is important to broaden the terms of the public debate about space in Australia to illustrate that there are differing logics of value co-existing within the sector, and which go beyond the prevailing narrative that space is, above all, an industry.³ In thinking about an expanded notion of "space sector" that includes actors beyond government and private companies who might contribute effectively and actively to understanding of the public purpose of space activities in Australia, it is crucial to debate the collective creation of value and "how value is owned and shared" (MAZZUCATO 2021).

One way to have a nationwide debate about space is through the design and implementation of a horizon-scanning process.⁴ This would be relevant also in the context of the newly announced Space Strategic Update, where a horizon-scanning process on Australia's space future can be incorporated into research, policy, and practice as a systematic search for potential threats and opportunities that are currently poorly recognised. This process would inform decision-makers on which issues might be most worthwhile to consider. This approach could ensure timely policy development and research procurement across the public, private, and academic space sectors in Australia. Additionally, it could benefit all decision makers, be they in government, organisations, or industry, as well as cultural organisations and civil society, to ensure that core visions and imaginaries are informed by evidence about a diversity of possible, plausible, futures.

² See the press release from 3 March 2022, "Keeping Australia's Space Sector Soaring" <https://www.minister.industry.gov.au/ministers/price/media-releases/keeping-australias-space-sector-soaring>

³ "Space is above all an industry", as defined in the report *The New Frontier: Developing Australia's Space Industry* (2021).

⁴ Horizon scanning has gained prominence as a methodology since the late 1990s to develop a collective view of future directions in an area of interest. A seminal publication by Sutherland et al. (2011) looks at several horizon scanning activities and recommends best practice based on these experiences. See Sutherland et al. (2011), "Methods for Collaboratively Identifying Research Priorities and Emerging Issues in Science and Policy".

The four frameworks for value assessment that we identify in this report are a starting point that might inform a consensus-building process about the public value of space for all Australians. This could be done through a series of workshops, scenario-building activities involving experts and specific communities of practice. These activities can collectively map threats.⁵ In broad terms, the *Commercial* and *Sovereign* frameworks for value assessment are at the top of considerations and have been at the core of the institutionalisation of the space sector, while the other two frameworks, *Inquisitive* and *Caring*, are treated as either optional or not crucial. The particular arrangements between the four are up to the actors themselves, but by providing them with this map we hope to bring sometimes hidden assumptions to the fore. We propose the need to value activities and initiatives that cannot be qualified only in terms of job creation, number of launches, and overall growth of the industry.

Taking as a starting point the responses from interviewees as included in Chapter 5 of this report and using inductive or bottom-up scenario-building methods, the “horizon-scanning” process could be designed as a foresight process aimed at revealing several plausible futures of civil uses of space to 2040. This process would illustrate the need for a concerted national effort to engage in public communication and participation across government, industries, universities, and civil society in ways that reflect the diversity of the Australian population. The process might also enlighten pathways for developing synergies, educational programs, art-science residencies, and living labs between the space sector and the Australian creative sector, and cultural industries could benefit the space sector in developing practical and strategic ways to open up the cultural landscape and support a range of narratives and stories of Australia’s futures in space.

There are many other relevant issues where a horizon-scanning process can be useful. One is the debate around the importance of space sciences, humanities, and the arts. In the Parliamentary Inquiry that led to the *Now Frontier* report, it is stated that “basic space science research is necessary for the development, long-term success, and competitiveness of the Australian space industry” and that “framing Australia’s space investment priorities around jobs and growth overlooks the opportunities generated by investments in science which includes social and economic benefits”. As the submission by the Australian Academy of Science

(the Academy) states, the single most significant support that the Australian government could provide the Australian space sector is to provide national coordination in space science. There is no body with a mandated role of co-ordinating Australia’s space science investments or actively supporting the development of space science. Despite the Australian Space Agency’s establishment, this is a critical gap that needs to be filled. This is echoed by Australia Space Futures, a consortium of three Australian universities (ANU, USW, AND USA), which has identified some barriers to maximising the university sector’s impact on space industry growth – including that the Australian space industry is wide but thin and not in a position to fund research at scale. As it notes, space research is not concentrated in one area but rather sits across many disciplines such as STEM, health, business, humanities, social sciences, and the arts. The role of humanities, arts, and social sciences (HASS) is crucial for a careful consideration of the public value of space activities in Australia. HASS supplies two thirds of Australia’s workforce and HASS skills are highly prized by all industry sectors.⁶ Therefore, an internationally competitive space industry in Australia will depend as much on a foundation of excellence in science and technology as on the embracing of HASS disciplines that provide vital knowledge and understanding of our world, its peoples, and its societies.⁷

Other critical themes where a “horizon-scanning” process could be useful is in co-designing deep engagement with Aboriginal corporations and communities in space matters as well as rethinking how to engage with youth and inspire citizens through educational strategies framed through a sustainable national space science program.

⁵ One model is provided by the Australian Council of Learned Academies (ACOLA) Horizon scanning series (<https://acola.org/our-work/horizon-scanning-series/>), where a horizon-scanning process on Space Futures could be proposed.

⁶ See for instance the 2014 *Mapping the Humanities, Arts and Social Sciences in Australia* report or the 2018 *Humanities, Arts and Social Sciences (HASS): Powering Workforce Transformation Through Creativity, Critical Thinking and Human Interaction* report.

⁷ For a recent analysis of the role of the social sciences in astronomy at NASA see Berea et al., “The Social Sciences Interdisciplinarity for Astronomy and Astrophysics – Lessons from the History of NASA and Related Fields” (2019).

This image captures the Antennae Galaxies, also known as NGC 4038/NGC 4039, an interacting pair of galaxies undergoing a vast galactic collision. Credit: ESA/Hubble & NASA.



INTRODUCTION

The guiding idea for this report is that space is a site of political, scientific, commercial, environmental, and cultural interest for Australia. It is not a single domain of activities, nor there is a single collective vision about it. However, more than simply stating that space carries different meanings for various actors, the goal of this report is to characterise that diversity and to provide elements to map it with the aim of enabling conversations about public value across those actors and meanings. The history of Australia in space has been judiciously covered in several publications, including Kerrie Dougherty's 2017 book *Australia in Space: A History of a Nation's Involvement*. This book describes at length the visions, hopes, and achievements of professional space scientists and engineers in both the civil and defence spheres together with those of space amateurs and a new wave of space industries and ventures. This major contribution was published just before the launch of the Australian Space Agency in July 2018.

The current state of Australia in space from the perspective of industry was recently depicted by the Parliament of the Commonwealth of Australia's 2021 report *The Now Frontier: Developing Australia's Space Industry*. This report acknowledges that "while the Australian space industry is often described as 'fledgling' or 'nascent', it has a long history in space tracking, launch, earth observation, and space science research" (p. 7). According to the report, the space sector is currently defined in Australia as "a set of space-related activities along the space value chain (manufacturing and core inputs; space operations; space applications; enablers)" and "part of the broader space economy [that] includes private, public and academic stakeholders" (p. 7). *Now Frontier* recommends that government, in consultation with industry, seek to define an overarching vision for the Australian space industry, as well as a set of long-term national space priorities to guide and galvanise the Australian space industry with the aim of inspiring the Australian public.

The future of the Australian space sector, again from the perspective of industry, has been conveyed in KPMG's report *30 Voices on 2030: The Future of Space; Communal, Commercial, Contested*, launched in May 2020, which provides a series of snapshots of how key actors in the space sector anticipate future developments in this field. The KPMG report sets out to make several projections to 2030 based on interviews with key thinkers and doers, mostly around the commercial development of the global and Australian space industries. It outlines the perceived benefits of space activities across all aspects

of social life and the combat against global environmental change. It frames this context around the “democratisation” of space, in which businesses and citizens benefit from the data, insights, and services made possible by space. It outlines accessibility to space, the commodification of space data, and key developments in medicine and manufacture as some of the key factors that will shape a sector driven and led by small start-ups and multinational businesses. It calls for a central international governing body to manage space data and respond to emerging sustainability challenges, such as through a moratorium on space debris or the recognition of the importance of space environments for future generations. The KPMG report offers a window into the main logics of value currently at play in the Australian space sector, and the ways in which the various activities that make up the sector are essentially assessed in terms of the business case for space. It also demonstrates how a dominant sociotechnical imaginary⁸ of Australia in space, and its concomitant notion of where value resides, can frame the present in terms of the future.

The *Framing the Futures of Australia in Space* report is not aimed at rewriting this fruitful and well-documented history of Australia’s engagements in space. It does not attempt to make predictions either. Its goal is to outline a framework for discussing Australia’s space futures with a focus on the public value of space that certainly includes its economic value, but it is not circumscribed by it.

The report shows that the actors interviewed have diverse ideas and expectations about what space can be as a domain of activities; what space innovation entails; how collaboration happens across science, policy, academia, and civil society; and the significance and timeliness of space endeavours, together with different perspectives on the very idea of what the right thing to do is when it comes to space activities. The responses from the 41 key actors interviewed for this report provide an expanded notion of a “space sector” in comparison to the one described in the Parliament of the Commonwealth of Australia review and report – one in which important differences coexist across industry, academia, government agencies, the space sciences, space law, artists, and cultural

institutions. The *Now Frontier* report calls for community education and outreach programs to be developed to promote the range of professions – not generally associated with space – that will all be required to support Australia’s space industry. In this call, cultural institutions and creative producers, artists, and the humanities and social sciences are left out, overlooking their contributions to the space sector and space activities.

From the understanding that value emerges from the interaction of the public and private sectors and civil society (MAZZUCATO 2021, p. 165), our purpose is to offer a novel approach to how the value of the space sector in Australia can be co-created as a collective process that emerges from open forms of discussion and debate. The recent Australian re-incursion in space activities takes place in a new landscape marked by a focus on the commercialisation of space activities, with a governmental mandate to foster the Australian space industry. In that context, cultural producers and organisations have been absent from a public conversation about the goals of the sector, and citizen engagement also seems missing, as is participation by researchers in the humanities, arts, and social sciences. If common purpose is being sought, participation requires reimagining the future together, and it is vital to bring different voices to the table with tools for navigation across the perspectives.

We had these considerations in mind as we approached the interviews with entrepreneurs, policy-makers, defence experts, artists, scientists, lawyers, science communicators, engineers, and social scientists. In what follows we reopen key questions about how to characterise the Australian space sector; who is (in) the sector; what Australia’s particularities are in the context of other nations involved in space; the role of the space agency; the present key debates around democratisation and sustainability in space; the role of culture; and what the future of space activities in Australia could and should look like. The analysis we offer is interpretive and structures the richness of the responses about these issues in a scaffold that focuses on three elements: the temporal framing of the responses, the actors involved in the characterisation of the various issues, and the frameworks of valuation deployed by the interviewees to articulate their statements. This work covers a period that goes from the few years preceding the establishment of the Australian Space Agency in 2018 up to 2041, two decades from the time the interviews were held. In order to map the different logics that make up the sector, examine their underlying frameworks to assess value, and open up spaces of deliberation, consensus building, and common purpose, we propose three lines of analysis.

⁸ The concept of “sociotechnical imaginaries” was developed in the late 2000s by sociologists of science and technology Sheila Jasanoff and Sang-Hyun Kim (2009, 2015) as an approach to understanding the relations between scientific and technological projects (such as space activities) and political institutions and power (such as space agencies or space law). See Jasanoff, S., & Kim, S. H. (Eds.). *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power* (2015). The notion has been widely used in energy futures research (Levidow & Raman 2020; Sovacool et al. 2020; Chateau et al. 2021) and recently in sociological studies about future visions of space (Tutton, 2021). In this report we use this concept as one way to understand institutions from the perspective of cultural meanings, specifically, how technoscientific projects are imbued with implicit understandings of what is desirable, where collective social values influence the design of space activities which in turn reflect normative commitments and convey particular understandings of space, and investments in space.

FRAMEWORK FOR VALUE ASSESSMENT	Sovereign	Commercial	Inquisitive	Caring
PRINCIPLES OF WORTH	Autonomy, defend, protect, acquire, maintain prestige	Profit and expansion	Research, inspire	Preserve, guard
"SPACE AS A SITE FOR..."'	Extraterritorial border that must be safeguarded and strategic site	Resource for exploitation and a marketplace to provide services (for earth and space activities)	Research site (compatible or incompatible with activities of exploitation)	Environment (not compatible with activities of exploitation)
TYPES OF EXPERTISE	Legislator, strategist, bureaucrat	Entrepreneur, investor	Scientist, science communicator	Environmentalist, custodian
MODES OF REGULATION	Restrict (security), collaborate (strategically)	Enable (risk)	Enable (collaboration)	Restrict (exploitation), protect with legislation
MODES OF ACTION	Assertive, defensive, contractarian	Competitive	Collaborative	Deliberative, contemplative
SCOPE	National focus, strategic international alliances	National focus (to defend their interests), internationally minded to expand markets and supply chains	International collaboration as a major driver	Global, planetary, local

1. An account of the institutionalisation of the space sector in Australia as a complex collective process of value co-creation.

By **institutionalisation** we mean an overall process of stabilisation that has four key components: the sedimentation of modes of understanding and doing in a given social setting (GLAESER 2014), the imprinting of these modes of doing and understanding in particular organisational forms (STINCHCOMBE 1965; JOHNSON 2007), the building of formal structures and processes within the organisation, and the acquisition of identity and legitimacy by the organisation (EBERLEIN 2011, p. 1202). In the case of a national space sector, the key organisation in this process is a national space agency.

2. An understanding of the Australian Space Agency as a *boundary organisation* in the context of the institutionalisation of the space sector through a national space agency.

The term *boundary organisation* has its origins in the concept of “boundary object”, which refers to objects “both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites” (STAR & GRIESEMER 1989, p. 393). In its adaptation to the study of organisations, boundary organisations are “complex and diverse organizations at the boundary between numerous stakeholder groups, often across jurisdictions, and including scientists from multiple disciplines” (LEITH ET AL. 2016, p. 379; SEE ALSO CLARK ET AL. 2011; GUSTON 1999). The term does not provide a prescriptive mode of organisation; its importance lies in its role of “facilitating interaction” amongst those actors that intersect in its activities, which is one of the main goals of this report.

3. A mapping of the different frameworks of valuation with which the actors and institutions in the space sector operate regarding not only current activities, but more importantly, possible futures for Australia in space.

Frameworks for value assessment are the various parameters used by actors to assess worth. Orders of worth are higher-order principles that underlie what actors or institutions conceive as desirable, valuable, and justifiable. Each order of worth contains “a repertoire of legitimate principles of justification which people can use in situations with contested values” (THORSLUND & LASSEN 2017, p. 839). Sociologists Luc Boltanski and Laurent Thévenot identify six orders of worth, each with its logic of value: market, industrial, civic, domestic, inspired, and world of fame/opinion (BOLTANSKI & THÉVENOT 1999). Drawing from these authors, from the concept of public value as a collective creation driven by public purpose (MAZZUCATO 2018; MAZZUCATO & RYAN-COLLINS 2019) and the emerging field of social studies of valuation (LAMONT 2012;

HEGELSSON & MUNIESA 2013; KJELLBERG & MALLARD 2013; ANTAL ET AL. 2015), we identify and characterise the four central frameworks of valuation that coexist in the Australian space sector in the following manner:

The plurality of modes of assessing worth is a crucial issue to understand the space sector in Australia. We treat this chart as a map that can help situate the key elements that make up the four frameworks. The very understanding of what space is and can be differs across the four frameworks, as well as the principles that guide action, the very idea of who has a voice at the table as an expert to define the terms of what is considered valuable, and the desirable modes of action and regulation. From this map, we hope that the next step after this report can involve the design and implementation of a horizon-scanning exercise to find commonly agreed roads of communication to shape a broader sense of public value for the Australian space sector.

OUTLINE OF THE REPORT

This report is organised into five chapters, following this introduction. Each chapter features at length the responses from the 39 interviews and is structured in terms of the timeframes in which they placed their responses, the actors they identified as key to the various issues discussed, and frameworks for value assessment suggested in their approach to the questions.

<p>CHAPTER 1 offers a characterisation of the Australian space sector examining the timeframes, main particularities, and actors included by our interviewees in their vision of the sector. The chapter outlines the centrality of the sovereign and commercial frameworks for value assessment with regards to the notion of public value of the sector.</p>	<p>CHAPTER 4 provides a snapshot of the interviewees' perspectives on the cultural dimensions of the Australian space sector. The chapter asks what might identify a specific Australian space culture, and points to the need to pay attention to the cultural implications of the development of a space sector in Australia. It addresses the crucial issues of the integration of Australian Indigenous perspectives beyond the buoyant field of Indigenous astronomy, and equity and diversity within the Australian space sector.</p>
<p>CHAPTER 2 highlights the perceptions about the Australian Space Agency in the period 2017–2021. It points to the reservations and achievements observed by the interviewees, noting ongoing and emerging challenges.</p>	<p>CHAPTER 5 is particular in its structure in presenting, in their entirety, the responses from all 39 interviews regarding their perspectives of Australia's futures in space. Projections about the future, both as forecasts and as aspirations, make values particularly transparent, and the answers precisely shed light on the coexistence of those values, and how visions, narratives, and imaginaries of space futures inform action and shape decision-making in the present.</p>
<p>CHAPTER 3 provides a summary of the range of perspectives that the interviewees have on three crucial areas of interest in global space activities: commercialisation, democratisation, and sustainability. Observing that all three carry different meanings and convey different value commitments, this chapter outlines possible areas of convergence and divergence.</p>	

METHODOLOGY

The research design of this report was divided into two parts:

a An overview of 30 industry reports and relevant opinion and media pieces, undertaken between June 2020 and December 2021.

b Implementation and analysis of 39 semi-structured interviews with 41 key actors across a wider spectrum of what is considered as the Australian space sector.⁹ Interviews were conducted between October 2020 and May 2021.

The interviews provided us with a deeper understanding of prevailing ideas, values, beliefs, and future imaginaries from these actors who, in various capacities, play a role in key decision-making processes and in the sector more broadly. Interviews allowed for flexible, in-depth analysis from a representative group, allowing us to place the focus of research on the views of the participants.

We employed the criterion of informational redundancy and established that the number of interviews conducted for this mid-size study was sufficient, as new information was not being elicited by interviewing more actors: once we judged we had reached informational redundancy we concluded the interviews. The 39 interviews are representative of the Australian space sector in its broadest sense.

The project was designed in three basic stages:

INTERVIEW DESIGN	DATA GATHERING SAMPLING	ANALYSIS AND REPORTING
Identify type of research interview and design semi-structured questionnaire	ethical review; undertake interviews	

Interview design

The interview process started with the identification of an interview style, a selection of research participants, and the elaboration of a set of research questions. This was followed by consideration of how these interviews could be supplemented with a literature review and identification of how they could provide the relevant kind of data for the outputs envisaged.

We used semi-structured interviews developed from a fixed set of 15 pre-determined questions. From these, we chose a subset depending on the interviewee (usually 10 questions per interviewee). The same interview script was used in many separate interviews, but not in all, still allowing for close comparison between different transcripts, maintaining data quality, and most importantly, allowing interviewees to shape the discussion and limiting potential pre-conceived researcher bias in shaping the interview. For this reason, interviewers were allowed to ask additional questions when a relevant new line of enquiry emerged in the interview, or when an interviewee added a relevant area of interest. This flexibility was important for this study of complex issues, such as outer space science–policy–industry interfaces.

OVERVIEW OF LITERATURE

There is a substantial number of reports and opinion pieces that provide accounts of the Australian space sector. We engaged with this literature to design the interview questionnaires and as background reference for the analysis. These works provide key clues for identifying meaningful sites of convergence and divergence across a range of diverse actors that contribute to the space sector in Australia.

SEMI-STRUCTURED INTERVIEWS

The semi-structured interview format was chosen to gain specific information on the perspectives of a group of key actors about a set of specific issues prevalent in Australia. The interviews allowed us to capture informed views from a diverse range of space-sector stakeholders about the past five years of development of the Australian space sector and about what they anticipate will be the major developments and issues in the next 10 years.

⁹

Two of the interviews featured two interlocutors each.

Data gathering

We used a combination of sampling strategies including a criterion of gender parity. We employed *key informant sampling*, where we looked at the public information (talks, publications, expertise) of key actors in the Australian space sector to ensure informed coverage of a range of matters of concern. We developed a profile for each of the potential interviewees identified. We combined this with *snowball sampling*, where during the initial interviews some of the key actors identified and interviewed made recommendations of other people to interview. We also included *theoretical sampling*, where after interviewing 12 actors and transcribing, analysing, and looking for initial patterns, we were led to identify further participants based on emergent themes. We did not employ *representative sampling* although we identified 50 interviewees as an appropriate representative sample from a range of areas related to the Australian space sector.

From this initial pool of 50 key stakeholders, we conducted interviews with 41 via Zoom and recorded them on audio; 19 interviewees were female and 22 were male. Interviews were conducted online via Zoom and recorded on audio. All interviews had a duration of between 45 and 75 minutes.

Identification of interviewees

All interviewees were de-identified for the purposes of this report and all were granted an opportunity to review a preliminary draft summary prior to public release. They all gave verbal consent to be interviewed at the beginning of the recording. Only one requested for the interview not to be recorded.

We divided the 41 interviewees in seven broad groups of *key agents*:

Analysis

The interviews were transcribed using professional transcription services and coded through tags for assigning units of meaning to the descriptive or inferential information compiled during the interviews.

Interviews proved useful to elicit stakeholder perceptions of the state of the art of the Australian space sector, or to explore the interests and actions of actors involved in crafting visions of Australia in space. Other uses of interviews included understanding perceptions from stakeholders of the Australian Space Agency and gauging stakeholder views on potential future scenarios.

After the initial coding, and as a way to structure the wealth of perspectives that came up during the interviews, we focused on three broad areas of analysis: the timeframes in which interviewees placed their responses, the actors they identified as key to the various issues discussed, and frameworks for value assessment suggested in their approach to the questions. Unlike the other sections, all answers from our interviewees regarding their perspectives on Australia's future in space in Chapter 5 are presented in their entirety.

⦿ **Academic experts** from a range of Australian universities and with a balanced number from HASS and STEM disciplines from law, history, science communication, political science, science and technology studies, engineering, and astronomy;

⦿ **Space company directors** from 10 Australian-based companies;

⦿ **Public sector civil servants** from ASA and CSIRO;

⦿ **Space sector consultants** in areas of law, commerce, and defence who also have had roles as company directors and/or academic positions;

⦿ **Artists and cultural organisations** across three Australian cities;

⦿ **Space industry associations and societies**;

⦿ **Experts from international space agencies** including ESA and NASA.

CHAPTER 1: CHARACTERISATION OF THE AUSTRALIAN SPACE SECTOR

Seven Sisters Songlines inspired Artwork by Barngarla artist Jonas Dare. Co-owner of Jonas Jaja Aboriginal Art Gallery in the Flinders Ranges. <https://jonasjaja.com/> Credit: Juan F. Salazar



In June 2020 the Australian Space Agency (ASA) released a series of online documents that included a definition for the Australian space sector (ASA 2020). ASA defines the space sector as “a set of space-related activities along the space value chain” within “the broader space economy” (ASA 2020). Following the Organisation for Economic Cooperation and Development’s (OECD) definition, the space economy is “the full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space” (ASA 2020). These definitions include “public and private actors involved in developing, providing and using space-related products and services ... ranging from research and development, the manufacture and use of space infrastructure, space-enabled applications and the scientific knowledge generated by such activities”. In other words, only those who are “participating in production, operation, supply and enablement activities that form the space value chain are part of the space sector” (DEPARTMENT OF INDUSTRY, SCIENCE, ENERGY AND RESOURCES 2020).^[10]

Drawing on the OECD’s definition of a space economy, ASA’s definition was also intended to allow for comparisons between the Australian space sector and those of New Zealand, Canada and the United Kingdom. For ASA this definition ensures comparability with other international space sectors and provides consistency for who is to be included in this rapidly growing and changing Australian space sector.^[11]

This is a narrow rather than a wide-ranging definition, as the ASA document argues. While it provides a foundation for defining the traditional activities associated with the space sector such as manufacturing, space operations, space applications, and space enablers, it leaves aside a number of important areas that are not

[10]

<https://www.industry.gov.au/data-and-publications/definition-of-the-australian-space-sector/defining-the-australian-space-sector>

[11]

In a similar exercise to this report, Space Australia asked members of the Australian space community to share their thoughts about this definition and the activities it encompasses. Several commented on the lack of a scientific agenda, the need to include a standalone section on education and outreach, including science communication, or the lack of mention of culture and the culture industries such as art and tourism. Importantly, others commented on the need to integrate Indigenous cultural knowledge and the humanities (such as the inclusion and importance of space art and storytelling) and expand further on the space sciences.

considered to be part of a space value chain or what is considered to be a space economy. The Australian Space Agency's *State of Space Report 2019–2020* presents a picture of Australia's space sector and its place in international space exploration and the space economy as one that is nascent and still underdeveloped. Following the terminology of a 2019 Deloitte Economics report that characterised the New Zealand space economy as NewSpace driven, the Australian space economy is also "characterised by a mix of start-up and well-established, small and large entrepreneur-driven and privately-funded space companies which service both government and non-government customers" (DELOITTE 2019). However, the scale of government activity in Australia is an important factor and major driver, which complements the strength of space manufacturing, research and development capability across several universities, and a vibrant and growing milieu of venture capital start-ups. Unlike in New Zealand, it is not only commercial activity that drove the establishment of the Australian Space Agency.

In the following sections we summarise the most significant responses from the key actors interviewed. The first question we asked all interviewees was about the Australian space sector and more specifically, how they would characterise it by imagining an interlocutor that knows very little about it. This was a deliberately broad question that looked for adjectives and content of the characterisation, and that also gave us a way to examine the timeframe and actors included in that definition.

In this first group of answers, in some cases more explicitly than in others, there were allusions to where the country is coming from and where it is heading, and there were also explicit and implicit notions of the precincts of the sector and who comprises it.

We identified three main features of the Australian space sector that emerged from the analysis of these responses. First, there is a common understanding of Australia's unique and intermittent space history. Most interviewees converged, on the one hand, in an explanation of the gap between the youth of the sector in its present moment and Australia's heritage in the early days of the space race, and on the other, in terms of the absence of sustained governmental interest, and hence, the sense of belatedness in the creation of the space agency and the urgency for Australia to "catch up" with the world.

Second, the sector has imprecise contours, and the inclusion and exclusion of actors in the picture depend on what is considered as its core. This heterogeneity of actors also means that the logics under which it operates, as well as its expertise and heritage,



are heterogeneous and unevenly distributed. For those who focused on industry, the youth and dynamism of the sector was the main feature they highlighted as Australia is one of the fastest-growing space sectors in terms of small companies. For those who included space sciences, particularly astronomy, as part of the sector, there is deep and long-standing expertise.

Third, regarding frameworks of valuation, this first group of answers allowed us to distinguish the centrality of what we call the *sovereign and commercial* frameworks in the interviewees' perspectives. There was convergence around the fact that Australia has unique advantages and capabilities that enable its positioning as a spacefaring nation; there was also a generalised view that Australia's version of "catching up" to match international developments is focused on the development of space industries.

1.1. TIMEFRAME: BETWEEN THE SECTOR'S NEWNESS AND ITS HISTORY

For many of our interviewees the main descriptor for the sector was its youth:

- ① "It's young, yet it touches on decades of experience, but it's very young, it's very unique. It's valuable. It's inspiring. It has huge potential. It's a little balkanised – if under one banner, it could be spectacular." (INTERVIEW 7)
- ② "I would describe the Australian space sector as young and small and trying to find its feet (...). Even after a couple of years we haven't got our act together. We don't even have a space program, we just have a space agency." (INTERVIEW 9)
- ③ "Young and naive, and also vibrant. The energy has come from the government openly supporting the space sector and setting targets for a number of jobs created for the network of the space industry." (INTERVIEW 6)
- ④ "The sector is quite young in that we have only recently established our own space agency, and we haven't seen that before here. We've had amazing engineering and astronomy work happening in this country for much longer than the past few years, but we have only recently established our own space agency." (INTERVIEW 8)
- ⑤ "I would describe it as young, optimistic, diverse – not in a sort of disciplinary sense, rather in a diverse and demographic sense, and probably still trying to work out where it's going." (INTERVIEW 22)

At the same time, Australia's history in space activities played a major role in the different accounts we found about the sector pointing to the apparent paradox of its long tradition and its current "newness". As summarised by an interviewee in one phrase: "We were early – then we became late" (INTERVIEW 29). Others discussed these issues at length:

- ⑥ "A lot of people now know that Australia has a space agency and think that everything started in 2018 and there was nothing in Australia before that. So, you may not know that Australia was at the forefront of rocket launch in the 1950s, 60s and 70s, was the third nation to launch a satellite from within its own borders and was very heavily involved in international cooperative space activities." (INTERVIEW 4)
- ⑦ "We are a NewSpace power, but an Old Space power. Our history goes back to the days of the 50s and 60s at Woomera with the European Launcher Development Organisation testing Blue Streak missiles and Europa launch vehicles from that site, and when the European Space Agency was formed and went to French Guiana, Australia's space sector just died with it because the government of the day really didn't want to sustain the investment into the space sector at the time, which is a shame because we could have been one of the top global space powers alongside the US and the Soviet Union had we sustained that sector, but we didn't. So, everything went essentially quiet for many decades. In the 90s, there were efforts to restart things, the Australian Space Office and various other efforts on the part of the government. But they really went nowhere because government really wasn't that keen to think about investing serious money in space. And I think at the time also the Space 2.0 revolution had yet to really take off in terms of commercial space, and so space was still seen very much as incredibly expensive for the taxpayer – people still thought in terms of a government-funded space program, i.e., a NASA Down Under type arrangement." (INTERVIEW 25)
- ⑧ "The Australian space sector reaches back for almost the same amount of time as the US space sector did. So, around the 50s and 60s, it was Honeysuckle Creek tracking station that helped broadcast the first steps on the Moon. That's how old we are. And we are, I think, either the second or third country in the world to launch a satellite from our own soil. So, we started at the same time as everybody else. But the problem is that in the decades that followed, we didn't progress at the same rate as some of the giants like the US and the UK. So as a result, up until about 5 to 10 years ago, the Australian space sector was, to me, non-existent. That's probably because I didn't keep up with the news. But also, it just didn't, it didn't have a uniting body. And then some work was done in the past decade that led to the Australian Space Agency." (INTERVIEW 12)
- ⑨ "The key thing to notice is that in the 60s, the Australian space sector was a player internationally, had some phenomenal leadership and was participating. But in the decades that followed, other than the partnership with NASA, which was managed by CSIRO, Australia didn't participate to the full extent that it could have in the space sector. What we've seen in the last few years has been giving back and working really

hard for Australia to retake some position in this, and to catch up to where we have the capacity to do so. It's been an interesting history. And as you've spoken to many people, you would see that the will, the frustration, the desire for Australia to really participate has been such a driving force probably over the last decade, to establish the space agency was part of that, but an important part, but really wanted the country to move forward. So there's many players who have been working so hard for many, many years to make this happen." (INTERVIEW 20)

(10) "I'd say the strength of the space sector is that it has a tremendous amount of heritage, and a proud heritage. I'm sure some of your other respondents have talked about the fact that we were one of the third nations to launch a satellite (...). So, proud heritage there, and I think a long-term heritage and world-class capabilities in using remote sensing for various industries within the nation." (INTERVIEW 21)

(11) "Australia was one of the signatory nations on the International Geophysical Year – or the paperwork for it at least – back in the 50s when they announced that 1957 would be the International Geophysical Year, and so you then started having UN COPUOS being founded shortly thereafter. Australia was one of the founding members and was heavily involved in supporting the American space race activities. This continues today, heavily supporting European space activities in the 60s and 70s by hosting European Launch Development Organisation out at Woomera, Australian payloads going on various other people's satellites, Australia having launched its own satellite back on a surplus US rocket, being WRESAT, putting Australia, depending on how you count things, either the third or seventh nation in space (...). So yes, long history. We have been doing a lot of things in space over that time, but actually building the hardware, actually launching the hardware, actually going to space as Australians, as a nation, doing things in the national interest, national benefit, national pride, national prestige, not a lot recently." (INTERVIEW 18)

(12) "If you compare Australia to other countries, there's obviously the countries that came up through the space race era who have huge government investment in space infrastructure (...). In Australia, we actually have a history. We do have the Woomera stuff, we do have some work with space and satellites and building rockets and mucking around, but that got forgotten. And so from a policy standpoint there's been a gap between Old Space and NewSpace and as a result the narrative at the moment is very much to say, 'Well, we're new on the scene but we're going to make a splash and we're going to' – what do they call them – 'leapfrog technologies' and all of that stuff. So that's a difference and I think it means that the Australian space sector is quite self-sufficient. I think it means that there's not a huge amount of trust towards government, that they're going to make the right policies or that they will know what they're doing. There's the sense that it's really the Australian space sector themselves that has to fight for what they need and that, I think, is really different to other countries." (INTERVIEW 5)

Three interviewees who took the same starting point about Australia's long history in space drew a set of specific implications for the present and future from this unique historical path:

(13) "When they began in the late 50s, space activities in Australia were very much a ground-up decision rather than a top-down decision. And why I'm mentioning that is that there was no government buy-in to the idea of creating an Australian space program or any Australian space agency, and for that reason you have a long-term situation in Australia where a succession of governments for various reasons have decided not to buy in to developing an at-home space capability, especially after the shut-down of the Woomera Range. So that's very much a defining feature of Australia's involvement in space in the last 60 years. We had a very early, very significant position, but that was built up very much on the basis of work being done at the initiative of the Weapons Research Establishment and some of the universities and that, rather than an initiative, a decision, like the United States made a decision that it was going to participate in space activities, the Australian government never made that decision. Another defining feature is that when government has put money into space activities, particularly in the 80s when there was a bit of a push to develop a space industry and potentially a space agency, it's never been funded properly. So it's never been funded to achieve the goals that government set for it (...). We've had a succession of governments that have had what I'd call the 'freeloader mentality'. In other words if they can get somebody else to pay for it, that's fine. Until very recently, all the defence communications satellites we relied on were American owned. It's only in the last five or six years that the Defence Force has even had a partial ownership of a defence communications satellite. So we've been very much prepared to ride on the back of other space programs if we can utilise the capabilities of those programs without having to pay for them or, you know, without having to pay for the infrastructure initially (...). So the defining feature of the industry in Australia has been frustration, ongoing frustration that time and time again there have been attempts to get government to support the development of a space industry in Australia and either the government has simply refused to do so or they've underfunded the programs that they have put in place." (INTERVIEW 2)

(14) "The argument about Australia needing a civil space program is based on assertion, not rational analysis. It's based on the dream, and also it's based on the lie, that Australia once upon a time had an advanced space sector. This goes back to the so-called glory days of Woomera of the 1950s, but especially the 60s and maybe into the 70s. We provided real estate, we provided vast tracts of land for the UK to do two things: to develop nuclear weapons and to develop a method of delivering those nuclear weapons to Russia or, more correctly, to the Soviet Union in the context of the Cold War. Many UK scientists came out here. They actually stayed and became the core of what was the Long Range Weapons Research Establishment – now it's called Defence, Science & Technology Group. Yes, there were some individual Australian-only rockets designed and tested that flew and there were some spinoff technologies that were actually adopted and turned into products that the Australian Defence Force made use of. Eventually, many years later, one of those, the Nulka decoy that is used on ships, was sold to the USA, but for the rest it's been a very

expensive development path to put very small devices on some Australian defence assets. So the golden days of the past are really based on a misunderstanding and a misrepresentation of really what happened. Some people say very proudly that Australia was the third nation to launch a satellite that it made from sovereign territory. Now, whether it's third or fourth depends on whether you consider Algeria to have been part of France at the time that the French launched their first satellite, because it was launched from Algeria (...). We make a big song and dance about the fact that we were very early in this business, just conveniently ignoring the fact that it wasn't our rocket." (INTERVIEW 24)

- ¹⁵ "I think the narrative is a bit disjointed because there's no recent stories to talk about. I think it definitely plays a really strong role in the nation. But it's a lot better to talk about what it is we are doing, or what it is we did recently, then talking about what we did a long time ago, and what we are potentially going to do in the future." (INTERVIEW 13)

1.2. KEY ACTORS: WHO IS (IN) THE SECTOR?

Unanimously, and expectedly, there were two sets of actors that all interviewees included in their accounts of the sector: government – more specifically, the space agency – and industry. From there, others emerged in some statements but were absent in others. These included research institutions, universities, cooperative research centres, CSIRO, the non-profit sector (particularly conceived in terms of institutions involved in outreach), and defence. There was a noticeable and surprising absence of cultural institutions such as museums and science centres.

For some of the interviewees, their picture of the Australian space sector was immediately equated with a picture of the industry and market:

- ¹⁶ "Australia's got a very young space industry. And, in many cases, the activities that we are doing are very foundational because we have no one key agency or industry player that has set the space tempo up until now. It's all very, very young embryonic work. And so we are still talking about going to space, about launching big rockets, and where Australia now needs to go. We've got a space agency, we've had the International Astronautical Congress, we now need to do and do so from a national perspective, that's the next hurdle that we have to overcome." (INTERVIEW 13)
- ¹⁷ "That's how I would characterise the market: very strong on satcom, a little bit weak on manufacturing, a lot starting to change, and a government that's really only recently woken up to understand what the space opportunity is. They have, approximately, 90 NewSpace companies that grew from between 2015 and 2020 (...). It might be that some of those ninety start-ups have already failed, because most

start-ups will fail in any market, but I think only Silicon Valley per capita was pacing Australia for the number of space start-ups that were being born." (INTERVIEW 15)

- ¹⁸ "In Australia at the moment we are developing space ports, launch companies, satellite companies, payloads, ground stations, networking ground stations, software – the whole ecosystem. There's little start-ups. If you were to break down the space ecosystem into boxes, there are start-ups in every box in Australia (...). This high incidence of start-ups in space at the moment means that the current culture is quite dynamic. A lot of clever, motivated young people with ideas, pushing their ideas, making it happen, really quite nice." (INTERVIEW 1)

However, other interviewees stressed that the space sector is not synonymous with industry or market and were more specific regarding the diversity of actors that comprise it, invoking images of a layered onion and a network as frameworks to paint their picture, and emphasised that broader communities and publics also comprise the sector:

- ¹⁹ "The easiest way to describe it from my perspective – it's like an onion. There's an internal core layer, which is your government, legislative, and regulatory layer. Surrounding that, you have your industry layer, and even within the industry layer there are different levels. So, the first and closest levels of the government I would say would be your primes, like your Lockheed Martins, Airbus, Boeings and all those big companies that are worth millions of dollars. But as you trend outwards, those companies get smaller in terms of revenue or market share size and they become more like a start-up kind of area. Now, that's our second layer. The third layer is the space community, and I say the word 'community' versus 'industry' because it's very important to distinguish between the two because that also includes businesses and start-ups and supply chains, but also includes the scientists and the amateur astronomy communities, and the observatories, people who are enthusiastic about space in particular. And that word 'enthusiastic' again I define a bit more than just the general population, so someone who has invested time and money in space, someone who's gone and bought a telescope rather than someone who just looks up at the night sky. And the very last layer – well, the most diffuse layer of them all – is basically the general public. That's just basically the people who might actually catch a bit of the news at six o'clock at night about space but don't really get involved in space. They might see an image of Hubble and go 'Wow, that's really beautiful', but that's their interaction with space. So that's how I see the Australian space sector: it's basically segmented from a core moving outwards." (INTERVIEW 37)

- ²⁰ "I think the Australian space sector is small but it's vibrant. The people in the sector are very passionate about what they do. The people outside the Australian space sector are also very passionate about space. There's a strong sense of the inspirational aspects of space and the way that that's enacted by the various people who work in the field. I think if I step back from it, maybe you could say there's the academic aspect, there's the NewSpace civil start-ups and companies, you know, the corporate aspects, then there's probably the defence aspects which are more on the military side

of things. So often when we talk about the space sector in Australia we only talk about the commercial side, but that's only one aspect of it. Something that's interesting is the cross-pollination between all of those elements as well. So you have people in academia who will go and work for a company for a while, you'll have corporations doing research in parallel, you'll have civil space companies who are doing civil work, but they're also doing some military work as well. So, from that perspective, you could look at the Australian space sector as this highly interconnected web of relationships and of networks of understanding and entanglement." (INTERVIEW 5)

The roles of astronomy and defence as part of the space sector revealed some significant discrepancies between the interviewees. Regarding the first, particularly those with roles in scientific institutions stressed that astronomy is not part of the space sector as the latter has come to signify "industry" or "business":

- (21) "I guess the sector is everyone who is not astronomers. So literally everyone who works on any aspect of space, but excluding astronomy research, because I don't consider that space normally." (INTERVIEW 6)
- (22) "One interesting dichotomy has always been astronomy and space business. I've always thought it was a little strange that the Australian government has treated astronomy and space business almost kind of lumped together as if they're the same thing, whereas I tend to think they're pretty different, actually. And astronomers and people who send things into space traditionally haven't always been in the same group, but I think that is merging together a bit more. Obviously, there's a lot of connection within NASA for example where you've got the Hubble Space Telescope and that sort of stuff and in ESA, but in Australia the idea that people looking in telescopes up are going to have a lot in common with people who are building gadgets to launch into space, it hasn't always been clear to me. It seems to be coming together more, partly because the CSIRO has decided it wants to own this space and it's kind of dominated by astronomers, so they've started to get into making space objects driven by the astronomers, and I'm not really sure why." (INTERVIEW 28)
- (23) "I get asked this [who is in the sector] a lot. And, for me, space isn't a discipline. It's a place. And so it means that it's incredibly broad. You can use it as a platform to do things you're not able to see from the ground. But it's also a laboratory – you can do fundamental physics or experiments from there, because it offers you a pristine environment you couldn't get on the ground. More recently, it's a platform for the commercial sector. It's now part of a business. You can wrap space into a business plan now, which you could never have done 15 years ago. And that's opened up the whole commercial sector." (INTERVIEW 7)
- (24) "If we're talking about astronomy, that's a very different area, you're talking and looking very differently at space." (INTERVIEW 8)

An interviewee included astronomy in their account of the space sector precisely to draw a distinction between the experience and trajectory in that field and the newness of the space industry:

- (25) "I think in Australia, space is mostly astronomy-focused, and the astronomy industry and the space industry tend to be quite blurred. We're very successful in astronomy, but it's only nascent in what I would consider a proper space industry for the most part. So, the key actors that you asked about, the Australian Space Agency, of course, which is a big one now. Before that, CSIRO was the biggest one, and international meetings that should have had an agency most of the time were represented by CSIRO." (INTERVIEW 38)
- While astronomy is the the field that came to most of the interviewees' minds when discussing "space science", others highlighted the important role of the life sciences and medicine in the sector:
- (26) "We have a massive opportunity here to further our capabilities in space life sciences, which I haven't seen many other countries do. I've spoken to people who work at NASA and from other places who see Australia as a really good opportunity and an expertise in biomedical sciences that can be converted to space life sciences. I'd really like to see more of that being spoken about." (INTERVIEW 12)
- (27) "Australia might not be large enough to have a viable space sector now in competition with the US, UK, and Japan, but from my perspective, I think that we just have to choose our battles, and I think Australia is leading in several very specific focused areas. It is one of the leaders in quantum; it's one of the leaders in space medicine. That really came from left field – like I don't think it intended to become the leader in space medicine, but it happened. And where it has a leading skillset, I would think it likely that it could eventually take a leading position in producing value in missions going forward." (INTERVIEW 29)
- Regarding defence, for some, it is the first obvious actor that is part of the space sector and is crucial for the development of the Australian space industry:
- (28) "I think that's the obvious one in most countries for the biggest reason that space security, the securitisation of space and militarisation of space have been there since the absolute beginning of the Space Age. But we are also entering an age in the last sort of five to ten years where space is becoming the next big thing again for defence, so it is a very important actor. They also have the most money in Australia to put into developing capabilities. And then, I would say, the space industry is the next biggest sector or group of actors." (INTERVIEW 3)
- (29) "Defence, although it's not part of the agency, benefiting Australian defence and sovereign content is a big thing for getting Australian industry ahead in space, and that's what the space agency is about, so the two are closely entwined." (INTERVIEW 4)

The key position that the Australian Defence Force has to protect the country, according to two interviewees, cannot be separated from the country's international alliances:

- (30) "At the most basic level, defence is still a national activity, and so whilst you could have collective defence in space perhaps with a NATO-type structure or some sort of trilateral arrangement here in the Indo-Pacific between Australia, Japan and the United States, I think at the end of the day critical defence capabilities in space will be run by national forces." (INTERVIEW 25)
- (31) "There's nothing that Australia would contemplate doing in space from a military perspective without deep consultation not just with the Five Eyes community but with an extended group of nations as well, like-minded nations – including Germany, France, and Japan – but the entire world has this fundamental dependence now on secure and assured access to some space services." (INTERVIEW 24)

A key move considering the creation of a national space industry refers to the Australian Defence Department "buying Australian":

- (32) "I think the feeling that domestic or quote-unquote "sovereign content" is really important has been spreading from the Space Agency to the Defence Department." (interview 4)
- (33) "If you accept my argument that the driver for what Australia does in space is essentially a national security driver and nothing much else, then the sector will grow only consistent with such investments as the Commonwealth is prepared to make in national security space (...). There is an absolute distinction between means and ends and a disconnect. For the primes, who of course are chasing the big Defence dollars, the primes see any local capability as means to an end. They know that to meet government policy, there has to be a certain amount of Australian industry involvement. If we're lucky, that'll be 30 per cent of the spend on the big projects. Most of the money on the big projects – and there are three big projects at the moment – will be spent overseas by Defence, and Defence won't be apologetic about that because Defence ultimately is about military capability; it's not about jobs for Australians. If jobs are created as a by-product that's great, and there is an expectation in government that there will be some Defence dollars spent locally." (INTERVIEW 24)

Other interviewees explicitly drew a distinction between defence and the space sector. This distinction is key to understanding the difference between Australia "doing space" and Australia "having a civil space program":

- (34) "And I didn't include any defence things in that [characterisation of the space sector] because I consider that a different thing altogether, so this is just about a civil space agency because defence is completely different people and budgets, not related to the civil ones that I would emphasise today." (INTERVIEW 38)

(35) "The big unresolved elephant in the room – well, it's not unresolved, really, it is resolved – is the primacy of defence. Defence basically is the dominant force in the Australian space industry and the discussions that we have all the time are around 'how are we going to integrate defence and civil stuff?' and it's always seen as incredibly problematic. And yet most other countries don't seem to have these issues. The question is what exactly is it to have a civil Australian space industry, and I think that's really difficult to define as long as everything we do is framed in those very Howard-era terms, because there is no room in that mentality for inspiration or aspiration or exploratory things (...). I think in the way this is framed it's actually a struggle to define or allow something that might – like we're allowed to be big players in these things. We're not allowed to lead in these things, so I think in answer to that, one of the things about the emergence of or having some kind of civil program, the problem with that is defence, the problem is how that is defined against defence." (INTERVIEW 4)

The issue of skills and expertise in this heterogeneous scenario is very significant, and there were several perspectives about it, some of which outlined an area of contention pointing to the uneven distribution of expertise across the actors in the space sector and the agency in particular:

(36) "The space sector in Australia is quite scattered in the sense that it very much feels to me like there's lots of pockets of quite deep expertise, actually. So we've got people over here doing something really exciting and worthy and very globally competitive, contributing to massive international science projects or being a critical part of the global logistical supply chain and things like that, but until very recently they haven't really known of the existence of all the other people doing very similar things, and that seems to be changing quite quickly with the creation of the space agency (...). Until recently all these pockets have operated very much in isolation, and it's only just recently that they've started to kind of link up and make these cross-connections." (INTERVIEW 31)

(37) "Australia is very unusual in that we have a great deal of skills across virtually every aspect of the space industry, and yet Australia up until recently did not have its own space program or space agency. In fact, you could argue that it still doesn't really have a space program – it has a space agency that's trying to nurture space in Australia (...). Australian organisations report skills in virtually every single one of the approximately 300 skills categories. And, interestingly, there are skills shortages in a vast bulk of those areas and anticipated skill requirements in most of those areas. The Australian space industry is growing, it's multidisciplined, multifaceted, yet there is a need for more of those skills. There are deep skills in a lot of areas, particularly communications, Earth observation, use of data from space, rather than with the upstream side of space, which is the manufacture of spacecraft or launch vehicles, although of course Australia is starting to move into that area. The industry is evolving. It's the dynamics of change such that Australia now can play more of a role in manufacturing small spacecraft and small launch

vehicles, and the commercialisation of the industry has changed the dynamics very significantly, so Australia has the ability to play in more areas than it did in the past.” (INTERVIEW 26)

Amongst those who considered astronomers as part of the space sector, that inclusion allowed them to highlight trajectory and expertise precisely as a major divergence within the sector:

(38) “I would characterise the space sector as deeply uneven in maturity (...). There is a high level of maturity in the space science sector in Australia. Many prominent space scientists who compete on teams and are part of major joint initiatives have a really high level of maturity when you look at the work that’s going into the Square Kilometre Array that has been decades in the making with partnerships. In the national security sector, I would say it is substantially less mature because it’s been a challenge. In Australia there’s a strong desire to send members of the Australian Defence Force to participate in activities with the Five Eyes, but then they come home and they get rotated into a non-space job, so it somewhat diffuses that space knowledge. In fact, the Australian Defence Force recognises that and are in the process of trying to figure out how they should be organised better going on. Having said that, because of that partnership and the sharing, for example, there’s a major telescope for tracking satellites to avoid collisions, which is a primary responsibility of the United States Air Force, now the Space Force, and it was recently relocated to Australia and so there are people who really are familiar. It’s substantially less mature, though, than the space science community. And then I would characterise – and I guess I should say that CSIRO, of course, going back on the space side has been collaborating with NASA but mostly – I don’t know how to describe this any other way – as a contractor. They are operating the Deep Space Network telescope at Canberra – they have a similar relationship with the European Space Agency – and what’s interesting about it is all this fascinating data flows down to Australia and in some cases Australia has access to it. But mostly it’s like, ‘Thanks very much for your radar and your antenna. We’ll take our data now. Appreciate your help.’ So that relationship is somewhere again maybe less mature than the science community, but certainly there are people who are very knowledgeable about running communications systems. Then that brings us to the commercial sector, and you can’t talk about the commercial sector without talking about the civil because they have been the primary interface. A lack of coherence in the Australian government and a deep misunderstanding on both sides about what the expectations are have led to a lot of tension and pressure, such that when the Australian Space Agency was announced, it was like watching a volcano erupt because the industry was so excited; they were like, ‘Finally!’ Now, they don’t really actually know what it’s supposed to look like either; there’s a lot of confusion on that subject. There were a lot of people who were like, ‘You’re going to be writing big cheques to us just like NASA does to its commercial community. Are you going to build the next SpaceX in Australia?’ So, it’s interesting to watch. I think there’s a little bit of the honeymoon is over and now we’re getting to the point where people are like, ‘You’re telling us all this stuff but nobody’s giving us any money.’” (INTERVIEW 39)

Within industry, however, there were also distinctions about trajectories and expertise outlined by another interviewee:

- (39) “I would say there is a small section of the industry that is very highly experienced in the geostationary satellite area (...). The way that I see it is a small core of highly experienced space professionals, some of whom are blowing like dandelions and seeding in other space companies.” (INTERVIEW 28)
- (40) “I’ve spoken to people from a university who are talking about developing strategies to help support Aboriginal people to connect with renewable energy. And I said, ‘Well, Aboriginal people have been in the industry for over 15 years, and they’ve been leading that – you could learn a lot from them.’ (...) There is a need for developing apprenticeships for Aboriginal people in other areas. Traditionally, there is a view that training happens in the workplace, and people’s self-esteem grows and develops. But it’s going to be a challenge to move into the higher qualifications. For instance, there’s the opportunity to go into training in the geospatial analysis area. That would enable people who live on Country and in remote communities to get employment in high-value areas. One of the big advantages we see is in the connectivity space. Given the challenges for living in remote communities, there is a long history in developing solutions for water, renewable energy, housing, on the physical side. But with increased connectivity, there’s the opportunity for people living in remote communities to show leadership in the adoption of e-health and e-education, but more importantly, to establish businesses and undertake jobs, like COVID has proven that people can work from anywhere. So, the rollout of increased connectivity will give people the opportunity to participate in high-value jobs.” (INTERVIEW 19)
- (41) “I have many feelings about this. One is the view that I would like to champion to the outside world that we, as an Australian emerging space sector, have a great tradition and history of being involved with space; we’ve been a main actor from very early on. We have played an essential services role in the past and I think what our new evolution is harnessing emerging capabilities to expand our platform and to undertake business from Australia out to the world, rather than cooperative arrangements to service the rest of the world. More internally, if I’m speaking to people who are already established space actors, I would probably be a little bit more blunt and say that there’s definitely a big divide between NewSpace actors and established space actors, and there is a great potential at the moment for a whole range of new business, but that potential is being taken up by literally people new to business and new to space business rather than established actors coming in or established industries translating across to take on those domains. So, I see that at the moment what is occurring is a very superficial crust of activity happening with a bit of a gap between what we potentially have as a great strength and resource to tap into and what really exists.” (INTERVIEW 32)
- (42) “More recently, now that costs have been coming down for small satellites, cube satellites and the like, there’s a lot of commercial push, and some of that commercial push is also supporting governmental goals. So we are both old and young in that

we've had people involved from the beginning still involved in supporting the big, flashy NASA missions and involved in supporting ESA ground stations, involved in applying what they learned at Australia's world-class universities in the agencies and the research institutions of other nations building instruments and leading sections of missions, but not a whole lot coming from Australia itself until recently, and a lot of that being commercially driven." (INTERVIEW 18)

(43) "I think, in general, space in Australia is an incredibly open and diverse community. Being distant from the US and the centres of real power in terms of being a spacefaring outlier – technically a spacefaring nation, but no one would really take that very seriously – has actually been to Australia's benefit because we've been able to focus on and develop creative thinking and leadership in much less mainstream fields like space archaeology and space law, space ethics." (INTERVIEW 30)

(44) "I think it would be good to provide opportunities for students to get training overseas, given that many students cannot train under the current space agency. In space medicine people have to go overseas to a more established space sector, like the US or the UK, to get training because we don't have any here. So, I would like to see more partnerships and opportunities globally." (INTERVIEW 12)

(45) "For people who are becoming skilled as aerospace engineers and professors the path is to go overseas for around five years to the UK or the US or another spacefaring country. Then if Australia is lucky they come back, and if it's less so then perhaps they don't. But in baby steps, I think the country has been encouraging its aerospace industries." (INTERVIEW 29)

1.3. FRAMEWORKS FOR VALUE ASSESSMENT

1.3.1. Sovereign: Australia's Particularities as a Country

Part of the conversation about the Australian space sector is predictably related to how the interviewees characterised the country as a whole and its unique advantages and capabilities to "do space". Amongst these advantages and capabilities there were three salient ones: geography, remote asset management capabilities, and Australia's international reputation and stance.

Some interviewees mentioned that a key driver to Australia's "space journey" was indeed the country's geography regarding location, conditions, and geopolitical setting:

(46) "Australia's expanse and its physical location on Earth mean that it must be involved in the politics of the Indo-Pacific region. Possibly more important [is] that geography itself is the contest of ideas between the international rules-based order, whatever it is,

and what an emerging China thinks ought to be the order of the world. The Chinese view is divergent from the global order that the West invented at the end of World War II. The tension between these worldviews will become more important over the next twenty or thirty years and Australia is going to be right in the thick of it." (INTERVIEW 24)

(47) "We have a wonderful advantage geographically. And that was always going to be an important place for us to start regenerating, and that's happening. We are getting significant reinvestment in Australia for observation now for launch, taking advantage of our geographic location. But Australia has so much more to offer. And so now we're starting to see the emergence of small companies and very far probably one of the fastest-growing space, small companies, sectors." (INTERVIEW 20)

More specifically, there are conditions that Australia has had to overcome and for which the country had to develop infrastructure in remote asset management and skills, placing it in a unique position in the world:

(48) "We are a big, safe, politically stable island with lots of water around us in the Southern Hemisphere. It's a single place where you might be able to do loads of remote sensing data." (INTERVIEW 1)

(49) "There are areas where we are good and have a track record on the ground. The next step is to prove that it's exportable, and the best example is remote operation and robotics (...). 'We're drilling in Pilbara. We could be drilling on the Moon. No difference to us,' and that's where the penny drops and you realise, 'OK, these guys know what they are doing.' They were drilling in environments that are far away, harsh, cold, dark, hot, difficult to access, really like space, and they are doing operations in a safe and professional manner all across the board. And when you see industrial expertise like that, you're like, 'OK, we are now ready to take the next step, the next step and export that to space'. (INTERVIEW 23)

(50) "There are a lot of capabilities in a huge territory, a lot of communication capabilities, downstream capabilities, mining and energy. I mean this is a country that fights with tyranny of distances so uses technologies to overcome barriers, and that's cool. It's very cool because it means that the space industry – think about Europe – in Europe the space technology in a sense there's a lot of science but the application of space technology is relevant but less relevant. Like if you think Europe is all a small continent, all close to each other, connectivities everywhere, you look at space if you really need to, but here you look at space because space covers what is uncovered everywhere, like whether our industries, in agriculture and mining and this and that unconnected, huge. So it's a country that has got the eyes up and needs space technology to solve a lot of problems. So I think that's good because those are customers for space applications, so it's not a surprise that the best start-ups in comms and automation come from here." (INTERVIEW 17)

⁵¹ "I think there is a recognition that Australia and Australian companies and organisations can play a role in a lot of areas. I think there are certain people who recognise that off-Earth resources are a logical significant opportunity for Australia. I think there is a recognition that Australian geography lends itself quite clearly to greater use and adaptation of communications and satellite navigation." (INTERVIEW 26)

⁵² "I think we've still got a really strong skill set, and a really compelling advantage in our use of ground stations to both track space missions but also to observe the space domain. So Australia's really leading in a lot of the work that informs space situational awareness. I think we really nicely use some of our other skill sets, including our broad geography and a strong research base to really support some of our other strengths and those are in position, navigation and timing. But we're also starting to see more of a presence of a launch sector and manufacturing rockets and actually providing access to space as well, and I think that nicely ties into our heritage with the Woomera Test Range as well." (INTERVIEW 27)

Next to these advantages, some interviewees pointed to deficiencies in the country's manufacturing capabilities:

⁵³ "We are historically inefficient in manufacturing. If you look at manufacturing in the past, the major manufacturing industries have all died in Australia. We just need to sit down and rethink who we are and what we are, and I think space is not the only thing, but I think space could be a useful metaphor for the broader idea about who we are, where do we sit, what's important to us, and I don't think many people think of it that way. Our Indigenous people do, of course, but I'm not sure our broader society does." (INTERVIEW 3)

⁵⁴ "I think Australia as a nation needs to start looking more at local manufacturing. There has been a problem where I think we've had about 600 satellites invested for manufacture over the last three years and that's mostly VC funding, a little bit of Defence but mostly VC funding. So if you look at all of those 600 satellites, 95 per cent of them have been slated for manufacture overseas. That's a problem. How do you plan to compete as a \$12 billion export market if you're not building products? If your metric is 'jobs and growth', you're using the wrong metric – you need to use 'product, flight, heritage' as a metric for success in this industry, and that's I think the one thing that they could be doing better. I do think they're aware of it, but I'm not quite sure yet how it's going to work. It's still early days though." (INTERVIEW 15)

Regarding collaboration and Australia's global reputation, the international community plays a role drawing the contours of the space sector in Australia as it shapes expectations, the understanding of strategic areas of development, and criteria of assessment:

⁵⁵ "[After the announcement of the agency] The international community was 'We're glad, we're glad you're finally at this party.' So they have embraced Australia, and the collaboration has been amazing (...). When we asked the nation, and when

we asked internationally, what do you see coming from Australia? The message we had back consistently from other nations is 'you guys don't lead the world on many things, but you lead the world and manage remote assets and robotics, but we're not using that in space.' (...) So the interest we get from the international community is this: how do we leverage this capability into space? And, and it also means, that's the biggest industry that we have, so it also has the capacity to invest. So I think there's some pragmatism around that. I think that tension, looking back perhaps 10 years from now, when we start to see Australian robotics on the Moon, on Mars, etcetera, I think we'll see them as space robotics. So the fact that it came from the resource industry, I think that tension will dissipate with time and with success." (INTERVIEW 20)

⁵⁶ "When I go to the United States, when I talk to my European friends, they [the agency] have done a very good job changing Australia's brand as a place which is not a serious actor to a place that people at the very least need to pay attention to in terms of possibility for investment, in terms of possibly even a nation to work with." (INTERVIEW 15)

⁵⁷ "The space sector has been strongly internationally dependent, but is now trying to become more sovereign. It's an industry that's increasingly looking at how it is entangled with other industries in Australia as well. So it's an outward looking industry in the sense that takes the view that space is an enabler for a whole bunch of other industries. There is not one fixed view on how the industry is going to develop this, but it's pretty open in terms of where development goes at this point, I think." (INTERVIEW 33)

This international reputation and stance results in a sense of geopolitical safety, which has also entailed a significant reliance on international partners:

⁵⁸ "Historically, we've just sat on the ground and listened to other people's satellites. The culture in Australian space has been freeloading and, you know, it really is time that we started thinking for ourselves and doing stuff for ourselves (...). So I think the historical culture's one thing, but this high incidence of start-ups in space at the moment means that the current culture is quite dynamic." (INTERVIEW 1)

⁵⁹ "Our industry is sort of now very focused on breaking into international supply chains, working on CubeSats and smallsats and having some kind of fancy high-end, inspirational mission (...). We are a small player with a lot of potential, but the main problem at the moment is that we're tying ourselves too strongly to the coat strings of others. Even though our rhetoric is all about how we're going to be doing it for ourselves now, we're still highly dependent on international partners." (INTERVIEW 4)

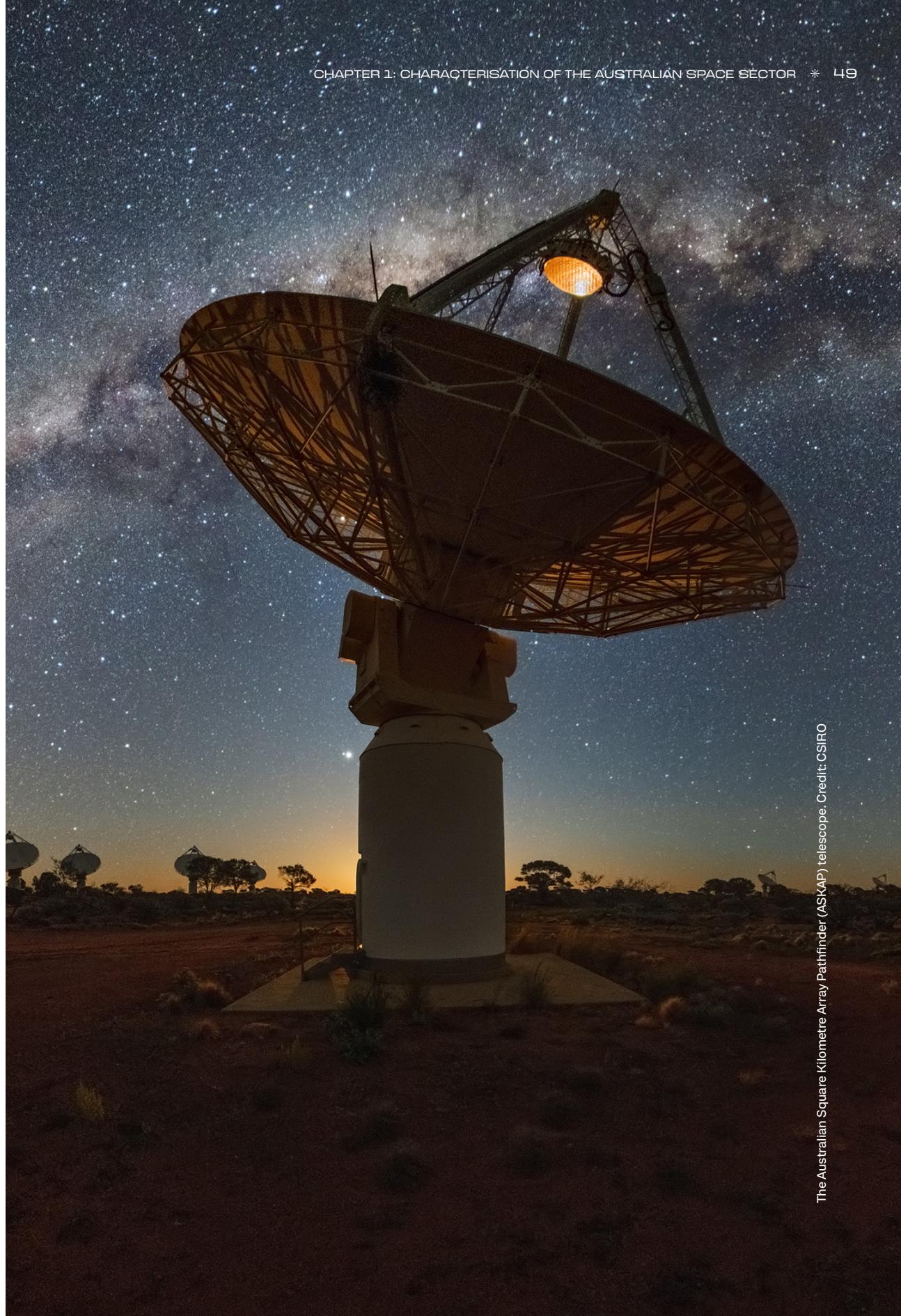
⁶⁰ "There have been a few times when we've developed a technology here. And I'm thinking of a particular technology we developed in the late 80s, which was very advanced at the time – large photon counting array for use in ultraviolet telescopes – and we actually more or less proactively went looking for an opportunity to use this,

so we took an initiative insofar as we took our technology to that particular program. In the end it got cancelled, but ultimately we did develop a test version of the telescope that was full load on the space shuttle, but again it never went any further because although we were going out there looking for a customer, we wanted to hang it onto somebody else's project rather than go the whole hog and develop our own satellite here. You get some similar things in the 80s and into the 90s with COSSA, the CSIRO Office of Space Science and Applications, which again wanted to get Australia involved in remote sensing and particularly ultimately have Australia develop its own remote sensing satellite." (INTERVIEW 2)

1.3.2. Commercial: Australia Is “Catching Up” in an Industry-Centred and Commercially Focused Manner

The expression “catching up” emerged in many responses during our interviews pointing to the fact that, after being an “early player”, Australia’s engagement with space went through a lagging phase until recently, and now there is a new environment where space is no longer the exclusive province of nation-states.

- ⑥1 “We are coming from behind and the sense of, you know, we've got countries who are much better funded and have been going to space and operating in space for way longer than we have.” (INTERVIEW 7)
- ⑥2 “We don't have the big US-style base prime, but we have a really rich and vibrant start-up community that works really closely with the academics who are in deep technology. A lot of the start-ups you see are spin-outs from various universities, and I think that contributes and drives the government's message and ability to try and triple the space sector. We also don't have this sort of large government-led space pedigree that you see in parts of Europe and most of North America, so it does drive a different dynamic in Australia and I think partly because of that our sector's surprisingly youthful and innovative. I think it seems to be attracting a cohort of younger leaders, more agile thinking, that is creating quite a different dynamic than what you get in other more mature sectors, say in mining or defence or culture, industrial manufacturing.” (INTERVIEW 27)
- ⑥3 “Australia is the country with perhaps the largest number of space start-ups per capita in the world (...). The Space Industry Association of Australia has been around for a long time, but has massively grown in membership in the last two years; it went from less than 100 to 700 members. And I think the companies that have been around for a while are actually taking on a bit of a mentorship role for younger companies, so although there's commercial competition, there's also really a sense that they'll lift each other up by making the Australian space industry visible and big.” (INTERVIEW 3)
- ⑥4 “This is a rapidly growing sector in the last three years —well, actually, I should say since 2015.” (INTERVIEW 15)



The Australian Square Kilometre Array Pathfinder (ASKAP) telescope. Credit: CSIRO

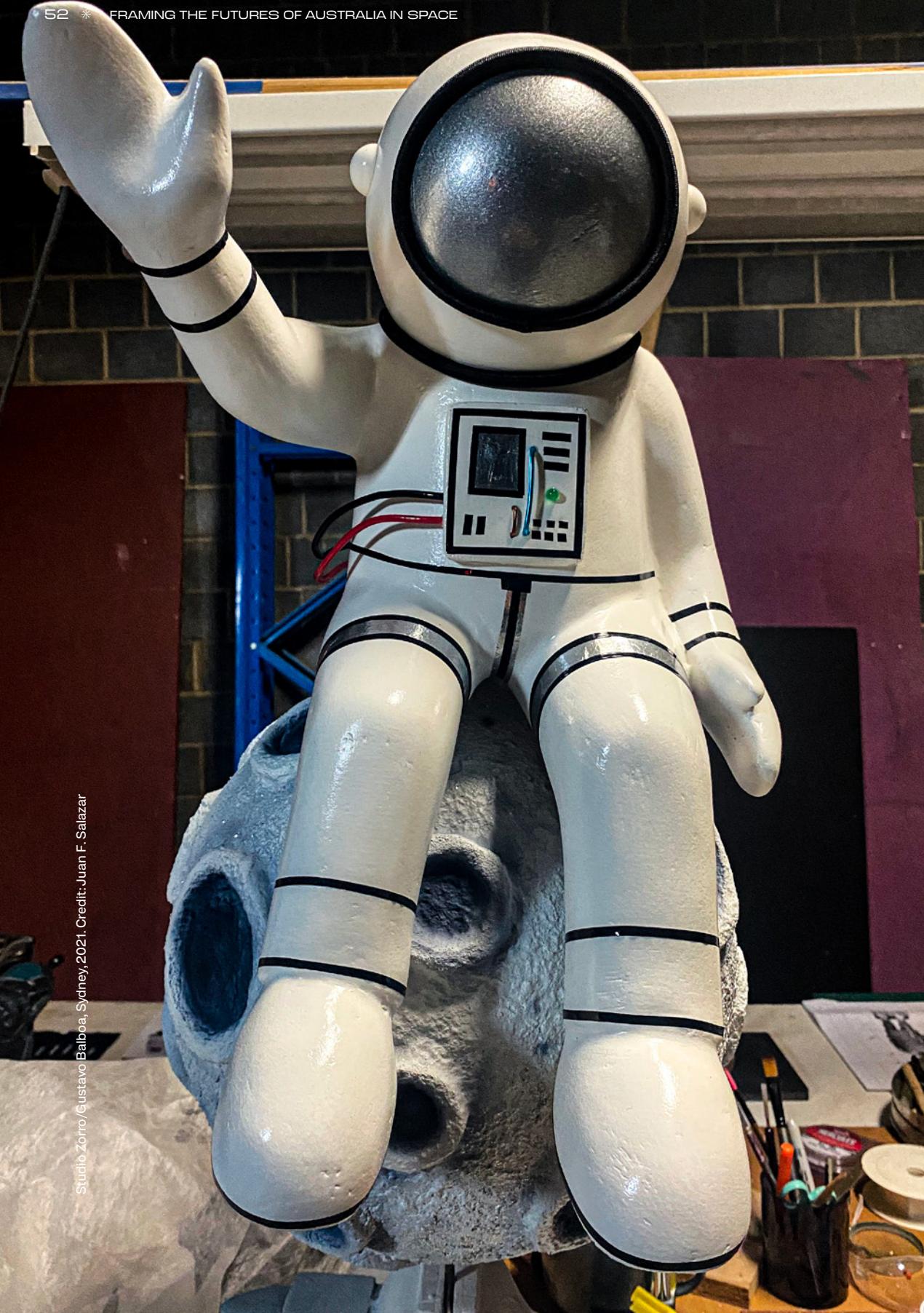
- (65)** “A common idea is that ‘if you’re starting a space agency now, the Australian industry must be miles behind everyone else’, and in many ways that’s true. But, on the other hand, the number of start-ups in the Australian space sector is higher than anywhere else in the world as a proportion of population or something.” (INTERVIEW 1)
- (66)** “And we’re really trying to stimulate that [the emergence of small companies and one of the fastest-growing space sectors]. And to use that to catch up quite fast. We don’t have a developed satellite manufacturing capability. We don’t have a launch yet, we don’t have a national program yet. So we really are in our infancy. But the early signs of growth and transformation. Also, the early signs are starting to come.” (INTERVIEW 20)
- (67)** “It’s still very early days. If someone was to ask me why Australia is interested in developing a space sector now, I’d frame it in the context that globally space has really shifted over the last decade or so, in particular with the emergence of new technologies. With smartphones we can now develop smaller satellites, we’re happy to put larger constellations and satellites into lower orbits, we’ve got more frequent opportunities to fly to space for cheaper prices because of advances in manufacturing and 3D printing of additive manufacture of rocket engines and things like this. So that has presented an opportunity for a lot of nations, not just Australia, to increase their space capabilities. So the way that I’d put it is that space isn’t special just because of the rockets and satellites, it’s because space gives us new perspectives, literally and figuratively, to solve some of our greatest challenges across the board. Whether it’s a more traditional kind of moon shot kind of idea of being a pharmaceutical start-up that wants to manufacture new drugs in microgravity or 3D printing synthetic organs and things like this, using the International Space Station, these things are all possible now, and so this is one of the big drivers for Australia, saying ‘We want to get into this area because we know that for our economic security.’” (INTERVIEW 16)
- (68)** “What’s changing today? NewSpace. Seventy nations. For Australia, there’s an opportunity to enter the global market. And I think the model would be the UK. The UK is going to 10 percent; they’ve got 4 percent global market. I think Australia can make a foray into NewSpace. But in some of the niche areas. So, the main players in the Australian ecosystem, as I see it today, you still have Defence as a very large player. Typically sending its money offshore, not much of it comes back to Australia. How to change that model? You’ve got the new Civil Space Strategy under the Australian Space Agency, which is trying to do everything that NASA does on a budget that is a thousandth of its size. So they’ve got a very hard challenge. And they’re sprinkling a lot of the money around what little money they do have. And then I think the other players are academia, with some interesting areas. And then we have some of the larger industries as well. So, even companies like Boeing and Northrop are still keen to play in NewSpace. And sometimes even look to Australia to disrupt themselves because they know they can’t do it in their own country. And then a variety of other agencies. Around those defence and civil agencies of the federal government, you’ve also got the states buying for a share. So a lot of new players. And I think that the difference is that 10 years ago, 95 percent of these actors wouldn’t have existed.” (INTERVIEW 36)

- (69)** “This is a really exciting time to be in the sector. Momentum is really high. We’re seeing the highest levels of conventional investment, we’re seeing job creation, we’re seeing that space is approved for the government.” (INTERVIEW 21)

1.3.3. An Elusive Shared Vision

Given the diversity portrayed so far a “national vision” of space is still an elusive horizon, which is a problem for some and an opportunity for broader discussions for others:

- (70)** “I think the space sector is a bit muddled and jumbled at the moment, so it needs to get more focused and perhaps a bit more disciplined in terms of the leadership’s clarity. So, everyone wants a piece of it at the moment, but that’s not going to really help us achieve something big.” (INTERVIEW 6)
- (71)** “I spent years in the space community, but what I still see as people started trying to do stuff in space is these little one-man bands doing their own thing, trying to get government to support them and saying they should have a space agency to support them. So, there’s no coherency that I can see in a single plan, a single program, that will bring all these elements together (...). I’m certain, unless the new head of the space agency says, ‘Well, we need a plan’, just like the astronomers. They get an enormous amount of money from the government, and the reason is they do a decadal plan that is very focused. They do all their arguments between themselves and then they present this picture of what needs doing to the government and they engage with the public, they do a lot of education and outreach outside of the space area and it’s very successful, very strong. We’ve got one of the strongest astronomy communities in the world – that’s what we need to emulate in space.” (INTERVIEW 9)
- (72)** “We don’t have a uniform view of space anywhere amongst civil society, amongst national governments, amongst the broader communities, and the international community. Different people have different perspectives of space and therefore the danger is that we only hear the loudest voices in the room, military and economic voices that are strong here in Australia. They are the loudest voices, but there are so many other voices, so I don’t think we will ever have a uniform perspective on space. The best we can hope for is to have a broad discussion, an open discussion and hearing all those voices. Still, you know, you have to decide what you’re going to do or not do, and I think that’s the nature of space: it’s different things to different people. But we shouldn’t be ignoring the different perspectives and that’s not a recipe for inertia (...). I think it would be terrible if we all had one view on space because that would so much disrespect the complexity and multifaceted nature of what space is, but it does make the debates more difficult and complex.” (INTERVIEW 3)
- (73)** “Space appeals to people at so many different levels. I mean it’s economic, it’s scientific, it’s spiritual, it’s that quest for the unknown, to explore. You know, Australians do have a frontier mentality – that’s a very clear part of our history – and our willingness to go out into hostile territories. We do have very strong scientific capabilities, skills, people with very strong scientific rigour, and we do have a thirst for knowledge,



Studio Zorro/Gustavo Balboa, Sydney, 2021. Credit: Juan F. Salazar

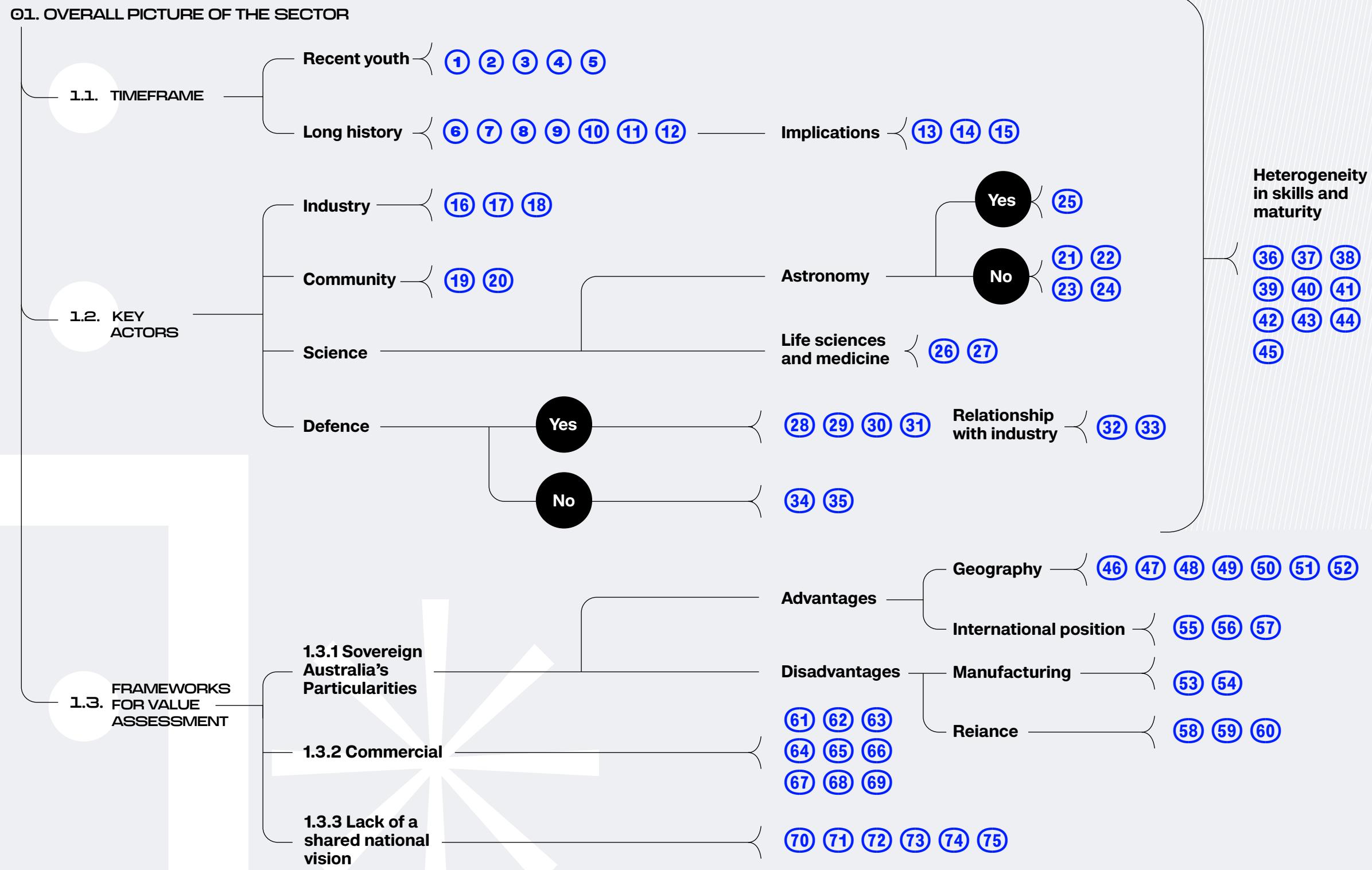
we have a quest for learning and exploring. I do think that fits, you know, that space fits into that very much, so, to me, space has all those elements. There are the legal, there are the spiritual, all these different dimensions of what it is to be human and to be part of a society and be part of a community. I think Australians fit into that and I think we have a sensitivity to some of those different dimensions.” (INTERVIEW 26)

(74)

“Communal, contested, and commercial. I like those three words because I think it’s like so much of what’s going on in our planet at the moment. Opposite things are happening at the same time and are co-existing in a way that you struggle to explain. How could it be that we could be communal in our approach to the Moon and at the same time fighting tooth and nail for the resources that might be unlocked? And I think the answer is we will. There will be ferocious competition for resources and real friendship and camaraderie around the safety in space. So, you’re going to have these really odd events where both these things seem to be happening at the same time in the same space, in the same location. But I think that is true of Earth as well as space. It strikes me that particularly the ethics of space are going to be very difficult to navigate or predict for all those reasons.” (INTERVIEW 27)

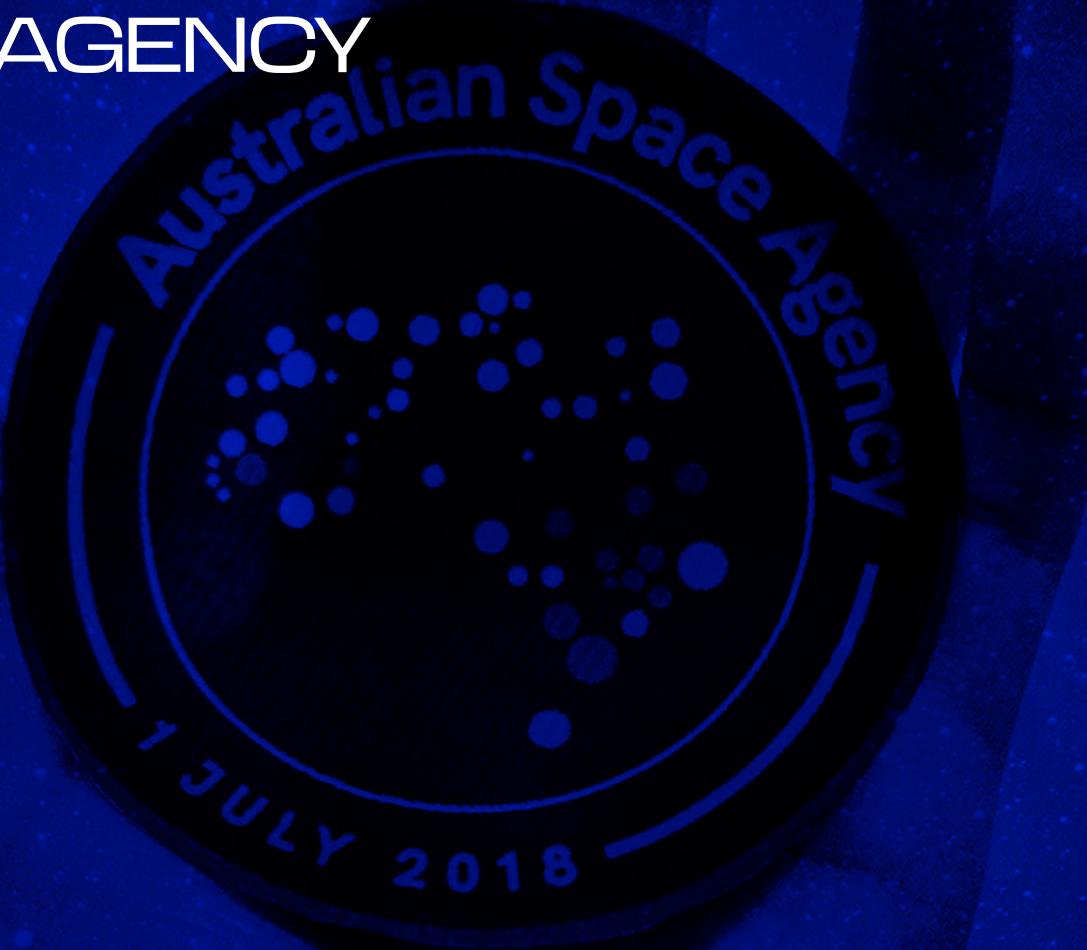
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“Narratives in Australia are very much in conflict with each other, I think, and it’s going to be really, really challenging to reconcile these different voices. I kind of feel like the space sector now is facing the same challenges that sort of industry and climate lobbyists have been facing for the past 20 years. On the one hand, you’ve got all this public spending and this private economic activity kind of building this industry that has real tangible utility and benefit to the public and at the same time you’ve got this cohort of people who are really saying, ‘Hey, hey, we really need to be careful here. We need to slow down, we need to think about what the implications are, the impacts, what’s the cost benefit here?’ I think that in climate change those dissenting voices have been very loud and a very big part of the public conversation for a very long time, and in space they’re really not. When you look at the broader public as a whole, and young people in particular, they’re much more receptive to those arguments.” (INTERVIEW 31)



CHAPTER 2: THE AUSTRALIAN SPACE AGENCY

Celebrate the launch of the Australian Space Agency in 2018 with the inaugural Australian Space Agency Mission Patch. Credit: composition Pablo Ruiz T.



The Australian Space Agency (ASA) was launched in July 2018 and is a non-statutory, whole-of-government entity located within the Department of Industry, Science, Energy and Resources (DISER) as a separately branded function. The ASA is the front door for Australia's international engagement on civil space and operates as the national priority-setting mechanism for the civil space sector.^{[1][2]}

During the 18 months of development of this *Framing the Futures of Australia in Space* report, the Australian Space Agency released three roadmaps, all of which bring together ideas and expertise from members across Australian industries and the space sector to outline aspects of Australia's future role in space exploration. These roadmaps, *Communication Technologies and Services*, *Earth Observation from Space*, and *Robotics and Automation on Earth and in Space*, are the first in a series of seven the Agency is developing to address its national civil space priority areas. The roadmaps envision the circulation and standardisation of technologies and expertises in the space industries. They articulate anticipatory insights framing innovation in the Australian space sector. They explicitly sketch programs for the future that stress the continuation and acceleration of existing economic and production practices. Through their programmatic statements, they shape a type of public imagination about space futures.

This chapter zooms in on a second key area of interest: the perspectives held by the interviewees about the Australian Space Agency. In alignment with the overall sense of a growing space sector, there was a sense of belatedness in the creation of a national space agency and diverging impressions about these first years of operation. There was convergence amongst our interviewees about the industry-focused nature of its mandate, and the fact that – despite common perceptions about space agencies fostered by NASA's model – the Australian agency does not have a scientific mission. Regarding the achievements of the agency,

its very existence was almost unanimously praised as providing the main “front door” for the country in space activities.

Next to these general considerations about the agency, its staff, and their achievements in these first years of operation, three major topics emerged in the question of areas in which the agency still has to deliver. Each one of these topics sheds light on frameworks of valuation that we propose to map the sector. First, the agency’s dual role of promoting and regulating industry (sovereign and commercial). Second, the role of science and outreach in the agency (inquisitive). And, third, the role that the agency has set for Australia in lunar exploration, which brings to the fore the complex intersection of perspectives, mobilising each one of the four frameworks of valuation.

Overall, these critical topics give a picture of the agency operating between all these stakeholder groups as a boundary organisation. Drawing on the work of Gustafsson and Lidskog (2018) to label the ASA a boundary organisation has a performative effect, as it might shape the agency’s identity, providing legitimacy and stabilising the interactions between it and other organisations, especially with the commercial start-up sector, defence, and space sciences.

2.1. TIMEFRAME: "AT LONG LAST!"

If there is a common denominator in perspectives about the Australian space sector it is the sense of needing to “catch up” with the rest of the world regarding space activities. In this context, having a national agency was a crucial step, and this is how the interviewees described the political sways that made it difficult to have an agency in the past:

- (76) “We have been overlooked as a nation of space capability by people internationally because of the lack of a space agency in the past, so people simply did not equate Australia and space in the same sentence.” (INTERVIEW 27)
- (77) “I think probably the Australian space sector, space industry, is quite unique, particularly for a western country of our type. We haven’t had a space agency by name. We’ve had a few other things which looked like agencies in the past but they’ve come and gone and they’ve been victims of various political types of – both political in the sense of, you know, politicians but also political machinations due to other agencies like Defence and CSIRO and whatever. So the fact that an agency has come through at this time gives us a bit of an interest – it’s a bit of an interesting environment.” (INTERVIEW 1)

(78) “For the best part of 30 years, I’ve watched a lot of ebbs and flows, and when the Australian Space Research Program came into existence there was a real outpouring of ideas and people finally thought there was going to be some money on the table. So, all of these concepts and ideas and activities and projects all bubbled up and there was a spurt of activity for about four years or so when that program was in place. And then, of course, the money stopped and there was an interregnum before the agency was created. So basically everybody stopped again or at least publicly and things went back off into the non-space grant arena or the commercial funding arena, so it wasn’t quite as publicly visible. Then, once the agency came around again, then a myriad of things started emerging.” (INTERVIEW 26)

(79) “It wasn’t a question of, should we or shouldn’t we have a space agency, and there wasn’t really an opposition. It was more, ‘What are we going to do with it?’ (...) I can remember when the agency was announced there was momentum here, there was real frustration. Ten years of solid work by people who came before. And they wanted this. I think the other bit to note was that actually we’ve tried twice before and failed. This is important. And when people saw that failure they thought, ‘Whoa, it’s not a given, it feels like a given, of course, you need a space agency’. (INTERVIEW 20)

About the timing of the announcement of the agency:

(80) “Up until probably the announcement that the agency was going to be formed, the dominant narrative of Australia’s space activities was that people who want to do it are beating their heads against a brick wall and the government isn’t interested. That has been the narrative: that we had a golden age in the past which the government let go and nobody’s been able to achieve. Despite a lot of attempts we’ve never really been able to get back up there. There are still people out there who work under that narrative. Then you’ve got very much the younger generation, the Space 2.0 generation, who say ‘Well, all that’s behind us. We’ve got all these whacky-do things we can do now, all the wonderful things we can do with CubeSats and light launches and internet of things and we don’t need the problems of the past. We’re just going to make a new slate and go forward.’ And in a lot of ways I think that is the narrative which is going to drive Australia’s future, certainly for the next 10 to 20 years until we see how things shake out”. (INTERVIEW 2)

(81) “In 2017 Australia secured a very prestigious space conference and that precipitated government to think more clearly around the absence of a space agency, and I don’t think anyone would suggest that there was universal agreement that Australia needed one, and my sense is that government at the time weren’t sure even how it would be received. And so when it was announced at that conference in a relatively quiet way – certainly wasn’t a lot of money, I think at the time \$47 million or thereabouts – it wasn’t a big splash and when that minister was greeted with standing applause and this real energy back, I think government was taken aback that there was so much interest in this, not just in the base sort of academic community but in the broader economy.” (INTERVIEW 27)

Considering the youth of the agency, we asked interviewees how, or in what, areas the space agency had delivered so far, and these were some of the responses:

- (82) “We have a uniting body, and a voice through which people who work in the space sector can come together, and a body that yes, that has helped to take it in a different direction. So now the landscape is one of optimism, one of hope, and one of agility because it's so new and smaller than it doesn't have the same baggage and the same ‘red tape’ that an older space sector like the US, so there's a lot more room to be able to do things, more room for creating new legislation, for example, but for trying out new things that haven't been done before. Australia around the world, to me, is known as a very ‘no worries’ sort of country and, and a very creative country that has a go, we use this phrase, we have a go at things.” (INTERVIEW 12)
- (83) “It's interesting how the Australian Space Agency has been established and how they run, and it's a really great case study for running this type of agency. In two years, they have really put a stamp on what it means to be in the Australian space sector. They've built an international brand, they have the strategic understanding statements or MOUs with pretty much every G20 space agency and major space company, so their value proposition to all those players is really quite clear. If you look at other space agencies, I think NASA's spending is in the order of \$20 billion US a year, Australia's Space Agency I think is still sub \$50 million AUD, but they're really on the far end of the business of the sector. So, instead of funding big research and government-funded projects, it is actually how to co-invest with business and both get a mutual good outcome. So Luxembourg and the UK Space Agency do bits of that, but Australia is probably the most extreme example and I think it's paid off quite nicely.” (INTERVIEW 27)
- (84) “Space for a long time, certainly when I was a kid and growing up and going to uni, was something that Australians supported, that Australians used, but not that Australia itself did, so the government didn't really have a vision. If we needed communication satellites for the national interest, then you'd have the various telecommunications experts going and talking to the satellite manufacturers in the US. Large, exquisite, gorgeous satellites would be manufactured and then launched, placed into orbit. There would be Australians at the ground stations, the ground stations would be in Australia, but a lot of the manufacture and the launch knowhow was kept by these organisations overseas. That's what was considered to be in the national interest at the time, so there hasn't been a lot of national goal, national dream, national interest for the Australian governments at various levels to pursue until recently. The formation of the Australian Space Agency has helped to change this.” (INTERVIEW 18)
- (85) “Delivering in the first two years was about building a space agency, an incredible task. And I think under Megan Clark's leadership and Deputy Anthony Murphy they did a tremendous job. I think, in many respects, the key success factors are the amount of inbound investment we've seen since formation of the Agency. So there was a goal in the charter, to stimulate by 2025, I think, at least \$1 billion of inbound investment.

That number has been dwarfed, and it's more than doubled now with the money being invested with commercial and other parts of the sector. So I think a key success has been stimulating that investment.” (INTERVIEW 21)

- (86) “The ASA is not so much a true agency in a sense like NASA, but more of an extension of another big agency or a department. So that immediately for me gives it a bit of an unfavourable balance to the Australian space community because we do have national science agencies like the CSIRO, for example, and so with the budgets and the resources that they have as a department and not an own agency, I can see how they're limited in what they can and can't do and in terms of what they want to roll out. Now, I think it would be absolutely terrible in any circumstances if we were to go backwards and lose our agency. If we do get to the point where the agency becomes irrelevant and we roll back the agency to being a nothing, then the Australian public will be like, ‘Oh, we tried to do it once. We spent money on our own version of NASA and it didn't work,’ and then we'll never get that public approval again (...). There is a strong push towards the industrial side of the space community or the industry side of things, so you'll see things about rocket launches from certain companies and you'll see things about signing MOUs and etcetera, but there for me has been no inspirational piece.” (INTERVIEW 37)
- (87) “Having Megan Clark as a leader was important. She was the type of leader that brings people together. It's a very specific strength to do that type of leadership during the formation of the space agency and in the two years of the space agency (...). And the reason why everyone celebrates the space agency is her. People forget that the space agency is a sort of start-up. They're hiring people, they've been given some money and they need to get some outcome, so they are trying to get their act together while bringing everyone on the journey.” (INTERVIEW 17)

2.2. KEY ACTORS: EXPERTISE AND STAFFING OF THE AGENCY

The nature of expertise in the agency was a divisive issue amongst the interviewees. While some praised this element in the agency, others stated that the lack of expertise in its staff is a major shortcoming. Amongst the first:

- (88) “They've hired well. So they've really got some excellent people in places, which gives the productivity of something that's probably three times the size of what they are. I think they had to ramp up quickly, and the quickest way to ramp up quickly is to borrow from the Commonwealth. I mean, they couldn't get people in quickly enough. So they really had to dig from within and maybe CSIRO. So, this is the first sort of six months to a year, I think that was the quickest way to ramp up a team.” (INTERVIEW 7)

⁽⁸⁹⁾ “I think this is something where the agency is doing good work because one of the advantages of having these people rotating in from other government departments is that some of them have actually worked with departments that are involved in Indigenous health and education before. So, the agency does actually have some people who know their stuff, and from what I’ve seen they are genuinely trying to do something about this that goes beyond the logo, so I do think that that is one area that they look like they might be going to make a bit of a difference.” (INTERVIEW 4)

⁽⁹⁰⁾ “Someone was telling me, ‘Why is the agency doing technical roadmaps? They have no technical knowledge in the agency to be able to do that,’ and the feedback after the first roadmap was, ‘That’s a very good roadmap.’ The agency also tested it with all the agencies – ESA, Canada, and NASA. And they all tick, tick, tick all the way. So to build this roadmap the agency consulted with the expertise in Australia and tested that with the industry and other agencies.” (INTERVIEW 23)

⁽⁹¹⁾ “There is definitely a perception out there that it’s a team of government bureaucrats that have come together and formed an agency. That’s not the case. It’s a passionate team – they are dedicated. On the regulatory side, there is over three decades of space regulation experience or associated regulation in the team. There is actually a lot of technical expertise. The agency is going to continue to grow that technical expertise. But as a government agency, actually having the skills to develop policy is as important as having technical experience. If the agency just had engineers that knew space, we would not get funding for any of the missions they want to get funding for. So you really need that blend of skill sets. There is good depth in space law. Some of Australia’s leading experts in the Outer Space Treaty and UN COPUOS activities are employees of the Agency (...). The whole discussion on regulation is interesting. And a lot of comparisons are drawn. And I think the agency acknowledges and it is on a continual improvement path. We are a nation that has not really launched domestically rockets, ever. We did the stuff back in the 60s. But that was a different environment, certainly, as it pertains to regulations. I think it’s just an education process that the agency needs to do.” (INTERVIEW 21)

⁽⁹²⁾ “Hiring Palermo as the head of the space agency is a really great sign that they are very much focused on getting someone who’s not a bureaucrat now to run the space agency and to say, ‘OK, what kind of space programs can we offer? How do we really develop our local supply chains?’” (INTERVIEW 16)

Amongst those who were critical about the expertise in the agency’s staff:

⁽⁹³⁾ “There’s actually very few people in the space agency who really understand space. So, they are government people who understand government processes and who are learning about space, and then there’s a small handful of people who really understand space and the space sector, and some of them are from abroad.” (INTERVIEW 10)

⁽⁹⁴⁾ “There were some expectations that agency staff would be recruited from within the community and would be people who knew the space industry very intimately and had that deeper background and had those relationships. And that pretty much was not what happened with a couple of notable exceptions. So we kind of ended up in a situation where all these young career public servants who knew nothing about space had no idea and still don’t, and sort of starting from scratch building relations with them was really interesting. The weird situation of having some 23-year-old who literally knew nothing about space being the point person to open discussions about this stuff. There are people who have been in the space industry longer than these people have been alive, who know the legislation inside out, who know the history inside out, who know the technology inside out and this person who’s just rotated in from another government department. It was weird educating people in the agency about how the industry works. But there’s the sense that you’ll put time into getting to know someone and cultivating them and then they’ll be rotated out into some other place and that is lost, that expertise is lost.” (INTERVIEW 4)

⁽⁹⁵⁾ “My sense is that the Australian Space Agency does not have a depth of expertise in international space law and that they are working quite fast to try and develop that expertise. That is indicative of some of their unwillingness to engage on some really fundamental questions of international space law at the moment.” (INTERVIEW 11)

⁽⁹⁶⁾ “Ninety-nine point nine percent of people in the agency now have had no involvement in any of what passed for government space activity previously. Many of them are young enough that they don’t even know about a lot of the early programs.” (INTERVIEW 2)

⁽⁹⁷⁾ “One of the scariest things is if the regulator does not understand the business, and we’ve definitely seen that with the space agency. It’s generally staffed by bureaucrats from other departmental industries, and what they don’t understand they fear. And so the thing that changes is you bring people in from the space industry like they’ve started to do with the new CEO who understands the industry and understands the risk, and that’s the only way to change it.” (INTERVIEW 14)

⁽⁹⁸⁾ “Dr Megan Clark led the review that provided the domestic basis for the agency to be established, and she carried on as the first head of the agency. Her challenge was to decide what to do with little money and a small, inexperienced but well-intentioned team. Few had standing in or were known to the national or global space community. However, each member of the agency had boundless enthusiasm. My sense is that Dr Clark set about to ensure that the agency could not be done away with. She quickly made agreements with several space agencies and with some big companies; a network of influence that would strongly object if government, at some future point, defunded the agency or tried to shut it down. She wanted to be sure, in my view, that the fate that befell the Australian Space Office in the 1990s would not be repeated.” (INTERVIEW 24)

Some interviewees addressed what they see as the reasons for the agency's challenges in this front:

- (99)** "The Australian Civil Service is based on the UK model, which is deeply administrative, and there is very little expectation that you are an expert in the thing that you are overseeing and people move around, they go from agency to agency, and that's perfectly normal. That's very different than in the United States where especially at a place like NASA or even NOAA or even in the Department of Defence experts stay in a field and even in a regulatory function. The Federal Aviation Administration has an organisation that's responsible for licensing the launch of rockets and they are all very senior, experienced people in space and they really understand it; they're technically very savvy and it's just a profoundly different model. And as a result – space is just different than many other industries for a handful of reasons that I could articulate, but it has led to confusion on the civil service side about their responsibilities, and at a political level there's massive confusion about the difference between industrial policy and subsidies. Rotation diffuses the knowledge." (INTERVIEW 39)
- (100)** "The expertise that is missing in the agency is employed at the company which is applying for permission. So, finding enough people to be able to approve things, to go through those layers of governance, and assess whether something is safe or not is actually a non-trivial task. I don't think that the agency has quite figured it out." (INTERVIEW 5)
- (101)** "NewSpace is new, even for countries that are emerging. So, about the expertise, if you look at the background of where the agency came from – and most of their people were in the areas of legal compliance, spectrums, filings, allocations, UN meetings, etcetera – it's not really the sort of start-up entrepreneurial hub that would have perhaps opened up a lot of other opportunities. But they did go out to industry and engaged a lot. I've read a lot of the industry responses both from the Space Industry Association from Australia, interested parties, and a lot of the recommendations in those responses to the space industries, opening to review the act, have not been taken up." (INTERVIEW 36)
- (102)** "One of the issues the agency faces at the political level is a bit of scepticism around what space could do. And government still hasn't, at the political level, adjusted to that. But they still feel like, if they announced an investment in space, they've got to explain to the average taxpayer how it's going to improve their life. The government developed an Australian space policy in 2013. It was taken into Cabinet discussions as the Australian Space Policy, and it came out as the 2014 Satellite Utilisation Policy. Because around the Cabinet table, everyone sort of was like, 'we're gonna get laughed out if we come out with a space policy.' So that's seven years ago. It's not that long ago. So, that's kind of where I see that kind of narrative come from. Another point is about the agency not having enough space experts. I'd agree that it's underweight for space experts. They're going to try and bring more expertise in, particularly in the regulatory area. But that's also to do with the fact that it's a pilot project. So if there aren't that many skilled people in space regulation, whether it's the sort of technical and policy

analysis, why would you commit to a space agency that's only got three years' worth of funding? You're probably looking for a little bit more security than that. So there are good reasons why it doesn't have that expertise." (INTERVIEW 33)

2.3. FRAMEWORKS FOR VALUE ASSESSMENT

2.3.1. Sovereign and Commercial: Foci of the Agency

The process of creation of the agency first involved making the case before governmental stakeholders and, using a common expression from those in the sector, removing the "giggle factor" when it came to outer space activities: in other words, arguing for value in terms of the concrete practical applications of space activities like satellite services for Australians:

- (103)** "A key factor was that Australia was one of only two countries in the OECD that didn't have a space agency, and apparently that was a really key factor for some of the key people. And it also helped a little bit that New Zealand just established their space agency, not officially in the documents but in the discussions." (INTERVIEW 38)
- (104)** "As of 2017/2018 when the agency was coming to be, it was just a point of transition for the rest of the world from big space, Generation 1 space basically, to Space 2.0 and commercial space. The agency was founded on the principle of commercial space basically." (INTERVIEW 29)
- Several interviewees agreed on characterising the agency as a "start-up agency", and this characterisation sheds light on how they perceive its functions, budgetary capabilities, and position within government:
- (105)** "The start-up is a very good analogy for the agency because I think the agency started just with Megan and the deputy heads. And together they had a white piece of paper and they had to build the agency, and they brought the team that was the right team to set up the agency: what are the operation guidelines? What are the comms we're going to do? What is the engagement to do with the industry? So really it's a small start-up and then it became 5 and then 10 and 24 in almost a year (...). It is now 50, I think, and so very small and having discussions with NASA, ESA, Canada, and there are one thousand and five more (...). It is like a start-up where the budget is very finite, so it constantly has to prove that it needs more budget to grow the industry. So, to me, that's the two big analogies with the start-up: starting from two people and with no money, and always trying to get more funding to grow and to deliver on its promises." (INTERVIEW 23)
- (106)** "At the moment, it feels like the Australian Space Agency is trying to be a bit of a start-up and run Australia as a space start-up for the world, which is a flawed

approach in my opinion because start-ups fail and that's the nature of start-ups. But, actually, what government can do that industry and companies can't do is act in the best interests of and on behalf of the entire country, and that's actually the role of government." (INTERVIEW 5)

(107) "In some respects, a start-up is a term that refers to a commercial entity. So pre-revenue, or pre-commercialisation. And we're never going to reach revenue, we're not planning to, so it might not be a directly transferable term. What I would say, though, is that aspects of commercial start-ups are true to the spirit of the agency: very flexible, entrepreneurial (...). Start-up maybe isn't a term that applies fully to a government agency, but it does to the ethos, the flexibility, and the passion. Many great start-ups are purpose-led, and I think we've got a team here that believes very much in that purpose." (INTERVIEW 21)

(108) "The amount of money set aside was almost ludicrously small when the agency was announced, and in fact I think going back to some of the analysis done by the Expert Reference Group some three or four years ago, if we were to have an annual budget akin to some of the other agencies that are doing what our agency espouses to do, then I think you're looking at something in the \$250 to \$350 million a year range, so the original 40-odd million dollars across four years was just laughably small. However, the reality is that the agency's approach is really to try to stimulate activity and to facilitate it, not really to be the cornerstone of the space program the way other countries have approached it, and in fairness to them they have added to that initial funding with other chunks for likely – well, the biggest, of course, is the Moon to Mars Program which almost dwarfs the original 40 million dollars, 40-odd million dollars that the agency has given." (INTERVIEW 26)

(109) "So this commercial model was both a blessing and a curse, because the agency was not on the traditional model and did not have funding that was appropriate to actually guiding/leading the Australian industry with missions that could pay for commercial development as the US did with SpaceX and plenty of others. It meant that Australia's agency had to create opportunities for Australian industry without actually coming in and paying for the output of that industry, so that was a challenge." (INTERVIEW 29)

More specifically, about the statutory nature of the agency, these were some of the views amongst the interviewees:

(110) "The space agency began life as a fragile institution. It was announced on the first day of the International Astronautical Congress (IAC) in September 2017. There was no Cabinet process and no money. Government had no clear idea as to what the agency would do. The announcement was simply, 'In principle we are going to set up a space agency in a year's time.'" (INTERVIEW 24)

(111) "One of the big issues at that time [when the agency was created] was whether it would be a statutory agency or whether it would be part of another government department, because so many people remembered the days of the Space Board in the

1980. The Space Board never got the budget, it never got the backing, and it was kind of doomed to fail. So people in that period were very anxious that there wouldn't be enough funding and that it would simply become a branch of the Department of Industry Innovation. And those fears have not been entirely allayed because effectively that's kind of what the agency has turned out to be." (INTERVIEW 4)

(112) "There is one piece the nation really wanted, which we haven't yet done, which was the statutory agency. So they said, 'Well, we've tried this twice before, and it got sort of pulled apart.' We want this to be embedded in statute, which is in most countries. That we haven't done. And it was decided that it would be better for the agency to get up and running and prove its worth to the government and then earn its way to statutory." (INTERVIEW 20)

(113) "The space agency right now is a very fragile institution. It was announced on the first day of the IAC. There was no Cabinet process, there was no money, they didn't know what it was going to do, it was simply 'In principle we are going to set up a space agency in a year's time.'" (INTERVIEW 24)

(114) "It doesn't have a statutory standing yet. So it's part of the department. But it certainly is at start-up phase. And so I think, yeah, but I would like to think it's got its phase A defence, if we're going to use commercial language. I'd like to think that it already has done extremely well, in terms of, you know, all the KPIs that it said it was going to do. I'd like to think that it's done most of those and it can accelerate into being more of a – I'm not sure if it needs to be statutory. But I think it needs to have more budget and a bit more control over what it spends its money in as it evolves." (INTERVIEW 7)

In these assessments about the agency, there was significant convergence amongst interviewees about the dual role of the agency:

(115) "The agency is trying to be the regulator but also be the customer. It's trying to provide grants and encourage industry growth, but also put limits on that industry growth at the same time. So that's a clear conflict within its operations, and that means that you have situations where you have grants going to companies doing space activities, then those companies come back to the agency and say, 'OK, we've used the grant and we've developed the tech. Now we need approval to test it' or to do something and then the agency's like, 'Oh, no. We don't have expertise, we don't know how to approve this thing, we don't know how to do this' and it flies around in circles in the office for six months or whatever it is and it gets very frustrating." (INTERVIEW 5)

(116) "The agency has a lot of roles. One of them is its regulatory role as the space licensing authority. And if you can park that to one side, it's not even a matter of my opinion, it's a matter for the record – they put on the record that they were industry focused. And one of the areas would be to make Australia attractive for both investment and for export. And so, I think they've already set that goal for themselves. And in that goal, the only place to play it, really, is in start-ups." (INTERVIEW 36)

(117) “I think the people that are leading the bigger space companies in Australia are all very optimistic, and I think there’s a general philosophy that the government has a very low imagination of what is possible. If you look at the space roadmap – and it has the two-year, five-year and ten-year goals – the people in the space industry think they can achieve the five-year goals in two years and they can achieve the ten-year goals in five years, but the government has a view that it’s going to take a lot longer than that and they’re a lot more risk-averse.” (INTERVIEW 14)

(118) “To have to meet their own targets and to get future funding, they’ve perhaps delivered on more safe and traditional programs and in that I mean awarding projects or grant opportunities to established companies who are not early-stage start-ups – they’ve kind of been in the market for quite a while but still considered as a start-up. So I take it that they’ve done that because they’re easy wins, the risk, low-risk, which makes for forming an agency perhaps laying the ground and notching up those wins, whereas the higher risk of, say, more external ideas or innovative ideas haven’t been perhaps as readily taken up.” (INTERVIEW 35)

(119) “When the agency was first created, there was this strange level of euphoria, and I think I was the only person wandering around and going: ‘Are you sure you want an agency? They’re just going to be a big regulator that wants to travel everywhere at your expense and they’re going to charge you fees. Be careful what you wish for.’ It was a very unpopular thing to be saying three years ago. I think it surprised me, the bump in excitement that was created in Australia because of the existence of the agency. It was always going to be the case that the expectations would be higher than their ability to deliver, partly because they only have a tiny amount of funding. So as long as there’s no financial largesse to lavish around, they could never make people as happy as they wanted to be.” (INTERVIEW 28)

(120) “There’s a tension right now on the regulatory piece because you have this entrepreneurial spirit that just wants to go, and the agency is also the regulator, and I think that fits well together. And you need to make sure that we balance between safety and risk with entrepreneurship that wants to move fast. The sector is transforming; it is growing. And that means that the agency has to be ready for maybe 60 launches a year, ready for maybe 60 to 70 satellite licenses, this is an order of magnitude more. And they have to handle complex things such as the *Hayabusa 2* return-sample mission, which is very complex, with the Japanese space agency with a little team. So I would actually say, that could put the brakes on if they don’t have that fully resourced to be able to service this growing industry. I think it’s a nice tension to have. But that’s a tension that could hold us back. But the good thing is the very first thing the agency did, within six to eight weeks, they got the regulatory reform as a platform. And they’re going to have to keep doing that regulatory reform and working with the sector to keep that agile and modern and as simple as possible.” (INTERVIEW 20)

(121) “On the regulatory side, I think the agency has fallen into a bit of a hole. They wanted to be a super-responsive industry-friendly agency but instead they have taken the most conservative possible path. Every time there’s been a possibility to exercise

discretion – obviously they have to work within the rules – but whenever there’s been an opportunity to take either path A or path B, they’ve taken the slower, more conservative path that is going to be more expensive for industry. So it’s meant that no launch facility licences have been issued and applications were put in for those more than two years ago and nothing has come out. They’ve required multiple layers of independent experts and they’re planning to charge them cost recovery for the experts that they themselves engage, so it appears from the outside that they’re riding instructions have been, ‘Just make sure that no matter what happens, there is never anything that goes wrong – no accident and no failure’. Because they haven’t been given any level of appetite for risk, what that results in is no approvals of anything. This is the message that people who work in that area of regulation appear to have received from the leadership. So, there’s been an unhealthy cycle where the agency knew there were really high expectations from industry, and they couldn’t meet those expectations, as they were probably underfunded and they probably had a whole lot of people who didn’t understand what they were doing.” (INTERVIEW 28)

(122) “This starts with the Australian civil servant view about regulations. The battles started with paying for your own licence application and cost recovery, where literally you’re paying for the civil servant’s time for evaluating. This is a very common thing in Australia and it works just fine if you are in the mining industry and oil and gas. Especially in commercial space and with the maturity of the industry, it’s just a terrible idea. But it’s an uphill battle, I think, culturally inside the civil service and so that was the opening shot against the bow when they said they were going to go for cost recovery and the Australian space industry just went crazy and said, ‘This is terrible.’ This is where not having a technical background really bites you and if you try to transfer your knowledge from a regulatory environment (...). It’s a very different thing when somebody comes in with the design of a new rocket and you’re talking to somebody who’s never done that kind of assessment before about what’s reasonable, what the risks and hazards really are. They understand they need more technical expertise.” (INTERVIEW 39)

In particular, the role of grants as a mechanism promoted by the agency came up in the conversation about this dual role:

(123) “The government has put out a space infrastructure fund, grants of about \$20 million and \$150 million for Artemis Moon to Mars missions participation. I think that has gotten people to believe that the government is behind such a transition to being able to be part of a supply chain for global space.” (INTERVIEW 29)

(124) “I think grants have to be looked at very much along the lines of the same decisions that venture capitalists make. They’ve got to be very commercially driven. If I give two million dollars to a company, are they going to be able to take the two million dollars and use it to get their business to a stage where they can start making commercial revenue? And I don’t think that lens is looked at at all, and so really what happens when you have programs that spread a little bit of money out to a whole lot of people, it’s almost like a sugar rush to everybody but it never gets anybody to a stage where they can really get commercial, and I think that’s the real problem

we have with the government right now. There's a number of companies working on technologies that are at least as good as the best in the world and I think the only thing that's holding the Australian space industry back at the moment is the severe lack of government funding to develop technology." (INTERVIEW 14)

(125) "In my company we never count on grants, we count on VCs and customers, try to go ahead. Not everyone is counting on grants, so everyone is collaborating in order to get grants – and I think this is such an Australian philosophy – I think for a healthy, healthy, healthy ecosystem you need to compete; I need to build, you need to build, he needs to build. We all build together, we compete and we grow." (INTERVIEW 17)

(126) "I think competition is good, hyper-competition isn't, and I think that might be the differentiation between what I'm saying and what you're hearing from elsewhere. This was the sort of market that before the space agency to get money in Australia was like fighting over grains of sand in the desert, right. There were no opportunities and the response is that everybody's at each other's throats. That's kind of what it was like. So I think what they're trying to do is they're trying to set up some competition without having the competitors kill each other; they want to have enough money on the table so that everybody can compete for the money but still survive, because it's a very kind of fragile time in the market at the moment in Australia, so I think, my opinion is that's what they're trying to do." (INTERVIEW 15)

(127) "Put money into start-ups, absolutely. Absolutely incubate the start-ups, give them a go, let them fail. The right ones will win out, you know. There was DEA Labs last year, Digital Earth Australia Labs run by Geoscience Australia and Frontier SI, they were giving \$50,000 to three companies. They had around 26 to 31 apply." (INTERVIEW 35)

(128) "I think we would say that their view on how much private investment is going to lead the growth of the Australian space industry is a little bit at odds with the evidence, both here and internationally. The reality, in pretty much every space industry, is that governments play the role as funder/guarantor clients. The idea that it's going to be a private investment that leads the space industry and helps us catch up here is not quite right, and government is starting to change its mind on that. I think the concern we have is that the agency is not sufficiently influencing what is happening in the national security space area in defence. It's aware of it, but it's not influencing it." (INTERVIEW 33)

(129) "I think particularly here in Australia one of the things which has actually been really important is the fact that the costs have come down so much that government can look at supporting the development of a space industry in a way that's not going to cost it huge amounts of money in the same way that it would have done in the past. So, in other words, by supporting the development of a lot of the growth of smaller entrepreneurial companies and small-medium enterprises, we can get a lot more bang for the buck now than we could have got even 10, 15 years ago." (INTERVIEW 2)

(130) "A problem in the sector is government funding. They put out a call and everyone applies like a frenzy. And then not much happens out of that. So we need, and what the agency is looking to do is, is some defining early mission, like a big when Australia does X, whatever X is, we all get behind it. And we contribute to that. I think that will matter a lot to defining what we want to achieve as a nation." (INTERVIEW 6)

(131) "I would not say that the agency has been a resounding success – I would say they're in a holding pattern. They're holding off the wolves, they're managing to upset a lot of people in industry (...). So there are discussions in industry: 'We need to support the agency because if we don't support them, we'll lose them,' coupled with, 'Well, what are they doing for us? We could have done this for ourselves,' and in fact all those launch operators did, they did. The agency didn't make that happen, the agency got on the bandwagon when those people made that happen." (INTERVIEW 4)

2.3.2. Inquisitive: Science and Outreach in the Agency

Unlike other space agencies, the ASA does not have a science mandate. In fact, a consequential argument for the creation of the agency had to do with Australia's international stance, and the fact that the agency would not replicate tasks undertaken by other institutions, particularly CSIRO:

(132) "I think the agency is very different by design and charter from a more traditional agency, whether it's a NASA or a ESA. The agency doesn't have, and currently is not planning to have – of course things always change – a large R&D in the organisation. That is because we have great institutions like the CSIRO, the country's national premier science agency. So by design, the agency is different." (INTERVIEW 21)

(133) "The government doesn't want to replace something functional with something else that might be equally or less so. So CSIRO with all of its efforts, and the SmartSat CRC and the SBAS system to improve the accuracy of GPS, all have budgets much greater than that of the agency – just SBAS is \$300 million, I think – and the agency when it was launched was \$41 million over multiple years, so you can see the challenge." (INTERVIEW 29)

(134) "It's almost more an Austrade for space than it is a NASA because so far we're not so fortunate as to have science missions." (INTERVIEW 29)

When inquired further into the reasons why the agency does not have a science mandate, these were answers addressing its commercial focus:

(135) "I would describe the Australian situation within government is really important to understand that it sits very closely to industry, that the objectives of the Australia Space Agency from the outset have been quite commercial and to encourage commercial engagement and the development of an Australian corporate sector." (INTERVIEW 11)

(136) “It was quite clear from the get-go that a NASA model wasn’t palatable by our government. Right? And to be fair, if you talk to someone from NASA, they would probably say if they were giving it another go, they wouldn’t have done a NASA model, either. And just given the commercial lens on space now, yeah. So the models that they looked at were Singapore, UK, Canada, they were the three main ones that come to mind, come to mind. And that influenced a little bit the direction in the charter preparation (...). It is a very commercially oriented agency. It’s here to support and grow our space industry very much. Some of the research side has wondered where they fit in there because it’s not been so obvious that it’s not a NASA model. Funding has been funnelled mostly to industry.” (INTERVIEW 7)

(137) “I think it’s a reflection of the government positioning. This particular government is interested in growing the space industry, and the very first goals of the agency are about that. So, although science projects can be used to grow industry, I think the agency and this particular government is much more interested in that kind of direct approach (...). I think it is very much driven top-down, the agency’s vision and goals, right, and so I think it would take sort of a ministerial desire for the agency to be more science-oriented. But the agency’s quite small and it can’t do everything for everybody, and so in many ways I don’t think it’s unreasonable that it’s kind of focused in the way it is. The question then is how do you drive the kind of space-based science aspect of things, you know, who does that within government if it isn’t the space agency? Do you need anybody to do or is it OK to carry on just as we were? The space science community absolutely thought that the space agency would be a science drive for them.” (INTERVIEW 22)

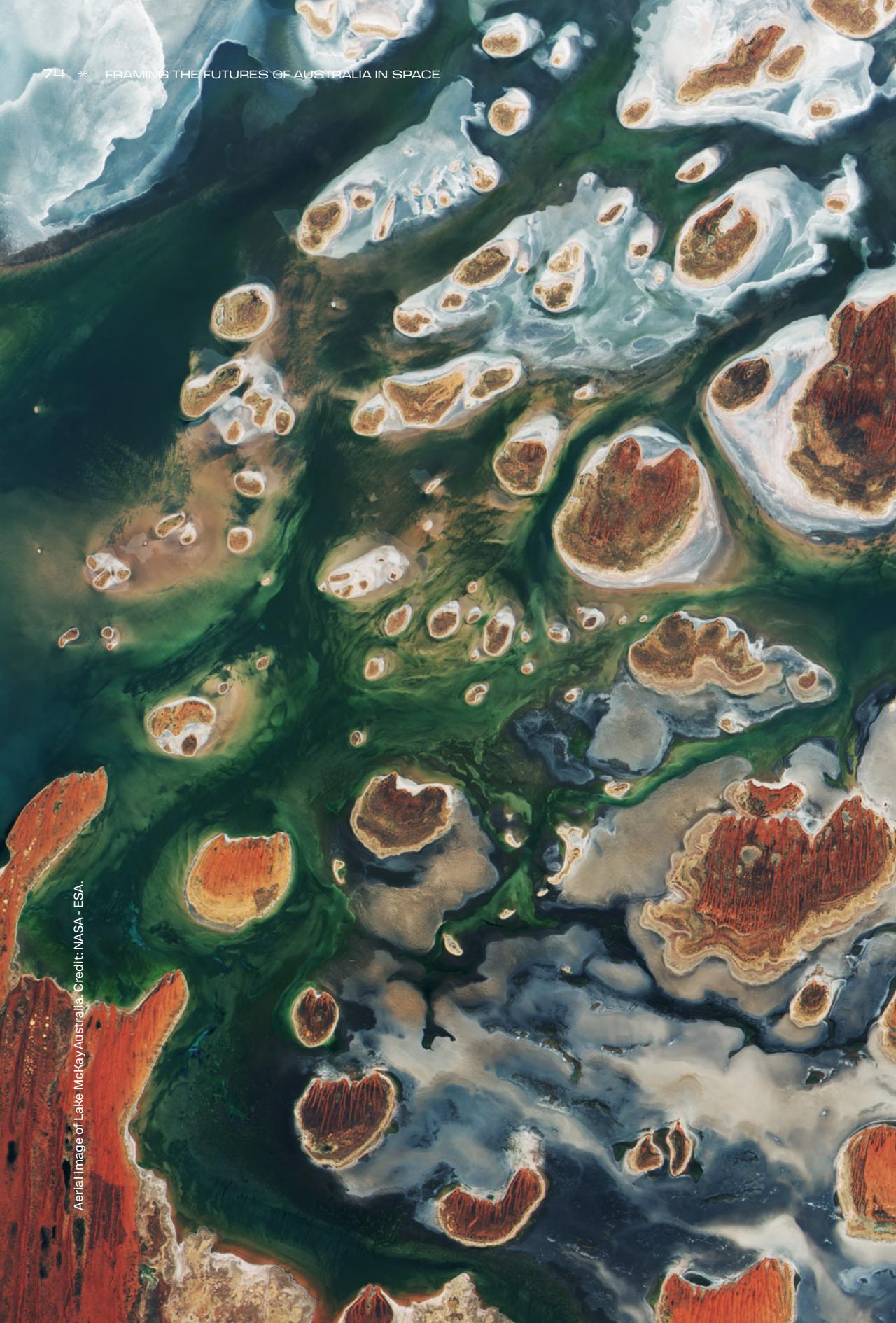
(138) “What is the role of a space agency? A space agency is the national strategic arm of that nation’s space policy. So if you think in terms of the US space agency, its unstated goal is to build jobs in economically depressed areas. The part of Houston that Johnson Space Centre’s at, NASA Goddard, if you look at the neighbourhood that NASA Goddard – NASA Ames I think is the only exception to this – but every other NASA facility has got projects which are building jobs and it’s essentially a jobs program. The Australian Space Agency’s mandate is also to build jobs but it’s really not. It’s to take advantage of the space industry’s rapid growth – and we’re expected, to grow from \$420 billion to \$1.2 trillion over the next ten years. So their whole purpose is to say, ‘All right, Australia is in the top 10 of the world for space research and academic research in space but dead last in commercialisation.’ So their role is to build Australia into a space producing nation, turn from a \$4 billion import market to a \$12 billion per year export market; that’s what they’re trying to do.” (INTERVIEW 15)

(139) “I think the agency’s visions and goals are very much driven kind of top-down, so it would take sort of a ministerial desire for the agency to be more science-oriented. But the agency is quite small and it can’t do everything for everybody, so in many ways I don’t think it’s unreasonable that it’s kind of focused in the way it is. The question, then, is how do you drive the kind of space-based science aspect of things? Who does that within the government if it isn’t the space agency? Do you need anybody to do it or is it OK to carry on just as we were?” (INTERVIEW 9)

(140) “If you look at all the agency models around the world, there were some choices, strategic choices. Most of the space agencies around the world have a dual purpose, which is scientific discovery of the universe, for its benefit, and commercial benefit for the nation. And many of them have come from the scientific discovery aspect and are moving into the commercial. So nearly all of them were moving into commercial. The Canadian Space Agency, NASA, everyone was on this journey. So the agency is not limiting its vision. It will do science and exploration, but you’ve got a look at the pragmatics of that government, what a nation needs, of where we are now, of what they need to see for the agency to be successful. And they chose a single purpose, which was to transform and build the space industry sector (...). There’s no question that, over time, the agency will earn the mandate of the nation to broaden out from commercial to exploration.” (INTERVIEW 20)

(141) “So the notion that they can try to identify areas of special interest and then go out and raise or obtain new funds for it is an interesting approach. Having said that, how they chose to invest in the Moon to Mars Program, much as I think it’s very exciting and a fascinating area for us, there was no outcry from Australia’s industry for funding something like that. You would have imagined that there would have been an outcry for agribusiness in space or other communications or something around GPS and mining equipment, etcetera, but when it popped up for the Moon to Mars that was just so out of left field. So to have a more conventional approach, which is the way the world would view this kind of thing, you would need a bigger chunk of money. And when people think Australia now has a space agency and they think we have a space program, they just can’t get their mind around the scale of money that’s within the agency’s remit. Now, I’ve been to a number of conferences where people from either the agency or elsewhere in government have talked about Australia spending hundreds of millions of dollars, and what they’ve done is they’ve ended up portraying expenditure on things like NBN in satellites or Defence and other things, they’ve tended to construe that almost as if that is a national space program when in fact it isn’t; it’s just a collection of disparate activities that may be funded by the government one way or another. So I don’t want to be negative about the agency – I mean it’s a big step forward for us or it’s a step forward for us but it’s still anomalous the way others in the world view it and what they expect from it. So there are dangers with being too much of an outlier because the rest of the world doesn’t necessarily get it or understand it.” (INTERVIEW 26)

(142) “I think because the agency is so young, it hasn’t quite developed the same legacy as other space agencies have, like NASA, in the UK Space Agency, or the Canadian Space Agency. I can see the reason why it focuses on industry and entrepreneurship is because it’s the easiest way to invest and generate an economic flow. But at the same time, it desperately needs to collaborate – it is already doing but it needs to continue to collaborate with bigger places, other countries. It has a massive opportunity in the Asia Pacific, to collaborate with them to put Australia more on the global stage when it comes to space.” (INTERVIEW 12)



(143)

"They've been given a remit to triple Australia's space industry, and that seems to be the only thing that they're interested in doing. So, obviously, they have been told they need to prove their worth, and their worth will only be judged in economic terms, will only be judged in terms of what they deliver to the economy, you know, with a capital E, and it just seems like a giant waste of opportunity, particularly given the history of our moral and ethical leadership in this diplomatic sense, that that's what we've come down to because we can't even compete on that level, really – like we're such a small player. So I don't understand it, except that I guess they're fighting to justify their existence to the higher-ups, but it just seems incredibly not representative of the amazing community of space activists and thinkers who are in Australia and who are particularly Australian in the way that they are prepared to embrace something like antipodean thinking, you know, standing outside of the centres of power (...). I don't know where they got that mandate from to triple the space industry. Where did that come from? They're meant to be representing us as Australians and I just can't imagine that the majority of Australians would be like, 'Let's go make some money in space' – just I'd like to know where that came from." (INTERVIEW 30)

Even though the agency does not have a scientific mandate, interviewees did see a key role for it regarding outreach about its work and about the space sector more generally as well as inspiring the public with space:

(144)

"I think the mandate 'It is the most industry-focused agency in the world', whilst important, this only reflects part of the story. I think industry is important, but there are so many other things that are important as well. If it is all driven only by industry and jobs, then I think the agency would have a limited mandate. Even though they have this inspirational aspect, if they're really focused just on these KPIs that, I think, filters down to the way we think about space. I think it reinforces this view that space is there to be exploited, it's there to be used. All of that's important, but I think there's more than that, and we need the language of 'stewardship' and 'custodianship' even amongst the agency." (INTERVIEW 3)

(145)

"Let me just say this about the Australian Space Agency: if it does nothing else, its most important job is education and outreach because our Australian economy depends on having scientists and engineers, and especially female representation." (INTERVIEW 9)

(146)

"If you ask the general public 'what does a space agency do?' they wouldn't be able to tell you if they know because the focus of the space agency has been towards the industry and especially those bigger players in the industry or the more well-known players of the industry. I'm not saying that as a criticism of what they do in terms of their capability because I know what it's like to work in a department of the government with limited people, limited resources and having a to-do list that is long and you can only do this much in a certain amount of time, and there's always going to be people you're going to make unhappy." (INTERVIEW 37)

(147) “It is one of the five or four key pillars of the agency to inspire Australians with space, but they have no funding and no resources to do that. It's not quite true because they've just opened the Space Discovery Centre in association with Questacon, which is a good, a good partnership, and that's a sensible thing to burn out. I don't think that's actually going to make any meaningful impact on Australians, knowledge of the agency, knowledge of the Australian space sector. And it's simply a small, essentially one big room in Adelaide. It's not a major city that people visit necessarily. Very often it's not, you know, a major museum and it really has that much potential, I think, to engage with Australians.” (INTERVIEW 6)

(148) “Cultural institutions are absolutely critical for a variety of things: inspiring, developing the workforce, and telling that story. The Space Discovery Centre is the agency's first cultural institution. And importantly, in Australia, the critical part of our culture is telling the story of Australia's role in space and what we can be proud of.” (INTERVIEW 21)

(149) “A lot of the stuff that the space agency is doing isn't very inspiring. And I remember a couple of years ago, I was at a space conference and in a town hall meeting people asked 'what could be done?' There were senior people saying 'we should really start getting people thinking about drones and, and military applications.' And this, this young student from Adelaide said 'I'm not here because I'm interested in drones, or surveillance, or remote sensing, I'm here because I'm interested in the human future in space.' Drones and satellites and all the rest have their place, but that's not what really grabs people's imagination. What really grabs people's imagination is the vision of a human future in space, on the Moon, the asteroids, and Mars.” (INTERVIEW 34)

(150) “One of the agency's pillars is the Inspire pillar (...). It hasn't been getting a lot of funding up till now, but this is something that the agency actually wants to move forward with now. Now that the agency's kind of found its feet and has its Industry Development Program, starting to run the Space Infrastructure Program, the International Space Initiative Program, so now the next phase is really getting the Inspiration pillar really moving so that you'll see more programs in that area coming out of the agency from next year.” (INTERVIEW 2)

(151) “I think the government really falls down with engagement and outreach, and I think when we are talking about the space agency we can't forget that it is a government organisation. I haven't seen any outreach other than advertisements, which I don't really know if that can be considered engagement.” (INTERVIEW 8)

(152) “This is going to sound a bit critical of the space agency but I'm just going to say it. The return on investment for the space agency to prove to the public is they need to have something tangible, so Earth observation for them is a really easy one. So if they say, 'We're spending money on building satellites' or 'We're spending money on services or space services', they can return that to the public by saying, 'Out of that we're going to get this satellite that looks back down on Earth and it helps us manage our bushfire disaster management', for example, so that's a really nice, clean investment, return on investment equation right there. I feel like what is lacking is the

investment in inspiration. There is something to be said in investing in young people and inspiring them in their education that needs to be, I think, even more so than the Earth observation return and investment equation because effectively that's our future – that's who's going to be doing all the science or the engineering or all that industry tomorrow and the day after.” (INTERVIEW 37)

(153)

“STEM is huge for everybody. There's no space agency that isn't heavily leveraged and aware of the outsized impact that space has on inspiration. In the United States it is just so obvious. An entire generation of astronauts was totally inspired by the Apollo Moon landings and, in fact, that's a challenge. How do we have the right tempo that you keep that continuous inspiration up when it's so expensive and hard to do these huge things? Water is so important to Australians, and in fact that's one reason why CSIRO wants to go after their own satellite, and the number one thing they picked was water monitoring. It's a very big deal and, in fact, it's such a big deal that there's a lot of people worried that there are people stealing water or taking water they're not supposed to and being able to track all that. It's a huge issue. It's a huge economic and equity issue.” (INTERVIEW 39)

(154)

“I think their public outreach has been very limited so far – they've done a few videos, they've got a social media account (...). Their effort to increase that science communication power by opening the Discovery Centre is going to be a really important part to have public support. When you ask people 'Did you know that Australia has a space agency? What do you think of Australia's space agency? What do you think they do?' Largely, the response is that people are either unaware that we have an agency or they think it should be something like NASA. And NASA and the Australian Space Agency are very, very different bodies. NASA has these big flashy missions, these huge rockets, whereas in Australia our expertise is much more focused and not quite as grand in its ambitions. We're supporting these missions, so Australia is part of the Perseverance mission, for example. We've got scientists working on the instrumentation, we've got the Deep Space Communications Complex, and it's going to be hard for the agency, I think, to tell those stories and to capture the Australian public's imagination in a similar way that NASA does. Our agency is very much poised in that regulatory and industry support, grant giving and that sort of support, whereas NASA – obviously – they're a space exploration agency, so they're very much involved with building rockets and space missions and operating them. I imagine that the goal of the agency's communications is going to be promoting the industry rather than promoting themselves. So it's about building support and public trust for the kinds of work that the Australian space sector is doing and also some of that coordination role that the agency's playing.” (INTERVIEW 31)

(155)

“Going back to what Australia should do, Australia should be looking at all of these aspects, not just the industry aspect, and it needs to support its research and it needs to support STEM, and it not only needs to do those things, it needs to get the public on its side for the space agency to have public awareness. If I went down the street right now and I asked a random person 'Do you know Australia has a space agency?' they would say, 'Really?' and that's a problem.” (INTERVIEW 9)

2.3.3. Commercial, Sovereign, Inquisitive, and Caring: Questions about Lunar Exploration

The relationship between Australia's role as a signatory of the Moon Agreement and, more recently, the Artemis Accords has raised a debate about whether the agency has precipitated a contradiction in the simultaneous participation in these two instruments of international cooperation. Amongst the answers that stated that there was indeed such contradiction:

(156) “I don't know where we stand on that now, so since signing the Artemis Accords and because the US has so explicitly rejected the Moon Agreement, I'm not clear on what the agency's position is. And the irony of this is most people who oppose the Moon Agreement have never read it because the Moon Agreement basically takes the Outer Space Treaty a little bit further but not a huge amount, and then everybody says, 'Oh, it's so ambiguous.' Well, it isn't ambiguous, actually – it's pretty clear to me what actions are entailed in the Moon Agreement. But what this has done, this has sidelined the Moon Agreement because the big sticking point, of course, is who owns the resources you extract, and I think the Moon Agreement actually isn't obscure on that at all. But what the US is doing is offloading the risk in that to these private companies.” (INTERVIEW 4)

(157) “My sense is that the Australia Space Agency's policy is to sit very closely to NASA. I haven't seen there be any willingness to articulate an independent policy platform. So, the signing of the Artemis Accords was indicative of that because it's directly contradictory to Australia's obligations under the Moon Agreement. Australia is still a signatory to the Moon Agreement, and it hasn't released any statements about how it is interpreting its obligations under that agreement. I think that decided to avoid the problem and see if they can get away with it – that's my sense at the moment – or they're making a gamble that the Moon Agreement is so undersubscribed that there will be no pushback (...). I am interested to find out that Australian space law expertise. There's very little academic memory of why Australia signed the Moon Agreement in the first place, which I find really intriguing – they seem to be uninterested in the history of that policy position of Australia internationally.” (INTERVIEW 11)

(158) “The bit that I'm quite critical of on the legal side is the Moon Agreement. So we're looking at going to the Moon, extracting water and so on, and many people say that if you're a signatory to the Moon Agreement then you are precluded from doing anything like that. There's a big regime that needs to be in place – the regime doesn't exist, and there's not very many signatories. Most – NASA for instance but many overseas people – have not signed that agreement and are critical of Australia for having signed that agreement. Now, Australia has also signed the Artemis Accords with the US, and again many people say those two instruments are contradictory – you can't have both. So we need from the space agency clarity, real clarity, on how you can be a signatory to these agreements, how they are interpreting them, to say 'We interpret the Moon Agreement to mean that we can do this that is consistent

with the Artemis Accords where we interpret it to mean this.' And that timidity from the legal part of the space agency is the weakest link. The worst part of the agency is the legal side. Very, very risk adverse, and space is all about risk.” (INTERVIEW 1)

(159) “There's a strong idea that it's going to be Australian tech that mines the Moon and Australian tech that like equips the Artemis Mission and that that's a source of national pride, but we actually have never had the conversation – even with the space sector – of why we're going to go and mine the Moon. Do we want to mine the Moon? And even before that, what do we want to do on the Moon? So it's a really weird question that no one asks, which is like, 'What is something we could do on the Moon that isn't mining it?' and people are kind of like, "Huh?" (...) There is this acceptance that we're going to mine the Moon. 'We're going to mine the Moon, so now we have to mine the Moon before anyone else mines the Moon and we have to make sure all of our laws are in place and all of our tech is in place to mine the Moon quickly because otherwise we'll miss out.' And, yeah, it's this weird thing that's like a race to do something that no one actually wants to do; they only want to do it because someone else might do it. And then if you dig into it, you find that their underlying presumption is that this is natural because humanity is on a natural process of developing civilisations and that it is our destiny to become a spacefaring civilisation and for humans to conquer and inhabit other planets and other solar systems. And if you dig into that idea, you get into a whole bunch of weird stuff around people's ideas of existential philosophy, basically, and the purpose of humanity, but suggesting that maybe that isn't the case tends to elicit strong responses (...). The actual conflict for me between the Artemis Accords and the Moon Agreement is around benefit sharing and the idea that the Moon Agreement says that the countries that mine the Moon have to share the profits or the benefits that come from that process with other countries and specifically with countries that were not involved in the mining effort, and that to me is the fundamental difficulty for the US in accepting the Moon Agreement.” (INTERVIEW 5)

(160) “We're in a really unique position because we are a signatory to the Moon Agreement. There are very strong views about this, and there are Australians on each side of the fence, some who believe that you have to use the Moon Agreement to establish appropriate rules of the road. I know there's very vehement opposition to that in the US and other parts of the world. How that plays out is very unclear at the moment because Australia, as I understand the Artemis Accords, is part of trying to establish some rules of the road but through bilateral agreements, rather than having some truly multilateral agreed treaty or process.” (INTERVIEW 26)

(161) “I think that Australia signing the Artemis Accords was such an act of betrayal. It's a way of trying to sidestep the Moon Agreement, but it's done under the cover of night, it's done under the cover of a fabulous, exciting project named after a goddess of the Moon (...). Luxembourg, UAE, Japan look like they will follow in the same way, passing their own domestic space resource ownership acts and then essentially, yeah, behaving as if they're going to give flags of convenience to any space operators who want to go and do this. I think Australia has to think really hard again about how and why it partners with the US. And obviously there's all sorts

of geopolitical things that I do not know anything about, and there's probably all sorts of pressure in terms of the Five Eyes network and the military connections and the national security stuff, and on that we're all flying blind. But the Artemis Accords are hollow and rotten to the core because they are founded on this notion that the US can give its own citizens this exceptional right to own something that should never be owned, and as such they have ripped open this whole idea of a space resource economy and have done so much damage to all of the years and years of treaty-making and established space law that's always defined space as a global commons." (INTERVIEW 30)

Amongst those who saw no major departure from the Moon Agreement but an opportunity in the signing of the Artemis Accords:

(162) "The Accords didn't turn out to be as worrisome as I thought. I was concerned that they would just be a vehicle for encouraging countries out of the Moon Agreement and for coercing countries into supporting the United States' view of space as an area that is not the common heritage of humankind, but that is, on the contrary, something that belongs to nobody on a 'first come, first served' basis. It hasn't panned out that way so far. Instead, I would speculate that the Moon Agreement countries and perhaps others have negotiated with the United States to tone down some of the rhetoric that appeared in President Trump's executive order. The Artemis Accords state expressly that everybody is going to comply with the laws that apply to them, so that to me suggests that Moon Agreement countries may have said, 'Well, we're not going to sign this Artemis Accord unless you soften it a bit.' So I think what that means is, we were worried that participation in the Artemis Program would be used as a carrot and stick, and if you stayed in the Moon Agreement or if you didn't agree with their particular view – which is a newly acquired view, really, in the United States – that you couldn't play in the NASA sandpit. But I think that threat, which perhaps was just imagined by me, seems to have gone away, at least for now. Now, whether or not any Australian companies will ever be able to play in that area or whether it was always just a promise that was held out but they never really intended to involve the international community, other than maybe the big ones like Airbus and, you know, the European Space Agency perhaps, I have a feeling that the reason they need the Artemis Accords was to make it look more multilateral than it is." (INTERVIEW 28)

(163) "The Artemis Accords is maybe having that push. We need that at times. We need a certain push to actually go somewhere. But how do we influence that, or how do we actually help to shift that narrative as well? And I say that in terms of Australia signing up. That puts us in a really unique position because we were the first one signed up and we're the only ones signed up to the Moon Treaty as well. So that actually gets us in a great spot to say 'No, let's not forget the Moon Treaty. We've done this great work, innovative back then, and let's hold onto it, not let it go,' and bring that to the table. And I would have loved to have seen more engagement from the space agency around some of the legal personhood [of the Moon] work, but I know they needed to step back because of the political sensitivities at the time around those conversations obviously happening with the Artemis Accords and not

being seen to stop lunar exploration through supporting legal personhood. But it's a shame, because it's never about stopping from my point of view, it's about adding to the dialogue and reframing, and it's actually helping to shift the narrative away from technology as rockets and hardware to soft law and legal structures. That's a technology, and I think legal personhood presents that. So the agency could also pick that up as they have the Moon Treaty and take it to the Artemis Accords and really innovate and allow for lunar presence." (INTERVIEW 35)

(164)

"Rather than being a disadvantage for Australia, being a signatory to the Moon Agreement, it's actually an advantage because at the moment there is no legal framework – this is before the Artemis Accords came along, but then the Artemis Accords are still fairly silent on a lot of this stuff – there's no legal framework for how you might go about using resources in space, to make things, extracting water, extracting oxygen, whatever you want to do. And within the Moon Agreement it is fair game for any country – because everything's done on a nation-state basis – to extract resources or to do that stuff for scientific purposes, so it's the only international instrument that says, 'OK, you can do this for this purpose.' So, as a starting point, the Moon Agreement might look like the best place to go. Within the Moon Agreement it then says: 'Anyone who's a signatory to this agreement will need to follow a regime.' So this thing was written in 1977, and since 1977 that regime has never been developed, so from the Australian point of view it makes perfect sense to me that we develop the regime. We say, 'If we're going to do this, then here is a set of rules'. And it's a multilateral international instrument. The Artemis Accords are bilateral instruments between the US and everyone else. So, the Artemis Accords are meaningless without the US because it isn't an individual signatory with all these different separate people, but there's no regime described there and it doesn't say how it's going to be legal and whatever else, so in many ways the Moon Agreement offers a way forward, but Australia's not taking the opportunity to do that." (INTERVIEW 1)

(165)

"The Australian government has decided on legal advice, as far as I understand, that there is no conflict between the two and that they're able to sign both and go ahead with both. And honestly again, pragmatically I think that's a win because I can't see a world in which we would not have signed the Artemis Accords, and I would hate to have seen us pull out of the Moon Agreement. I understand that there is a legal argument to be made, that if it's for scientific purposes, then it's in concert with the Moon Agreement and there are no issues there. I think from a practical perspective, saying that it has to be for scientific purposes is an interesting one within international law in the context of, say, the whaling case: what does it mean to be for scientific purposes, what does it mean to not be for scientific purposes? (...) If you say something's for scientific purposes or that we're just going to be doing scientific mining, it does make everyone a lot more comfortable with the idea, and there's some benefit to that because realistically technologically we're so not there. We are not going to be there for a decade at least. This idea that we're suddenly ready to mine the Moon and make billions of dollars is ridiculous. First of all, who's going to buy the stuff? No one needs it. And second of all, we have barely got to the stage where Japan was able to send a little probe to an asteroid and make a little explosion and collect a little bit of dust and that was super exciting. So I see that there are legal

and conceptual impediments to strip-mining the Moon, which I'm glad are there, but I also take great solace in the idea that technologically things will move a lot slower and we will have ironed out a lot of this stuff by the time we actually get to wanting to do something." (INTERVIEW 5)

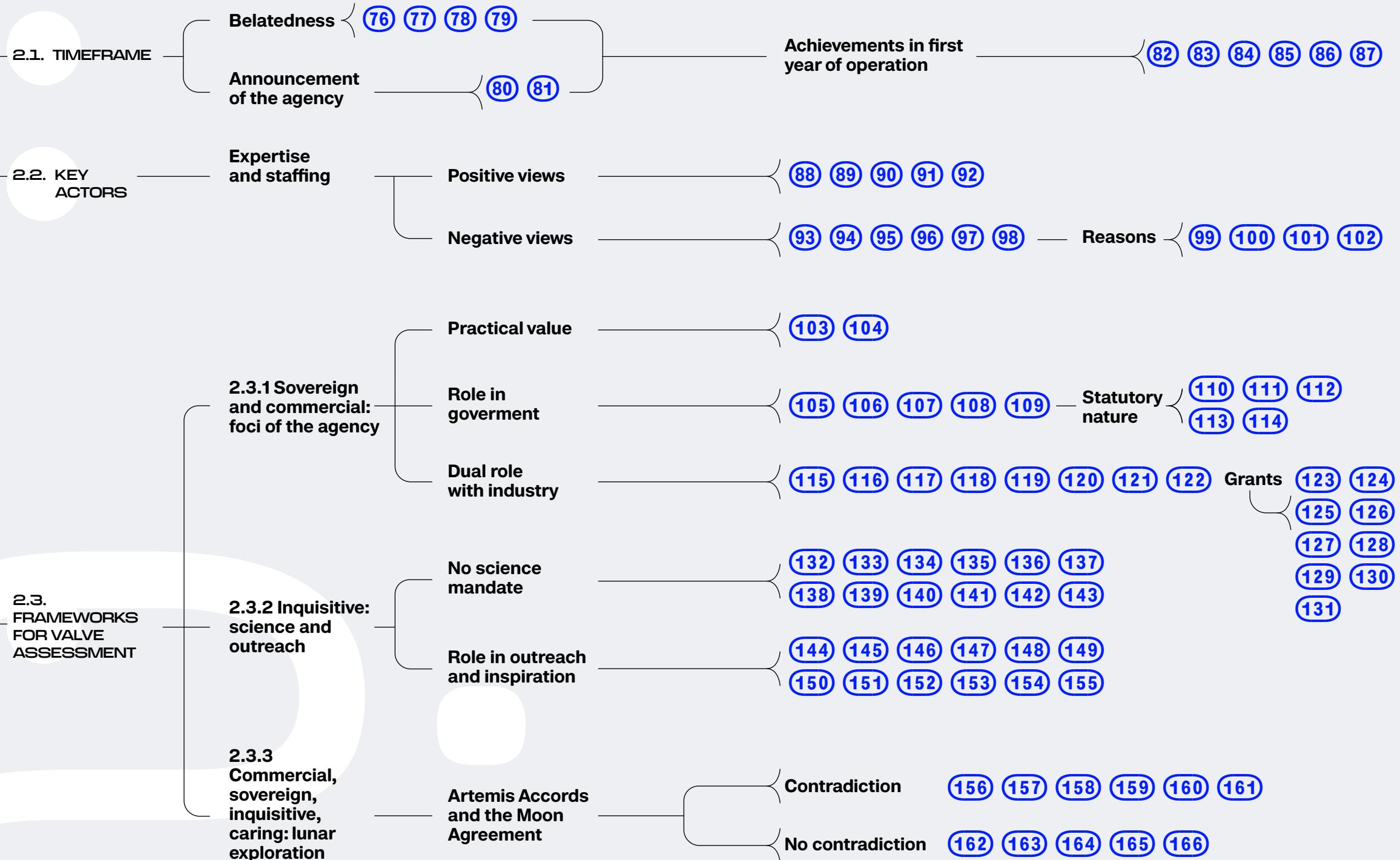
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"We signed the Moon Treaty, which said we weren't going to go and try and mine the Moon, and then we signed up to Artemis, which says it's okay for private companies to mine the moon, so I find that interesting. I don't know what industry thinks – I think industry is quite excited to be working with NASA and anything to do with Artemis. I think it's inspiring. I think human exploration is very expensive and very risky. I would have preferred something like more of a robotic approach, like the Chinese are doing, because it just makes things more possible. We're not geared for human exploration. It's extremely expensive. And so we'll always be a second cousin to the US. Whereas if we, if we're doing fully autonomous, we could have really contributed in a niche novel way." (INTERVIEW 36)



On the Way to the Full Moon Credit: Luis Argerich

02. AUSTRALIAN SPACE AGENCY



CHAPTER 3: PERSPECTIVES ON KEY GLOBAL ISSUES IN SPACE



Australia's institutionalisation of its space sector around a set of goals and a national agency is taking place in a period marked by fundamental changes in the role of space. In this brief chapter we summarise perspectives around a key area of interest in the interviews which involved how our interlocutors characterised the recent past and current moment in global space activities, and what they see as the most useful concepts for that characterisation. Terms like "NewSpace", "Space 2.0", and "Space 4.0" have gained great currency in the last two decades, and issues of "democratisation" of space and "sustainability" in space have also emerged strongly. These categories currently circulate both as descriptors and as aspirational horizons and, as such, convey different meanings and value commitments. Our aim in this chapter is to observe the convergences and divergences of perspectives around them.

3.1. TIMEFRAME AND KEY ACTORS: WHEN AND WHO IS "NEWSPACE"?

Regarding the overall characterisation of the present state of space affairs, some interviewees discussed the meaning of the term "NewSpace" regarding its usefulness for Australia in the last few years, the new actors that it brings into the picture, its overlaps with "Old Space", and other terms that could describe the present dynamics:

¹⁶⁷ "I think it was only 10 years ago that there was a shift from Old Space to NewSpace with start-ups starting to blossom, and start-ups doing some space situational awareness, ground-space sensoring, and looking at quantum communication in space, optical communication. And just lots of great innovative ideas and wanting to start implementing that." (INTERVIEW 23)

¹⁶⁸ "In Australia, Old Space or the old narrative comes to 2017 and a new narrative begins at that point with the establishment of the space agency. That's what I hope will be." (INTERVIEW 2)

(169) "NewSpace is one of those catchphrases that stuck and caught on and became industry slang. So, we all know what it means in some ways, enough to get along and have a conversation. I guess it does describe the new period of time where there is a groundswell of activity as opposed to the last 30 years." (INTERVIEW 35)

(170) "We all understand what space is. Traditionally, what has been for many years were big satellites, big rockets, billions of dollars poured in every mission just for government and big companies – that's Space 1.0. So, in the past twenty years I think there's been a lot of injection of innovation coming from the software revolution, such as the dot.com revolution, in which software methodologies were brought into space. This is a different approach that is lowering barriers. People building a rocket, exploding then failing, etc., that for me is what Space 2.0 is, a step towards small increments of development instead of big. A very commercial focus and less investment." (INTERVIEW 17)

(171) "I think for Australia 'NewSpace' is a useful concept because it brings with it that sort of agile, new kind of 'you can start small, you can be focused' kind of ethos. And because Australia only has a small and NewSpace agency and does not have large space primes with a long history of building large-scale space activities in the country. Space 2.0 is how we characterise it, but I guess it's the same as NewSpace. It allows you to – as a small country in the space ecosystem – to say: 'OK, we're small but we can still do these kinds of fast, agile things in a way that maybe other space agencies find more difficult because they have more kind of vested interests.'" (INTERVIEW 22)

(172) "I think you have to have something to describe this moment because clearly we've moved on from the old days in which essentially space is something that major powers do through government-run, taxpayer-funded space programs that are end-to-end. You don't see the Australian Space Agency building rockets and satellites. The commercial sector is doing that, so we clearly need to have some sort of term that describes it. Space 2.0 I think is a good term because it recognises there's been a step change from that original approach that is epitomised by NASA or ESA or Roscosmos to where we are now where you're having a whole host of small, medium, and large commercial actors. NewSpace I think is a term that is bandied about to describe the sort of billionaire Elon Musk, Jeff Bezos space leaders in trying to do things themselves, but I find the NewSpace term less useful than Space 2.0 in that sense, because to me it's all about the commercial side of things. I would suggest that where we're headed if things go well is we're going from Space 2.0 to Space 3.0, which is really about space-based manufacturing and space-based economic activity, and that all really depends on accessing lunar and space-based resources and that's, I think, where the next big leap in space activities is going to occur." (INTERVIEW 25)

(173) "Space utilisation is one way of looking at space, and I think NewSpace was a mission driver – it was about democratising access to space. NewSpace now, I think it's used a little bit more – how do we say it – sarcastically to reference a little bit more of a start-up approach to space, making use of the opportunity of this new access to space. When I think about the Australian space ecology, I really only use NewSpace in terms of its space start-up culture." (INTERVIEW 32)

(174) "I both hate buzzwords but at the same time I'm learning that they're really useful because I end up developing new definitions, and then no one knows what I'm talking about so it's really a double-edged sword. There is a sharp change between Old Space and NewSpace. I think things have dampened over the last couple of years in particular where we realised 'Well, it's not that NewSpace is an entirely new way of doing things.' A lot of people will say – five, ten years ago – that NewSpace was going to be this entirely different way, totally detached from the old way of doing space, which was seen as very conservative, with lots of huge big budgets where things had to be government-funded. But we've got NewSpace, the ability for small entrepreneurs to come in with minimal projects just to try things and just see how they go and that everything would be done entirely differently. These two things have kind of converged now into one. Old Space companies are operating just the same as NewSpace companies. You know, SpaceX has learned that they can't just do things the way that they were doing when they first started, especially when they have to work within regulatory frameworks that are developing now as well as ULA and those sort of traditional companies have realised, well they have to operate a little bit differently; they have to do more innovation; they can't just rest on their laurels anymore. So there's been a bit of a convergence there. That does still mean that there is a big difference today between the space sector as to what it looks like before. So Space 2.0 as a term probably does make sense to talk about, but I think it's always helpful to realise that in terms of, you know, the intricacy. It's not like there was just a step change and these things are totally detached, it's just that things have evolved and they're different." (INTERVIEW 16)

Other interviewees focused more specifically on the different meanings conveyed by this terminology and the need for some clarification:

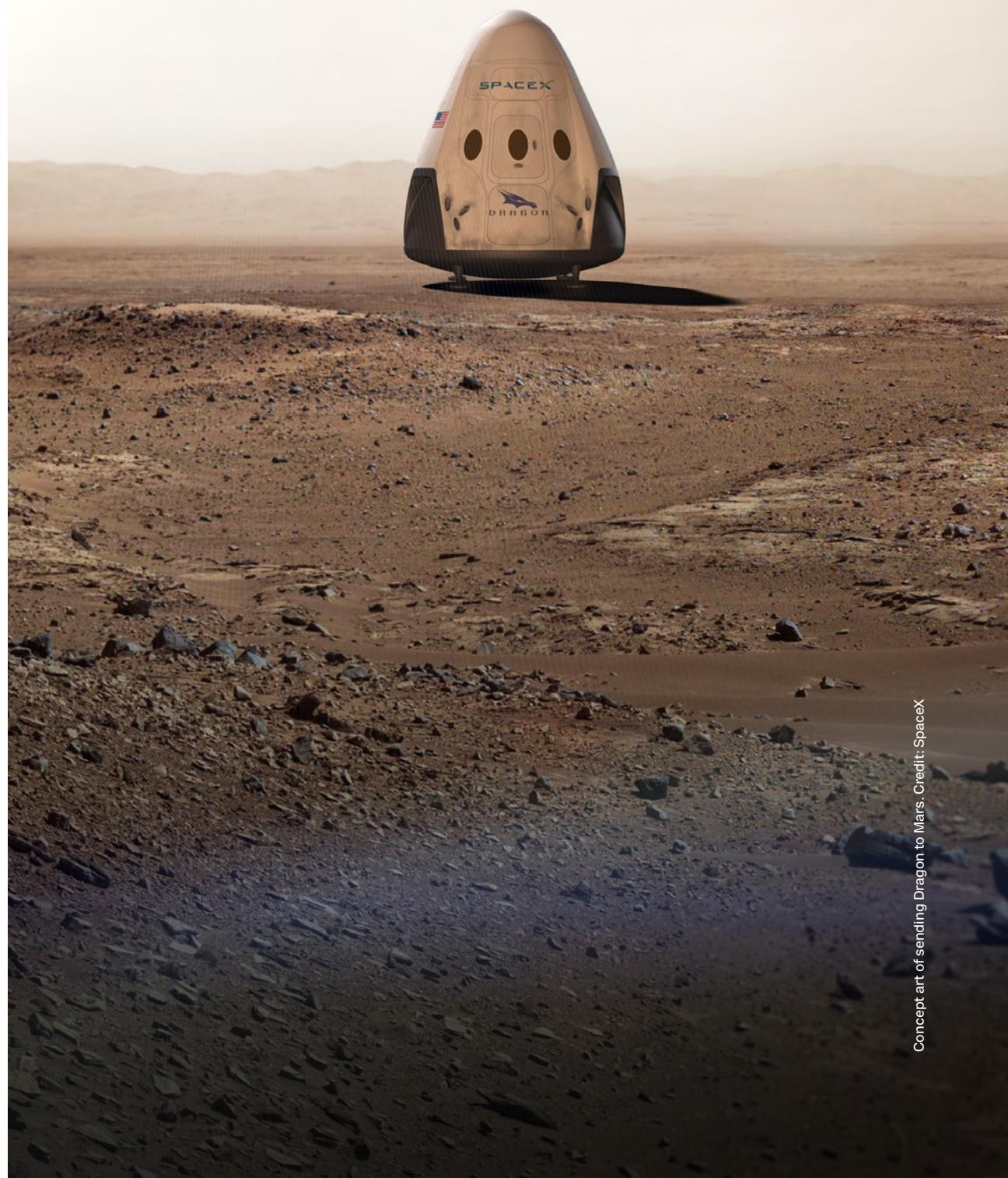
(175) "NewSpace means a bunch of different things to a bunch of different people. To some people, NewSpace means commercial space, and if that's the case we've been doing it for 50 years because telecommunications, satellite relays for phones and television signals have been around for about 50-odd years now – it's not particularly new anymore. Doing it as purely commercial stuff in the US, that's about 30, 35 years old, so, yeah, not particularly new. People saying, 'This commercial revolution', no. Space has been more commercial than otherwise for a long time. I believe, thinking back to the last time I read the US Department of Transportation Commerce Office Civilian Space Economy or State of the Space Economy Report – something along those lines – they had this big pie chart where they divvied up revenue from direct space business by various sectors, and the largest sector, accounting for about a quarter of the entire amount of revenue, satellite television, because people like watching football. You then have GPS, cellular phones, other bits for communication, navigation, timing, pointing. Governmental space is about a quarter of the total space expenditure around the world. So, saying NewSpace is commercial space, no. For NewSpace being CubeSats, again CubeSats are about 20 years old, not particularly new. People figuring out stuff to do with CubeSats that you could actually use to turn a buck, that's new – that's only about five, six, seven years old. So it's a combination of things, as a lot of these answers are. It's a confluence of lower barriers to entry, lower

cost barriers, and broader capabilities that has driven a lot of people realising that they can actually do a lot of things in space that they didn't think they could even a couple of years earlier. So to me that's NewSpace." (INTERVIEW 18)

(176) "In my opinion there is so much misuse of some of that terminology. NewSpace for me was about the different funding dynamics, and it essentially starts with a handful of billionaires who are redefining everything. They want to do things with commercial funds but they don't have to play by traditional commercial rules. They've got extremely deep pockets, so they don't have to report to their own like shareholders – they are driven by personal visions they want to pursue with their own money (...). Space 2.0, on the other hand, is the adoption of the kind of IT world's view of quick iteration, deploy things quickly, you test it, break it, improve it, you don't stand still, you keep moving things forward, and you shift away from the kind of super-duper high reliability, long-life, super-expensive technologies that used to characterise space to more nimble technologies that follow this paradigm of 'fly it, test it, break it, improve, fly it, test it, break it,' and 'let's just deploy something that'll work for two or three years' knowing they're going to replace it. Technology evolves; IT systems evolve very quickly. So that to me is the essence of Space 2.0, which is very different to the long-term visions of the people who characterised the early NewSpace era. And the other thing with NewSpace is that it was about doing things that could only ever have been thought of as the domain of governments previously, whether it was developing launch vehicles and technologies, building space habitats, and I would argue that it extends now to things like off-Earth mining, space-based solar power. People are looking at these through commercial lenses and their benefits to humanity, the benefits to the future of humanity, and that to me is the key aspect of what NewSpace is about, and I personally hate it when people interchange NewSpace with Space 2.0; I think they're very different things." (INTERVIEW 26)

(177) "Everyone has their own particular definition of what these terms mean, and I've heard some people say that we're actually in Space 4.0 or even approaching Space 5.0. Old Space was governments doing stuff, NewSpace is private companies doing stuff. I think Space 2.0 is this idea of moving towards space-based industry, self-sustaining if you like, and techy stuff, but it is just a buzzword. It's something that sounds cool and it's something you have to say in order to sound current and relevant. It means something to people actually working in companies in the sector and it does have a meaning, but the constructed meaning is very much just one of 'this is the current thing and everything else is old school.' That would be my take. I think they're useful terms in the sense that they allow us to demarcate who would consider themselves part of that club by using that term." (INTERVIEW 5)

(178) "I keep talking about Space 4.0 instead of Space 2.0 because I actually think that's more useful at the present time, and people who are talking about Space 2.0 are lacking in imagination. And the NewSpace thing is, I mean that's kind of interesting, isn't it? All this stuff is about having agile operators who are working on small budgets and small technologies that will have big impacts. I'm probably very cynical and sceptical about all of these terms." (INTERVIEW 4)



Concept art of sending Dragon to Mars. Credit: SpaceX

3.2. FRAMEWORKS FOR VALUE ASSESSMENT: DEMOCRATISATION AND SUSTAINABILITY

Regarding the notions of “democratisation” and “sustainability,” above all, they appear as values in their circulation. We asked about them in the same question, which led to some interviewees to treat them in a unified manner or to draw specific connections between the issues raised by these terms:

(179) “I think we embrace the democratisation of space and the sustainability of space. We have technology that can deorbit itself from space. We can develop technology to grab other satellites and take them down when they’re dead, and what is really missing is a mandate to do that. And I’m quite concerned that some of the American satellite companies are taking away more of the fair share of the orbital paths that are in low Earth orbit, and I think that’s a big concern. You look at SpaceX especially – they’re going to have 40,000 satellites in orbit between like a thousand and 1,200 kilometres. That’s very, very congested and makes it extremely difficult for anybody else to go there, and so I think we have to kind of start adopting similar rules to geostationary orbit where we allocate a certain amount to each country and keep it fair like that.” (INTERVIEW 14)

(180) “Democratisation obviously implies there’s a greater number of actors in space, both state and non-state, and that’s apparent to everyone. The commercial space capabilities that have evolved since the 90s have made space easier and cheaper to access. It’s not just about SpaceX launching reusable rockets, it’s about the lowering cost of satellite technology to be able to do more with less and utilise multiple satellite swarms to achieve the equivalent of what a single large satellite could do. That opens up innovation cycles that are faster and you can do quicker for less money. So, the end result of that, for big powers, is to have the potential to exploit new capabilities in radically new ways. And, for small actors, they can get into space is the outcome; they can do space, whereas they couldn’t before. And countries like Australia, which previously couldn’t even consider building satellites, now can build satellites and launch them. So that then creates the problem of sustainability in the sense that if we have more countries and more actors doing things in space with more stuff up there, we have increasing congestion in space, increasing problems with space debris. How do you maintain spectrum frequency allocation if more satellites are up there doing things? We do have to come up with some sort of legal and regulatory structure to manage this, and I think that we’re just starting to grasp this problem now and what probably needs to happen is some international conference on space sustainability that deals with some of these big issues. In the same way that we’re having regular meetings on climate change, we need to have something about space sustainability, because otherwise you do have this escalating, out-of-control competition that ultimately makes everything worse for everyone.” (INTERVIEW 25)

(181) “I don’t hear a lot about democratisation of space anymore. That used to get talked about a lot in 2015, 2016, when small space was kind of a new thing. Now people

talk more about accessibility and interconnection of space assets. We’re like, ‘OK, we democratise space, we set up a bunch of small cube sets from universities.’ But it’s got to be bigger than that. Now, they’re thinking more about congestion and space rather than democratisation of space. Sustainability is interesting because that kind of gets thrown around in a couple of different contexts. One is, what’s the sustainability of the Australian space industry? How do we make sure that the jobs are here tomorrow? Then there’s the environmental sustainability discussion. Increasingly, we’re starting to have a discussion around the language where space is more about an enabler monitor of climate change, sustainability, and interest in that from an Australian perspective. So, yes, it’s a word that gets used in different ways.” (INTERVIEW 33)

Two interviewees focused on the issue of democratisation in terms of cost of entry to commercial activities, while others had a broader approach to the term, which allowed them to raise points of critique of prevailing notions in the sector. Amongst the first:

(182) “Democratisation of space is very much tied to the price point of the entry. You’re always going to have big companies that want to be bigger, you’re always going to have medium-sized companies that flirt with the idea of becoming primes. I think that’s normal, I think that’s normal capitalism and economic drive. The problem happens when you have fewer smaller actors able to enter. It’s all about your ability to start a new company, a new venture. Right now, when CubeSats first started, the price point was about \$150,000, and that included launch. That’s gotten more expensive. Now if you’re starting your own CubeSat company, you kind of need a half a million to do everything you need to do, so it’s become a little bit less democratic, and you’ve seen that in the volume of new companies that are starting, and we don’t want that. We want things like 3D printing to reduce the cost down to \$30,000 per satellite, something like that. As far as like space resources and things like that, I still think that’s far enough in the future that it’s not really easy to predict at this point, but it’s all going to come down to the ability to produce new businesses at the end of the day.” (INTERVIEW 15)

(183) “Big business has always been in space. Being able to get smaller systems up into space means small businesses get to space too. So it’s not so much a democratisation as you don’t need to be a really big player to get into space anymore; you can get into space as a medium-small nation with a modest budget. You can do this by raising about the average price of a house in Sydney; you can have effectively for that price the same level of space program that the entire Soviet Union had in 1957. You too can send Sputnik up for the cost of a house in Sydney – that’s democratisation. Admittedly, you still have to have the price of a house in Sydney, which last I had a look at any of the news articles it was something around 800, 900,000 Australian dollars. So, yeah, not cheap, but you don’t have to have the entire resources of a nuclear power behind you in order to make it work. So it’s not big business, it’s small business, and because small business is getting more people up there, you need more regulation, you pay your money, you take your chances.” (INTERVIEW 18)

Regarding critical perspectives of the current use of "democratisation:"

(184) "The word 'democratisation' is often used around CubeSats, and the idea that this stuff is suddenly a lot more accessible, and that communities are suddenly going to be availing themselves of space data and be launching their own satellites and doing all that kind of stuff. And I suppose there's an element of that. I mean if you look at what Fleet and Myriota are doing, they are Starlink-like sort of lowering the costs of accessibility to space data that can be incredibly effective in doing things like running agricultural businesses in remote areas and across large scale, so in a sense that's an accessibility issue, I guess. I mean whether access to these kinds of things increases people's ability to participate in democratic processes or strengthens democracy and participation and inclusion is a completely other question. And the other reality is that we're not yet at the point where you can buy a CubeSat off the shelf, pay someone to launch it and craft it to get your own data – we're not at that level of democratisation. Democratisation is a process. If that's meaning more people can get involved, then OK, maybe more people can afford to invest in CubeSats and invest in launch than could before, but those are still going to be investors; they're not going to be households or people traditionally excluded from this market. And then if we go onto the other side of that, is this technology and this data going to contribute to the democratisation of political and social processes? Well, I don't think we have any evidence to suggest that that's going to be the case." (INTERVIEW 4)

(185) "I think democratisation is the word that's thrown around a lot. I think it's masking something that is very much not democratisation, which is that we've moved from governments having access to space because they're the only people who can afford it and that is inherently democratic in a sense because they're elected by the populace who then support through the process of democracy their political and policy decisions. The idea that private companies having access to space because it's cheaper now is now democratic I think is fundamentally flawed just from a logic perspective, because actually that just means that rich people with resources have access to space and the vast majority of people on Earth never actually get asked whether or not that's OK. And examples of that would be the Starlink satellites, for example, where there's a decision made that 'We're going to make this thing and that they're going to look a certain way and then we're going to launch this many', and then that goes through government in America who then approves that, that's fine, and they get launched and there was no process by which America consulted the rest of the world on that because it wasn't a government decision. Whereas if it had been a government decision to launch all of those satellites, there would have been an international discussion about whether there was to be an international collaboration, and other countries would have had the opportunity to on behalf of their people raise any issues they had. So that's just an example where I think you can clearly see that it is not democratic. For the vast majority of people in Australia, they don't ever get asked about what they want to do in space, and my experience of speaking to young people in particular has been that they don't like what's happening in space, that actually there's a sense that we're out of step, that the government and technology people and companies are heading towards saying, 'Let's launch loads of satellites and let's

go and mine stuff' and the young people are saying, 'Hey, hey, hey, no, no, no. Let's do some science and fix what's happening on Earth and fix climate change and fix consumerism and deal with the problems of post-colonialism and capitalism and the tensions and wealth inequality and human rights abuses and all of those issues on Earth. We actually do not care about sending another Rover to Mars or whatever.' So democratisation is a buzzword and I think it is just a buzzword, and in a way it's a bit Orwellian in that it says that it means something it means the opposite of." (INTERVIEW 5)

(186) "People talk about a democratisation of space, but I think it's a misnomer. Why are commercial actors doing it? Why are the bigger actors doing it? They're doing it to make money, notwithstanding all of the words they say about greater good and benefit for all and all those visions. They're doing it largely for their own reasons, and I think we will see a greater divide in space capability like we have the digital divide (...). Democratisation in one sense means more and more people are having access to space in some way, shape or form, but the differential in their access is growing wider and wider and wider. And so I don't think it's a true democratisation. I think there are more actors, but that's not democracy, because democracy, the very essence of democracy, is that everybody has a say in decisions. and I think we're actually moving away from everybody having a say. Decisions are being made or inevitabilities are being constructed without asking those questions because we can do it, and so because we can do it, because industry is creating capabilities or at least spruiking that they're creating capabilities – because what industry says and what industry can do are two different things – we bypass the question of 'is this something we should be doing at all?' So, we're moving further away from asking the questions where the whole range of voices have a say – that's for me what the democratisation of space should look like." (INTERVIEW 3)

(187) "There are many irrationalities in the argument that they're democratising space, that by making space cheaper that more people will access it. I have such a problem with that (...). Democratisation is not just about access, it's about design, so I feel like the way they think about democratisation is kind of like it's incredibly paternalistic; it's like, 'We will design the modes and the nodes through which you will be able to access space, but you'll have no control over that.' We live in a world designed by systems that we didn't necessarily design and that don't fit well with us, and we know the damage that they've done but we're stuck in them. I don't want to live in those same sorts of systems in space. To me, that's not democratisation at all. And, yeah, if they were really serious about this being democratic, they wouldn't be so threatened by criticisms of those models (...). We're going into a very dark place but nobody seems to notice because they have these little – you know, I think of them as magician tricks that they're using to just distract us from the real things at stake." (INTERVIEW 30)

(188) I'm not so strong on that narrative of democratisation. I guess I'm stronger on the narrative 'giving everyone a voice about what happens', and that is opening up a wider dialogue beyond the space industry to engage more non-space actors to have a voice, so perhaps that links into democratising by – because a lot of the public

don't even know what's going on, you know, and that seems to be the first thing is education, raising awareness as well as bringing the new narrative and then giving them something practical to actually take away and help decide. Industries opening up and CubeSats being launched and that does attract a certain type of person, more engineer-focused, more commercial-focused, and that's a reality of the world we live in is it has to be commercial and it has to have an outcome to be sustainable." (INTERVIEW 35)

(189) "There is this idea that once we're in space it's going to be like *Star Trek* and that we are going to be the best versions of ourselves. The fantasy that 'space will make us respectful and tolerant and wonderful to each other and there'll be no problems with colonising Mars'. And that's the word that we use is 'colonising'. Have we learned nothing from the past hundred years about colonialism?" (INTERVIEW 31)

(190) "If we are truly to democratise access to space, then we need to start to think about the human component of that, the human voice. We are envoys and envoys of humanity inclusive of a whole range of cultures and disciplines, and as we are preparing spacefarers, star travellers are increasingly asked to expand their repertoire of skills to be excellent communicators, to be infinitely available to be socially engaged throughout their missions." (INTERVIEW 32)

The notion of sustainability raised a long-standing and profound discussion about the nature and purpose of space exploration and the legal status of outer space bodies, and here views amongst our interviewees differed in ways that are indicative of broader unresolved issues in the relationship between exploration, custodianship, and exploitation of outer space:

(191) "I agree that an environment has a right to exist in its own right, but I think, importantly, even before you get to there, we have to realise that space is not just a playground for a couple of billionaires and two or three very wealthy countries, and it's not just a playground for people who want to create businesses. It is, in addition, a place that has an important place in literature, religion, in culture and for Indigenous peoples around the world. It's not for us to impose our own world view on something that is an important aspect of people's lives and culture." (INTERVIEW 28)

(192) "Sustainable is one of those words that you stick on anything to make it sound more politically sustainable, so I think there is an interest in doing things sustainably, but I think there's more of an interest in being seen to be doing things sustainably. If you look at Antarctica, what ended up protecting Antarctica was the strong green movement which was saying, 'We actually don't want to go and mine this place. This place is really special and we're destroying the Earth through everything else and we don't want to do that in Antarctica.' When it comes to space, I don't think that there's such a green movement as such: there's a sustainable movement which is a halfway house of, 'OK, we'll go and do it, but we'll kind of do it nicely,' which I think history tells us probably won't work, and again I think it's out of step. I think that you've



2021 Antarctic eclipse. Credit: René Quinónes/NACH

got the younger generation coming up who are saying, 'Why are we doing all of this stuff? Why are we sustainably mining anything in space when we aren't sustainably mining Earth? There's no need for us to do that. We should be focusing on having less of an ecological impact on our Earth, not going and making more money by chipping bits of the universe off and selling it to each other for more money.' That's my sense of those two words, that they're being used to try to bring more people into the conversation, but really actually they're being used to make people think they're being brought into the conversation and they aren't actually bringing anyone into the conversation at all." (INTERVIEW 5)

(193) "If you talk about sustainability, if you talk about protecting the environment, then the centre of your focus is the environment, and clearly you are more likely to protect the environment. But our discussion about sustainability is protecting the environment so that others can use that environment. The danger of space now, particularly with commercialisation, is that more and more of us see space as something to exploit. I think we owe a responsibility to be able to justify what we're doing." (INTERVIEW 3)

(194) "I'm increasingly dissatisfied with 'sustainability' because it's a term that's thrown around; it's never interrogated effectively; it's used as a stand-in for the Thatcherite-Howardite efficiency productivity kind of thing. 'Sustainability' in these contexts is simply a word that sounds nicer than 'exploitation'. That's how it's playing out as far as I can see. So I'm just getting very irritated with it and stopping using it myself altogether." (INTERVIEW 4)

(195) "No one is even asking the first principles questions of like should we go out there, do we even have the right to do any of this stuff that is being proposed, and particularly given the wild, dreaming nature of the economic plans and the fact that there's really no business model and then the fact that any science that's done out there right now is not very urgent, compared to the problems that we are facing on Earth. I am more and more in the camp of 'we don't even deserve to go out there'. There's no real reason to be going out there and to be stuffing things up. I would just love to see the Moon never touched again by a human foot, by a boot print. There's no reason for us to be going into space, really. If we actually looked at what we should have learned from climate change, we cannot just keep putting our own needs above the needs of landscapes, not just the life, not just biological life and the way we understand it, but we can't just assume that everything is there for us to use (...). Space has always been a source of beauty and wonder and awe, and all of those are good things in our lives – and I can't bear it when those things are co-opted and taken away from us and put into service by the space industry and capitalism. And that for me, if that's all I do in my life is just sort of try and point out the little bits when that's happening, that would be enough." (INTERVIEW 30)

(196) "The legal personhood [of the Moon] thing is very much rooted in a western legal system which on the one hand gives it a chance of success because it's a language everybody can understand and because it already slots into that stuff. On the other hand, obviously it has limitations because of that. I don't really expect that anyone

is going to take it to the point where that legal personhood is granted. I mean, what would be the instrument? There's no national instrument to do that with, so that's obviously an obstacle to that. Something I do notice – I don't know if you've noticed this so much but it does seem like the critiques of the language of colonisation and extractivism and everything are getting more traction at the moment, don't you think, like that people are more open to this, just watching on social media the reactions. But I think the Moon is critical because that's really the key to our relationship with the rest of the solar system, isn't it? So if we get it right with the Moon, we've got a chance to get it right with every other celestial body out there, and I think we do have such an intimate relationship with the Moon." (INTERVIEW 4)

Amongst the group of interviewees that sees space as a site for exploitation, there was also a concern with boundaries in this regard:

(197) "Half of my view is formed, the other half still doesn't know. The part that's formed is in how we can use space to be more efficient in what we're trying to achieve today. This is how space-based technologies can improve our farming efficiency, how they can help us manage our limited fishing resources better. And that's when we have to start to think outside of how we've used space in the past. In other words, don't put up big satellites that stay up there forever – put satellites into low Earth orbit, and are less than 400 kilometres, they have a lifespan of less than 25 years, after which they fall back into the atmosphere and burn up. Right. So it's almost a planned obsolescence approach to sustainability. And that's formed a bit of my idea. The unformed bit goes, 'if you've got stuff out there in space, how do you use it to identify or further the industries or technologies that we haven't yet thought about?' So mineral extraction. We can do it on the Earth. But why do it in space? What does that actually mean? Do we use it in space? Or do we try and get it back to Earth to help us do something back on the Earth's surface? And understanding the benefit of that is something I don't yet have a full grasp on. And by that, I mean, I think we need to think through that." (INTERVIEW 13)

(198) "I think in people's minds commercialisation is a lean towards profit in space and exploitation of assets or resources in space and I think the balancing of those two interests. There's a level of exploitation required for us to move off this planet and towards other parts of our solar system and galaxy. That to me requires – you know, a commercial motive will help us to achieve that if democratisation comes with it as well." (INTERVIEW 27)

(199) "If you take an intention of caring for those elements of our natural system, then your actions then are different, whereas if you come at it from perhaps a commercial intention or otherwise it causes destruction and your blinders are on and you have a different outcome (...). The issue of legal personhood to nature is about removing yourself and then listening and then acting and having a relationship. So legal personhood is about giving voice to nature and allowing it to be a stakeholder at the table and setting up frameworks and governance around how to actually help that happen. So I don't personally see it as stopping human activity or inhibiting actions

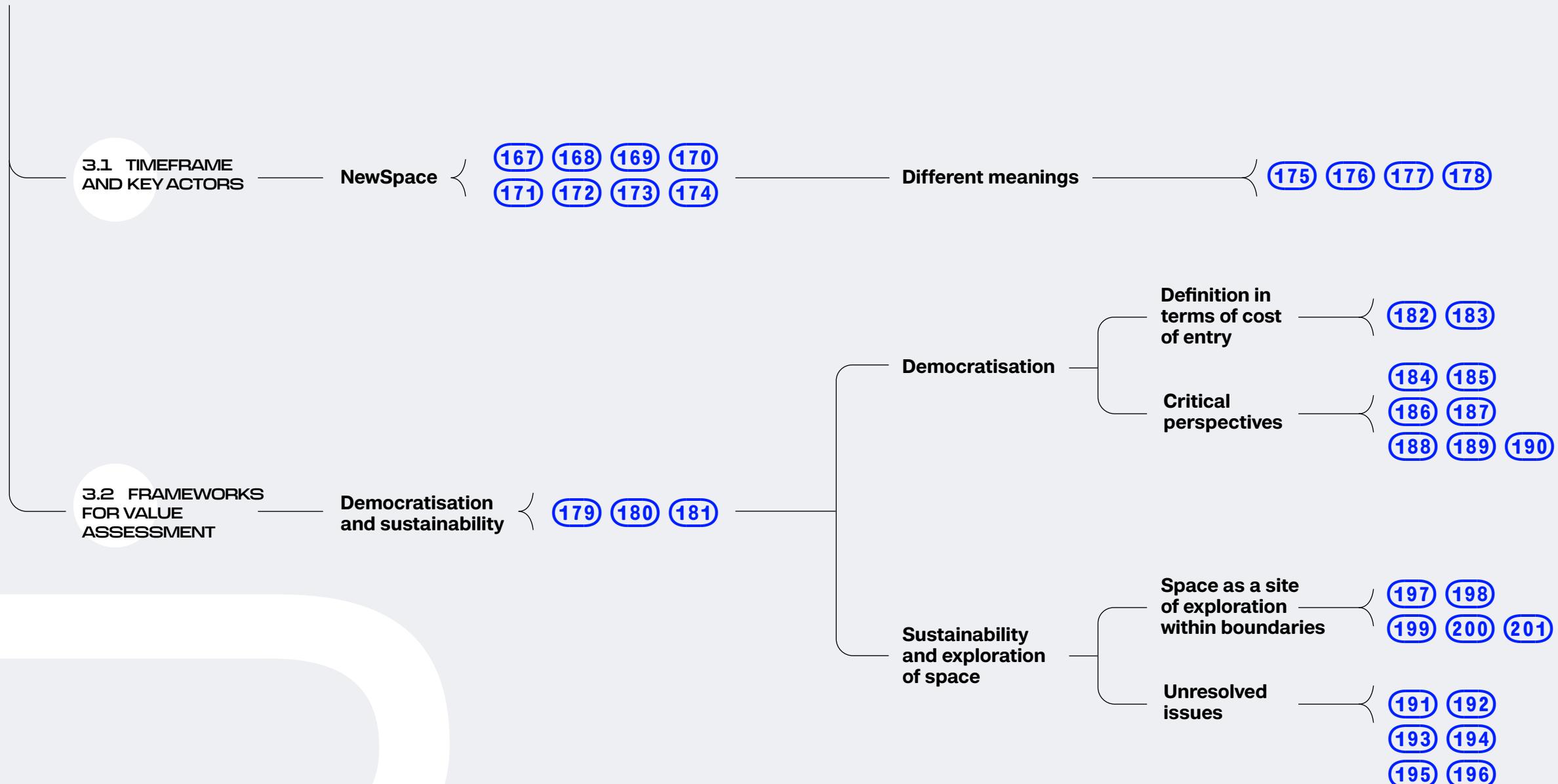
or excavation or mining or habiting, but I see it as a way of having a relationship with place, with landscape, with systems, and understanding the whole. So legal personhood is really perhaps a step along the way from my point of view as that narrative rather than an activist's or environmentalist's point of view towards creating a barrier; it's really about moving forwards (...). Another thing is advocating for the international law of ecocide. For that to become an international crime would actually extend throughout space because it's an international law and the International Space Treaty, Outer Space Treaty, actually, all those laws still adhere. So you'll see in a lot of big organisations CEOs actually can't care for the environment because they're legally bound to destroy the environment for shareholder needs, so that legal governance is not correct and that is a crime; ecocide is a crime as opposed to civil – I think it's civil – crime, civil law." (INTERVIEW 35)

(200) "I think it's going to be very interesting to see how commercialisation of space develops in terms of the commons, I suppose, right. I don't think the international community has or possibly will come up with a consensus sort of approach to how this is going to work. CSIRO is not really talking about mining in space as such, but about using mining technologies in space with an interest in *in situ* resource utilisation, which is obviously it's a nuance, but I think it is quite a different model and one that I personally am more comfortable with, at least for unique bodies like the Moon. I think asteroids are a slightly different question, right. I mean there's a lot of asteroids and it's an ethical and philosophical issue. Like most aspects of this kind of commercialisation, presumably there will be pros and there will be cons, and I guess we'll see which sort of side of the ledger things fall, but we probably won't know for a long time." (INTERVIEW 22)

(201) "I don't buy into the whole 'the Moon is a person' thing. The Moon is a natural body with resources to be exploited. What we need to do is have laws and regulations that allow us to exploit lunar resources or asteroid resources in a sensible manner that doesn't generate competition and conflict and doesn't essentially sort of strip-mine the Moon – we shouldn't be doing that. But I think it's ludicrous to think that somehow you grant the Moon personhood that we then can't use lunar resources because the Moon is central to our long-term future in space. To me, getting back to the Moon and understanding how we use space-based resources is the key that unlocks everything else, because we can then utilise those resources to do so much more in space than what would be the case simply by landing on Mars and doing a flags and footprints mission. So in my perspective, the Moon is more important than going to Mars because it unlocks everything else, but we do have to set up the legal and the regulatory side of things to manage that and allow that to happen. Cutting our access off to the Moon and saying, 'We're never going to use the Moon or asteroid resources' is a non-starter in my opinion and I know who says that, but, no, I disagree with her." (INTERVIEW 25)



03. PERSPECTIVES ON KEY GLOBAL ISSUES IN SPACE



CHAPTER 4: CULTURAL DIMENSIONS OF THE AUSTRALIAN SPACE SECTOR

Alice Springs Datalon antenna has been upgraded and painted with an Indigenous artwork to recognise the Arrernte people as the traditional owners of the land Credit: Geoscience Australia



While Australia's space histories have been well documented, Australian space cultures and space futures are yet to develop as core areas of social and cultural research. This section highlights a set of issues that are frequently overlooked in the more industry-centred perspectives that predominate about the Australian space sector.

The concept of culture is very broad and has been understood in many ways. This report draws on two main approaches. First, following anthropologist Christopher Kelty, we employ a notion of culture as an “ongoing experimental system, a space of modification and modulation, of figuring out and testing”. Culture as an experimental system “crosses economies and governments, networked social spheres, and the infrastructure of knowledge and power within which our world functions today – or fails to” (KELTY 2008, p. 2). Along these lines, the question about an Australian space culture is precisely about the enabling conditions for such an experimental space where different voices and perspectives can come together.

The second approach is in a more specific relation to space. “Space culture”, on the one hand, can be understood as “the culture found within space science and space industry settings, and the broader culture that surrounds this”, as cultural theorist Kat Deerfield observes (2019, p. 4). This approach is relevant for our purposes because it illustrates not only what the space sector in Australia does but the potential cultural implications of the latter in Australian popular culture. As Deerfield notes, “space culture reflects [...] values in its colonization narratives [that] are characterized by heteronormative views of sexual reproduction and normative kinship as the way of accessing a spacefaring future” (2019, p. 118). On the other hand, the notion of “space culture” is associated with popular culture and imagery from science fiction. The United States, as is well known, has a very distinctive “space culture” where the Space Age has had a profound impact on popular culture and where outer space figures prominently in cinema, television, literature, contemporary art, and other forms of popular culture. As Emily Rosenberg notes, the Space Age “offered national and global imaginaries that projected

assumptions about, and debates over, national identities and global futures" (2008, p. 157). Another example is provided by sociologist Janet Vertesi, who has studied organisational cultures at NASA for an extended period of time. She argues that "fluency with science fiction worlds certainly serves as a geek cultural identifier mark of a form of membership at NASA and at this lab" (2019, p. 138).

From a different angle, historian Alexander Geppert uses the term "astroculture" to refer to "a heterogeneous array of images and artifacts, media and practices that all aim to ascribe meaning to outer space while stirring both the individual and the collective imagination" (2012, p.). For Geppert, the notion of "astroculture" aims to insert a distinctly West European (mostly British) element into "the hitherto largely us- and ussr-centered historiography, elucidating the complex relationship between science and fiction, and emphasising the significance of outer space as a site for the projection of competing versions of the future" (IBID., p. xx). Geppert sees outer space as "one of the major sites of twentieth-century utopian thinking" (IBID., p. 4).

This question of emerging "space cultures" within national contexts has also been asked about countries such China and Mexico. Molly Silk (2021), for instance, recently observed how China is developing a distinct space culture. She describes a process that is not widely discussed outside of China, where traditional Chinese culture has been infused in the country's space industry, where state actors propel ideologies of Chinese space exploration, and where "commercial products and media related to China's space program have exploded onto the domestic market" (SILK 2021). For Silk this is an emerging quintessentially Chinese space culture grounded on historical influences and the foundational role of three key "spirits" (in the traditional Chinese civilisation) on which the successes of the Chinese space program rest. Anne Johnson (2020a; 2020b) studied the recently created Mexican Space Agency and its programs, practices, discourses, and alliances to show how Mexican imaginaries of outer space are both shaped by perceptions of past knowledge, present social issues, and future projections and limited by geopolitical realities. She argues that there is a "Mexican space micro culture that involves scientists, entrepreneurs, students and artists involved in clubs and other organisations, academic institutions, and collectives [that tend] to orbit around the AEM [Mexican Space Agency] as a central networking node" (2020a, p. 403). Interestingly, for Johnson the Mexican Space Agency also enacts a boundary role as an organisation allowing for distinct groups who are "future-oriented [to] view investment in the space industry as a viable means of achieving social and economic development in the region" (IBID., p. 404).

These approaches informed the interview questions and responses that we summarise in this chapter. First, we asked what the contours of an Australian space culture might be, or how it might be defined. Second, we bring to the fore Indigenous perspectives beyond the buoyant field of Indigenous astronomy. Third, we provide a snapshot of the interviewees' expert perspectives on issues of equity and diversity within the Australian space sector. And finally, we offer some insights about civic participation in space matters.

4.1. TIMEFRAME: AN AUSTRALIAN SPACE CULTURE?

We asked interviewees if there is something that could be identified as "Australian space culture" in the past or present or as something that is in the process of becoming. We observed a broad consensus around the idea that Australia heavily relies on the United States as a source of cultural models. In this context, however, some interviewees stressed that there are particularities in the way Australia translates the US influence:

(202) "I think we're really just latching onto that US narrative. Some of us are now starting to increasingly highlight the role that Australia played during the space race and things like that as well (...). I think that we're not necessarily going to develop a space culture overall because space is going to be so normal – it is already a part of our everyday lives. We don't really have a culture around airplanes and things like that anymore, even though we get upset if we can't have a hundred megabyte per second internet while we're flying over the Pacific Ocean. That's absolutely incredible, but it's just normal and expected, and that's the way that things should be; we've created new wealth and opportunities for people to access these things, and it should just be expected. So for that reason I think that space isn't necessarily going to be too exciting in the future, especially as we start to realise that space isn't just this homogenous one single location beyond Earth. We've got Earth orbit and Mars and the Moon – these are all separate locations. The locations themselves might become interesting for whatever reason, but I think that with low Earth orbit for example is already becoming less interesting to a lot of people as we start to talk about, 'Well, it's going to be this place where we can manufacture new drugs and new structures and things like this, fibre optic cables'. No one's really going to be interested in that so much unless you're an engineering kind of person who loves that stuff." (INTERVIEW 16)

(203) "I think there's a long way to go before Australia has a space culture like the United States, but I think it's very dependent on launch. I think once we start launching to space and people realise that launching can be done from Australia and Australia's putting satellites into space and there's an awareness of that, that people will become more enthusiastic about space and comfortable with it." (INTERVIEW 14)

(204) "I'm not seeing a distinct Australian space culture yet. There may have been, back in the 60s, but I say that because the community is still quite disconnected, quite fragmented. There are still start-ups who've never had any kind of engagement with a big space prime or prime in a big space company, and just have no conception of the issues. And even some people who are quite prominent in the industry still haven't had a lot of connection with a small firm if they're a big one, or a big firm if they're a small one. So it's quite fragmented. I don't think there's a lot of things that are settled about what this industry is, and what it looks like." (INTERVIEW 33)

(205) "I don't think there is an emerging space culture. I think there is a subculture of aficionados, and they reinforce their own opinions by talking to each other, but by not talking more broadly to the community. The people who are talking about space publicly are astronomers; they are not space scientists or engineers who seek to build space objects. In the 1950s, Australia made a big bet, on the basis of our geography, to invest in radio astronomy, and we still do. A large part of the SKA telescope is being built in Western Australia. In making the bet for astronomy, we left most of the rest of the space argument to the Defence and the National Security Community. Here it became highly classified and beyond the reach of public discourse." (INTERVIEW 24)

(206) "I don't see an Australian space culture at the moment. When you think about NASA – and yes, America is far bigger than us – but when NASA was introduced, again going back to its education and outreach and its public profile, half of NASA, that was half of its remit and it still is half of its remit, so it's a very important function that it carries out and I think that is related to promoting ideas about space. But I think that places like Hollywood have – we don't have a film industry or even an author ace to create those kinds of things (...). It's important because if you ask people in NASA about how they were inspired to go into a career in space, a lot of them will say they were inspired by *Star Trek*." (INTERVIEW 9)

(207) "It's all about what we've done in the past. If you go to the Space Discovery Centre here and there's a huge rocket yard, but they're talking about big rockets and NASA, and I think that's not Australia. That's not what Australia's doing. And so we as Australians need to focus on what we are doing. And if we want to inspire the next generation, it's up to us to do that. Culturally, it's our culture. It's our history that should be doing that. Not relying on the Americans' culture and their history." (INTERVIEW 13)

(208) "I would say Australia just follows the American one. So fall for American hero NASA thing which creates that divide between – I don't want to generalise too much – but mostly the older men who've maybe experienced that or feel it emotionally attached to the Moon landings and a lot of younger people or women who just think 'oh, we could spend that money on hospitals or something'. So you get that black-and-white simplistic view, and it's about flying heroes to the Moon and actually worse, we've got the Hollywood culture now, which is about going to space, blowing things up. And again, the very sort of sexist tropes." (INTERVIEW 6)

(209) "I think we are much more influenced by American space culture but, if anything, I think Australia has a translation of its core cultural features into the space domain. There's a belief that we can do things. We've had to do things on a shoestring budget in the past, and so Australians still tend to think 'Hey, we can do this without having the massive budgets that America or Russia or Japan'. I see Australian companies that have this kind of 'can do' attitude that they believe that an Australian company can compete with others out there in the frontier. I still hesitate to call it an 'Australian space culture'." (INTERVIEW 26)

(210) "Australian space culture is hugely influenced by NASA. Best brand in the world, right? (...) I find the popular culture in the sense of the language, the holidays, the approach to everyday life is still very UK-driven, but when you get into business or defence it is very, very aligned with US culture. So I think that Australia's going to develop something that's uniquely Australian, I do believe that; I think the sustainability thing is a piece of that." (INTERVIEW 39)

(211) "It's hard to talk about a space culture because I'm in it. So I can't speak for somebody who was outside of the space culture. To me, I live and breathe space. And I think the space culture is becoming more and more prevalent, more and more prevalent people, there are more events happening. More people are jumping on Twitter to join the space community, people are becoming less and less afraid to be a bit different. And to pursue something that inspired them as a kid, which is space, they no longer feel that they need to go overseas like to NASA to achieve their dream; they feel that they can do it here by a research or industry. I think the space culture is increasing in that way. Having said that, if you pick someone random off the street, they probably won't be able to tell you very much until we launch an Australian astronaut from home soil into space. That's when the country will know about it. And that's when the culture will go up." (INTERVIEW 12)

(212) "I see great improvements in the last three or four years. When we started the company, nobody was interested in space or very few people and there just wasn't a lot of engagement. Now, literally every university wants to start a space program; most of the science museums are very focused on space. I think it's been a sea change in the last three years and everybody's involved in it and it's just going to grow and accelerate." (INTERVIEW 14)

(213) "There is not really a space culture in Australia at the moment. We excel in extreme environment operations and medicine, from mining to Antarctica and just in general with outback life, but we haven't been able to translate yet over to the space sector or to explain how much of that is reliant on satellites. So the general public is still 'Oh, no, not the *Star Trek* topic' when space is brought up. And the general public looks at any comments under any space article and it's like, 'Oh, well, waste of money. Why do you want to send astronauts to Mars when we have problems with hospitals? We need to spend more money on schools.' So space is prevalent in education programs, but I think it's also presented as a kind of cool, expensive faraway concept, and astronomy is often confused with the space industry here, where it's very separate when you look at Russia or US and Europe and Japan with established space cultures. So the

Earth Sanctuary Observatory outside Alice Springs. Dark Skies Festival 2021. Credit: Juan F. Salazar



cultural institutions, I think, would be huge in assisting with outreach by explaining downstream satellite utilisation that happens every day. So whether GPS, phone apps, ATM transactions and banking, because that uses precision navigation and timing, which is all satellite – so every time you use an EFTPOS machine in Australia, that's satellites. Live sport on TV is huge for Australians. Live news, remote outback community internet and communications, satellite phones, of course, are used a lot in the outback and Royal Flying Doctor services, coastal protection, bushfire monitoring is a huge one, of course, flood monitoring and response, even the surf report, like all of that is space. And Australia's got a huge landmass plus oceans because we're actually responsible for the ocean.” (INTERVIEW 38)

4.2. KEY ACTORS

4.2.1. First Nations Perspectives

Another aspect of this broad question of space culture in Australia relates directly to First Nations perspectives and how they are embraced by the space sector or rendered invisible. An example is the Australian Space Agency's *State of Space Report* (2020b), which documents the Australian government's civil space responsibilities and activities and engages with Indigenous Australian experts and perspectives, by highlighting branding opportunities. The report mentions the HIDDEN IN THE STARS project, held during Reconciliation Week 2020, to highlight “the connection between the Agency's brand and Australian Indigenous culture” (p. 78). This campaign “involved the Agency sharing several Indigenous constellations that sit within its logo and the story behind each. (...) The campaign was a great opportunity to not only highlight this connection to our brand, but also educate our audiences too” (p. 78).

While this may be an important positive step forward, there is also a serious risk of cultural appropriation for purposes other than those culturally appropriate. The deep history of Aboriginal space observation (Sky Country knowledge) is mentioned in one sentence in the report.^{1 3} Something similar might be said of

^{1 3}

There is a summary of a project in which Geosciences Australia (GA) commissioned an artwork from Lakota Sioux artist Rosaline (Little Eagle) Oren from South Dakota for the reflector surface of the Landsat satellite antenna at the Alice Springs Ground Station, to complement the Australian Indigenous artwork on the primary 9-metre antenna commissioned in 2016 from Arrernte artist Roseanne Kemarre Ellis. The *ASA* report states that both artworks recognise “the ancestral stewards of lands in Central Australia and in South Dakota (where USGS also operates Landsat antennas) and showcases the indigenous connections between the two agencies” (p. 42). The project was executed to recognise “the strong relationship between GA and the USGS” (p. 41), and the statement that it “showcases the indigenous connections between the two agencies” is clearly problematic as the artworks are left unconnected and

ASA's engagement approach with students and schools in remote communities "via individual awards, telescopes, books, Agency merchandise and opportunities for Agency representatives to talk to students". There is a sustained misunderstanding of what engagement means in this instance. Engagement requires a relationship built on trust and integrity: it is a sustained relationship working towards shared goals. Compared with the experience in similar settler countries, Indigenous engagement in Australia is not based on a comprehensive legal framework that enshrines certain rights for First Nations, grants significant levels of ownership, or pays attention to the importance of investing in Indigenous governance capacity and related resources. In Australian copyright law there remains a significant gap in legal protection for traditional cultural knowledge.¹⁴

In section 2.3. we briefly referred to Australia's role as a signatory to both the Moon Agreement and, more recently, the Artemis Accords. We highlighted an ongoing debate about whether ASA has precipitated a contradiction in the simultaneous participation in these two instruments of international cooperation. In Canada, this debate also included arguments presented for the ethical and legal requirements of the Canadian Space Agency to consult with and to be inclusive of Indigenous rights and concerns as Canada moved to support the Artemis Accords. As is the case in Canada, and considering its status as an international (and bilateral) agreement, does the Artemis Accords trigger the application of the United Nations Declaration on the Rights of Indigenous Peoples in an Australian context?

In the last five years there have been very important developments in Australia, which are perhaps unique in an international context. These relate to the agreements between start-up companies and Aboriginal corporations to build commercial rocket launching

serve a purely decorative purpose. sbs covered the story in 2019 as "Indigenous Australians to lead space industry at new Alice Springs earth ground station. Indigenous Australians are expected to become leading participants in global satellite and space industry." See <https://www.sbs.com.au/news/video/indigenous-australians-to-lead-space-industry-at-new-alice-springs-earth-ground-station/45bzmlvqm>

¹⁴ Take the example of the Seven Sisters Consortium, a collaboration of Australian space, remote operations, and resource exploration companies that was established in 2020 as a companion to the Artemis and Moon to Mars missions with the goal of discovering abundant resources for humanity's exploration of space. It is not possible to discern what has been the process of consultation for the use of Indigenous cultural knowledge. As Margot Neale notes, the Seven Sisters Songline is one of Australia's most significant foundation stories and stretches across the entire continent of Australia "like a web of interconnecting pathways encompassing multiple sites" (NEALE 2020, p. 75). In this case it is being used in a completely different context, for a very different purpose. See for instance *Songlines: Tracking the Seven Sisters*, an Aboriginal-led exhibition that included over 100 artists that was exhibited at the National Museum of Australia (Canberra) in 2017–2018, and that took visitors on a journey along the epic Seven Sisters Dreaming tracks, through art, Indigenous voices and innovative multimedia and other immersive displays. <https://www.nma.gov.au/exhibitions/songlines>

facilities. These include agreements between Equatorial Launch and the Aboriginal Gumatj Corporation to build a at a remote site near Nhulunbuy; Southern Launch and the Koonibba Aboriginal Corporation in South Australia; and Gilmour Space and Kyburra Munda Yalga Aboriginal Corporation in Queensland, which allows the company to build their spaceport on Juru Country after signing a Cultural Heritage Management Agreement. As Karlie Noon et al. (in press) point out, Indigenous sky rights are closely linked to Indigenous land rights, which sit within the realm of the Native Title Act (1993). Traditional owners have access and use of their lands and waters in ways that are consistent with traditional laws and customs. Internationally, major conflicts in this field have emerged with the construction of astronomical and space facilities and launching sites on Indigenous lands. These lands, which are regarded as optimal and necessary by astronomers and space scientists, are also often sacred and culturally significant to Indigenous peoples. As Noon and colleagues put it, "it is essential to recognise that Indigenous leaders and community members have a wide range of views, and proposed projects may be supported and opposed simultaneously by members of those communities and that obtaining unanimous community support is not always possible" (in press).

Below we present the responses triggered by the broader question about an "Australian space culture" which led some interviewees to reflect about the country's heritage and the role of First Nations knowledges, the nature of the space community's engagement with Aboriginal astronomers and corporations, and the participation of First Nations actors in the space sector.

The difference in perspectives here was stark, mostly between those who saw a positive engagement happening and others pointing to ongoing forms of colonialism and the extractive nature of space research and activities. Amongst the former were the following:

¹⁴ "One thing that has been surprising is that, more than any other industry I've come across, there is a desire to involve Australia's Indigenous people in this journey. It might be done inadequately and clumsily and patchily and there is always heaps to criticise, but there are so many of these companies where that's their first conversation: 'We want Indigenous people to be front and centre of everything we do', and that's genuinely what they say." (INTERVIEW 28)

¹⁵ "I think Australia is really well-tuned and appreciative of its Indigenous heritage. Everyone knows the traditional land they're on and I think we're starting to see that engagement come through in the space sector. So there's an Indigenous-operated ground station that's been set up. I think the engagement with like Equatorial Launch and the extent of engagement they'd had to really make sure that there's been an understanding there is really valuable." (INTERVIEW 27)

(216) "I was delighted when the space agency selected the logo that they did, which was a conglomeration of Indigenous constellations, and I am fascinated, actually, with Indigenous legends which are just remarkable around space. I do think that there is a narrative about space services bringing equity to rural locations which are so hugely underserved in Australia and creating valuable jobs that can be worked from wherever you might be." (INTERVIEW 39)

(217) "I think there is an opportunity there for us to lead and beautifully tie our growing and evolving space culture – move it away from that white industry perspective – and tie it really nicely into some of the humanities that we have here. So for example we have that historical context of our radio astronomy history, we have a beautiful and 65,000-year-old Indigenous culture of astronomy that we can really work with and put front and centre." (INTERVIEW 37)

For a high number of the interviewees the focus of Aboriginal engagement is solely through astronomy and seeing a culture stuck in the past, rather than a lively culture responding to and adapting to twenty-first-century challenges.

(218) "Australia doesn't tap into its old culture, the Indigenous culture. I know a little bit more about what was happening 60,000 years ago, and the only place in the world that was doing astronomy at the time was Australia. And so that, to me, is an incredibly strong connection to Australia probably. I think of Australia being the founder of astronomy." (INTERVIEW 7)

(219) "I am very sceptical of the agency's move to incorporate Indigenous iconography. I see it as very akin to the Australian mining industries' attitudes towards Indigenous communities. I don't think it's in any way concerned or interested in any real kind of decoloniality or any real distribution of resources – it's not in the slightest – it's just basically token inclusionism." (INTERVIEW 11)

(220) "It is very noticeable that beyond acknowledging Country and meetings full of white people and having a nice Aboriginal designed logo, that there appears to be no meaningful engagement that I'm aware of. And the only project and the real kind of success story that I've seen is a tracking station in Central Australia, which is, I think, run by an Aboriginal corporation. So that's a success story, but it seems like that's something that has happened through their hard work and knowledge, but not through any sort of particular assistance or attention by the powers that be. So I think there is a lot more to do. I was disappointed by the demographics of the Australian Space Agency advisory board. There is a lot to do there, and I can't see people putting that on the agenda very high up. Unfortunately." (INTERVIEW 6)

(221) "I think there's been a huge focus on Indigenous astronomy, and to my way of thinking this has got in the way of any meaningful consultation with Indigenous communities about the kinds of technologies they might want to support or buy services from or be involved in the creation of. So I've heard a bit, particularly with some of the launch sites where, of course, in order to set up they have to go through

all the environmental and heritage management hoops, they have to legally consult with traditional owners and native title holders and all of that, so I've seen a lot of people in space industries saying, 'Oh, this is great this company is doing that'. Well, a lot of it is what they're legally required to do, so there is no virtue in doing what you're legally required to do. Having said that, some of these companies have gone above and beyond to make sure people are involved in the process to make sure that they get benefits from having the launch site located on their Country, so I think there has been some good work that industry has been doing there. But I also think that everyone's glamourised by Indigenous astronomy, but the problem with it that I see is that it puts Aboriginal people back in the past (...). Care for country and ideas of the Moon with legal personhood, those are places where Indigenous perspectives on relations to land or Country or Sky Country can be incredibly useful, I think, just in reframing a future dialogue." (INTERVIEW 4)

(222) "Although I'm wary of us always just looking to Indigenous knowledge as the cosmos and the Seven Sisters and kind of putting that knowledge in the past, at the same time I think it's a really great way to tap into this desire to have an Australia space culture and the obvious linking is with Indigenous knowledge of the stars, and so, well, let's start there. I do think that there is – like I critique the branding of the space agency as having this Indigenous logo on it and then doing nothing else about that, but that's a really smart way to come up with, 'This is Australia's space culture. It is not a NASA, it's something really different, so I think there's a really great potential for it.'" (INTERVIEW 10)

(223) "I think that Indigenous perspectives are important and there are areas of Indigenous knowledge that we should be looking at, but the agency overemphasises Indigenous astronomy. Indigenous astronomy is hugely important culturally to the Aboriginal communities; of itself, it doesn't offer a great deal to the development of the space industry. Culturally, of course it offers a wonderful perspective to counterbalance the modern commercial perspective. I think we have an enormous potential if the agency was to encourage investigation into Indigenous food sources and Indigenous medical knowledge to find some really valuable insights and really valuable technologies based on Indigenous knowledge that could be incredibly useful to human space flight. And I actually think that's where we should be looking for things that will support the space industry and, hopefully, empower Indigenous communities and bring Indigenous communities into the space sector in a way that's more than just acknowledging cultural knowledge of astronomy (...). Also, the whole idea of how you care for the country I think is important. Especially if we're trying to set up a base on Mars or the Moon, you want to manage the environment in a way that is in harmony with the environment, if I can put it that way. And I don't know, I do think we have possibilities to learn from cultural knowledge there too, and not only Aboriginal knowledge, of course, but Indigenous peoples in other parts of the world." (INTERVIEW 2)

(224) "From what I've heard within the industry, it seems like Australia's lagging a bit around the leadership, which obviously means that there is an opportunity for us there. And I think the unique part of that is that linkage between Aboriginal people

and the constellations and the land, and as I said before, Australia needs to mature as a country to be able to accept that Aboriginal people can actually take some leadership in these sorts of initiatives in high-end technologies and develop local solutions. That's been difficult to overcome for most Australians (...). We don't want to see that Aboriginal people are just passive end users of technology. They should be involved through a process around the development and then the rollout with and impacts to Aboriginal people, and people right across remote communities in Australia." (INTERVIEW 19)

"I think it's really important when stuff like this is happening and when institutions and researchers are engaging with Indigenous peoples. It absolutely needs to be mutually beneficial and that benefit Indigenous people as a whole, and because with the branding that they have used and the way that they tell the stories, it's very general, right when there isn't really a general Indigenous Australia. If you're going to be talking about all Aboriginal and Torres Strait Islander peoples, that should have a positive impact for all Aboriginal and Torres Strait Islander peoples, and I don't think I'm seeing that. I don't think it's appropriate. I think it could definitely be done appropriately, but I think at this stage it's just purely branding from their perspective and it's working and that's kind of foreboding (...). So when the agency was first being constructed and was first kind of announced, I was told that they were looking to, as with pretty much every other organisation, they were looking to have their three per cent Indigenous people being employed by them. For me, like when you're going to take the branding and your whole image is built off these entire groups of people, like that's just not enough, like three per cent is not enough. If you're going to make this an integral part of who you are as an organisation, you need to be led by those people, and I don't see this happening. Whether they have the two per cent or three per cent, I wouldn't be completely shocked if they did manage to get that, but also I wouldn't be shocked if they didn't, but the main thing here is going forward, like if there's no outreach and if you're not specifically engaging Indigenous communities and Indigenous people with the goal of going forward with them and having these Indigenous people in the leadership roles and building up the space section allowing them to share their expertise and in interest in space, then it is tokenistic." (INTERVIEW 8)

"Tradition is seen as something that doesn't evolve, which is just not true. Indigenous people, not just Indigenous Australians but Indigenous people are like the most adaptable people. Change is how Indigenous Australians are the longest continuous culture in the world, because there has been adaptability (...). A really big concern that is just a reality in this space: we don't know who is being considered an expert, and in my experience most of the time they're not Indigenous, which is really disheartening. Things like bushfire management, for example, and the Indigenous knowledge around bushfire management, that should work hand-in-hand with Earth observation. So, you know, what are satellites seeing? Let's feed that information over to people in the Indigenous community who know how to manage bushfires and tell them what's going on from above and then integrate those two sorts of services together so you have that beautiful cultural knowledge of fire management combined with the inflow of data coming in to help us prevent disasters holistically." (INTERVIEW 8)

(227) "There are a couple of Indigenous-led businesses, but there's no start-ups that I'm aware of. It's something that again on the educational side where we try to support educational initiatives, there's a few initiatives there that are working in that area. Like Equatorial Launch Australia, I guess to some extent. I wouldn't say – like they're definitely not an Indigenous, they're not an Indigenous company, but they work incredibly closely with the populations in Arnhem Land and that kind of thing and as far as I understand that's really fantastic and we want to do more work with them there too. I am absolutely in love with the Indigenous astronomy and like all of the things that are happening there, so I think that there's a lot of scope to increase the amount of Indigenous-founded companies that are working in this sector as well, but at the moment there hasn't been much work there." (INTERVIEW 16)

(228) "I think most of these space companies, and government as well, are not seeing it the same way that they see mining, for instance, because with mining there's a much more obvious environmental impact, and it's larger scale so you don't have to look for what kind of cultural heritage might be impacted. And there's this kind of idea that, well, you just have a launch pad and it's small and there's not enough understanding again about the environmental impact of those activities, the long-term impact. And the piece that I think's really missing it's not just about land use, it's also about use of the air and it's also about the impact of those activities, because of the sense of identity that most Indigenous cultures in Australia have, their connection to land, to water, to skies, and also the cosmos, any activity that takes place in Country – and all of that is Country – impacts them, and they're responsible for it. And so if you're launching military satellites, for instance, which might have a weapons purpose, it's not just about the launch on Indigenous land but it's also about what are you using that for, because that impacts Country as well. I just don't think there's enough thought put into the fact that this is another form of land use that needs to be approached in the same way." (INTERVIEW 10)

(229) "I see this idea that we're just taking the branding aspect of Aboriginal astronomy and putting it over everything. But, that said, the Aboriginal astronomers in Australia are fantastic individuals doing amazing work and they should be celebrated for that, and I'm glad that they are celebrated. I just wish that the conversation was more open-ended and that the space sector was more willing to listen and hear the word 'no' from Aboriginal people in this country on a whole range of issues." (INTERVIEW 5)

4.2.2. Equity and Diversity in the Australian Space Sector

A third aspect of this broad question refers to organisational cultures and issues of equity and diversity within the Australian space sector, broadly defined, to include astronomical and planetary sciences, cultural institutions, and HASS disciplines.^{[1][5]}

The 2021 theme of World Space Week was “Women in Space”, in a clear attempt by the United Nations Office of Outer Space Affairs to bring awareness to the issue of gender diversity in the space sector and highlight that women constitute just 20 percent of the entire space industry workforce. Similar findings are contained in the *Women in Stem Decadal Plan 2019*, which highlights that Australia has not yet made the systemic changes required to achieve diversity in science, technology, engineering, and mathematics (STEM), with the current underrepresentation and underutilisation of women in the STEM workforce posing a threat to Australia’s prosperity. Women make up 47.5 percent of the Australian workforce and 16 percent of the STEM-skilled workforce, but only 8 percent of chief executive officers (CEO) and heads of business in STEM businesses in Australia. As Lisa Harvey-Smith has said publicly, “it’s not just an equality perspective that’s important here, it’s a business imperative”.^{[1][6]} These figures are even more dramatic with Indigenous women. Aboriginal and Torres Strait Islander peoples are also severely underrepresented in STEM, particularly at the university level, where 0.5 percent of the Aboriginal and Torres Strait Islander population had a STEM qualification, compared to 5 percent of the non-Indigenous population (OFFICE OF THE CHIEF SCIENTIST, 2020).

As several reports on organisational cultural diversity in Australia highlight, the Australian space sector is most likely missing out on important opportunities by failing to effectively measure the degree and breadth of culturally diverse talent in their leadership teams, workforce, customer base, and labour market pool. Below we reproduce some of the responses to the question of whether there is equity and diversity in the Australian space sector. The aim is to

^{[1][5]}

While figures for Australia don’t seem available, it is interesting to note for comparison purposes the *Demographics of the UK Space Sector* report (THIEMAN & DUDLEY 2021), which presents an overview of the demographic results of the 2020 Space Census, the first national survey of the UK space workforce. The report highlights how women are significantly underrepresented; LGBQ+ people appear to be well represented; ethnic minorities are underrepresented; foreign nationals make up just under a fifth of the workforce; disabled people are underrepresented; people from more advantaged socio-economic backgrounds are overrepresented; and the sector skews slightly younger than both the workforce as a whole and the STEM workforce.

^{[1][6]}

See the media release where this quote is taken from at <https://www.scimex.org/newsfeed/under-representation-of-women-in-stem-is-holding-back-national-prosperity>

showcase the opportunities for further research in this area and for space sector government agencies and companies to consider developing standards for measuring, reporting, and benchmarking on workforce cultural diversity and workforce cultural capabilities.^{[1][7]}

These were the views from those who saw a lack of diversity in the sector:

⁽²³⁰⁾ “It’s entirely lacking diversity and it’s something that I’m actively trying to understand. How do we change that? There are a lot of women in the space sector who are quite well known, but for some reason there aren’t a lot of women entrepreneurs coming up through the start-ups. One of the things that we’re doing is we try to get more resources to run some of those early-stage programs to try to bring people together to try to get a better understanding of what are those barriers that are preventing this at the moment. We’ve got some really amazing women leaders in the space sector and there’s some good diversity there, but overall it’s not diverse at all. And we’re seeing some difficult things, like there’s an emerging sort of space hub happening in Sydney called the Wolf Pack, and so there’s not an awareness around how the use of language might deter people from it.” (INTERVIEW 16)

⁽²³¹⁾ “If you look around anywhere – even if I look around the National Committee on Space and Radio Science, even within universities, you look around and everybody involved in space is male and white and I don’t know anybody – I’m just trying to think, do I know anybody of colour involved in space? Probably not. I’m sure they’re there, but there’s that education and outreach and research should also concentrate in that area, and the diversity of our population is not represented at the moment at all in any area that I know of.” (INTERVIEW 9)

⁽²³²⁾ “Coming from the astronomy community into the space sector a few years ago, I was very surprised by the lack of diversity. In astronomy it’s been quite some time since you would go to a conference and there’d only be men on a panel, right, especially within the Australian community at least. The Australian astronomy community for at least the last ten years has taken gender diversity very seriously and has quite a lot of high-profile men who’ve kind of championed this as well.” (INTERVIEW 22)

⁽²³³⁾ “Australian space communities or space culture in Australia is effectively very white – in particular white males. For example, the Australian Space Awards. I’m very happy that all the winners got selected and they all very much deserved it, because I know them all – like some of them are my friends and some of them I work with, so I know they all work really hard – but looking at the actual list of nominees and the list of the winners it was basically mostly white, white men, it was like white men.

^{[1][7]}

See for instance the *Counting Culture* approach developed by Diversity Council Australia (DCA), an independent, not-for-profit workplace diversity advisor to business in Australia.

There might have been a few people of colour, there might have been a few women, and I'm glad Sarah Pearce from CSIRO took out the grand award and she made the statement saying, 'Look, we've got to pull up the actual women in Australia and get them all up in space,' but I just think again it's white. Like I looked at it as it was and went, 'There's basically no one in there – there's no people of colour, there's no recognition of LGBTIQ people, there's no Indigenous awards,' like it was just a white awards ceremony from my perspective, and I think that's really damaging. I think that's quite damaging to a lot of people who looked at that and went, 'Hmm, that doesn't represent me and if that's the Australian Space Industry Awards then where do I fit in?' and it becomes a bit more alienating and isolating for people." (INTERVIEW 37)

For other interviewees, the sector is diverse, and they characterised that diversity in these terms:

(234) "There is the diversity you see and the diversity you don't see. There's actually a lot of diversity in the space sector in Australia in terms of people's backgrounds and experiences and philosophies and hobbies and reasons for being involved and mindsets, but two people might look exactly the same on the face of it and have those very different ideas in the back of their minds, so there's that diversity which I think is very much in existence. The diversity in terms of people of colour, for example, I think is still lacking significantly, but Australia is a pretty racist country and I think that being in the space sector requires a lot of privilege already. There aren't very many jobs, there aren't very many entry-level jobs, there aren't jobs that you can just walk into. Actually getting a job in the space sector means that you have to know people and it's highly competitive, and you have to be the sort of person who has the support behind you that you could be unemployed for a year and still be able to wait for that job, so that in itself self-selects out a lot of people who don't have that kind of privilege. About gender, I think there's a massive push towards having more women in STEM, having more women in science, and women in space. But also what worries me a bit is the push towards representation on a branding level, on a marketing level, this idea that if we slap 'Aboriginal astronomy' on something and it suddenly makes it acceptable and good. And so if you look at every space activity in Australia, there's 'Aboriginal astronomy' all over it, and that is good in the sense that we should be recognising that there is Indigenous knowledge in this country and that there is a strong history and that we did colonise that history and strip away that knowledge and that's really good, but we also have to recognise that there are Aboriginal people in Australia today who are doing science, who are doing space science, who are not being seen, who are not being funded, who are not being supported, and also that Aboriginal knowledge is valuable even when it doesn't help us to better science. So this idea that we only engage with Aboriginal knowledge when we want to know something, like about bushfires, because suddenly all our houses are getting burnt down so now we go out and we ask them to give us their knowledge so we can use it to make capitalism better." (INTERVIEW 5)

(235) "I think in the agency it's 52 percent of women, you have all different types of accents in the agency, and LGBT community – everybody's represented and I think that's one of its biggest strengths, being able to have all these people coming from different

backgrounds. It creates so much better performance as an agency. So that's the agency. In the sector you see lots of women around as well in the start-up fields, and I think we are probably the country where all the community and diversity is the most represented to be honest." (INTERVIEW 23)

(236)

"The sector is still very white, very much so. Interestingly, there's a lot of women in their mid-forties, early to mid-career, who are knowledgeable, who are excited, who are enthusiastic, and there's a lot of them and I keep coming across them, but they're not at the top of the organisations. So this is typical of every sector – it's not just space – that even in areas where you might have a majority of women like in the junior positions, you don't see them in the senior position. But there are a lot of very knowledgeable and enthusiastic women, again mostly white. I haven't come across many women of colour. I've come across a few – I've seen more men of colour, I've seen more Indian, Asian, like first-generation immigrants to Australia or second generation who are in the STEM side of things, so there is a little bit more diversity, there is some diversity in there, but I think like any sector – and there's a complete lack of Indigenous faces. There's a few and quite a few of them in astronomy, like experts in astronomy, but there's not many in the space industry, and there's certainly none in government." (INTERVIEW 10)

(237)

"So I think there needs to be a community, and I think there needs to be some safe spaces established for people to come up through the ranks, for people to converge, for people to have promotional and leadership opportunities, for people to develop community. And the other is the LGBTQI+ community, their space. They're an invisible component of the space community globally, no less in Australia. When we give talks or keynotes on diversity or access to space, that as a phrase is never raised. So they talk about gender diversity, geographic diversity, intergenerational diversity and disciplinary diversity, and there is not that question of gender identity." (INTERVIEW 32)

4.3. FRAMEWORKS FOR VALUE ASSESSMENT: PUBLIC COMMUNICATION AND PARTICIPATION

The final section of this chapter on the cultural dimensions of the Australian space sector has to do with participation, outreach, and processes of public engagement with a range of Australian publics. Recommendation 33 of the 2021 *Now Frontier* report recommends "that the Australian Government develop a community education and outreach program to promote the diversity of employment, careers and opportunities within the space sector, and that this campaign should also target underrepresented groups within the space industry to help increase diversity across the sector."

This issue was reflected in our interviews where there was a broad convergence amongst the interviewees that engaging Australians with space is an educational process. The divergences emerged in relation to the content and nature of such engagement:

(238) “Getting people to understand how space affects our daily lives is something that’s an educational process, and I think that part of that is getting people to understand how the space industry and the space sector have changed since the days of Apollo. People still think very much in terms of space equals space shuttles and lunar landings, whereas it’s so much more than that: it’s about how it shapes our society going forward. We’re already sort of focused very much on 5G; we’re going forward into 6G which will be increasingly space-based; you’ve got Elon Musk developing Starlink, which will give us a space-based internet. The internet of things is going to be relying heavily on mega-constellations of satellites. So, in other words, our society going forward in the next 20 years is going to become a space-enabled society, and people need to understand that. So getting various different groups within society to understand that I think is key, and that’s an educational process which the space agency can do, but other organisations, both in the private sector and in, for example, higher education, can do that as well, and the media too.” (INTERVIEW 25)

(239) “The reality of people’s enthusiasm it’s very limited. An example is the International Space Station: incredible experiments going on there, the science, the human knowledge, the health science benefits, material science, research, understanding of plants and how they interact with you know, zero gravity, microgravity and different environments, the experiments where they are putting life forms on the outside of the space station, incredible stuff. You never hear anything about it, even in the science pages of the news. So I actually don’t think people are that interested in science, in the realities of science – you have to over dramatise it in some way, or you have to dress it up in a way that touches them emotionally. And that’s again, what I do, but the sheer facts of space, I don’t think people are terribly interested.” (INTERVIEW 6)

(240) “It’s really a case of awareness. People just need to be educated about how space impacts them with examples like GPS. I got in a taxi last year and the guy had his Google Maps up, trying to take me somewhere, and I said, ‘Do you know how that technology works?’ and he said, ‘No, I don’t know.’ And I said, ‘There’s a signal that comes from a bunch of satellites that connects to your phone that tells you exactly where you are and shows you how to go’ and the guy was staggered. He was like, ‘I can’t believe that. That’s amazing.’ So one of the things I like to say is whenever you go to an ATM and you take money out of an ATM, that also connects up to a satellite that tells the bank instantaneously that you’ve withdrawn money here so you can’t withdraw money from somewhere else. And when you ask for a two- or three-day weather forecast, that information comes from space. There are just so many examples of how space – and the other thing people don’t realise is how companies use space and how it’s critical to their operations; so mining companies, farming companies, utility companies, they all use space, assets in space, to help the businesses grow.” (INTERVIEW 14)

An area where contrasting views emerged was the purpose and content of outreach activities. While some argued that they are mostly about informing people about the impact of space activities in their lives and their role as inspiration, others argued for the need for a more critical engagement with the nature and direction of space activities in the country:

(241) “Space is already underpinning a lot of our infrastructure and we don’t really acknowledge that, and that’s only to become increasingly important as time goes on for all our major economic sectors. So it’s not just unique to Australia, and it’s great to see countries like the Philippines and Egypt are now getting their own space programs and space agencies and it’s all around this shift from saying, ‘Well, we need big government-funded space projects like what NASA and to a slightly lesser extent ESA and those traditional spacefaring countries have been doing over the last 50, 60 years or so’ and more around saying, ‘Well, how do we develop the commercial capability there? How do we enable private industry to get up there and to do what they need to do to amplify our industries back here on Earth?’ So it’s a very different way of thinking to just saying ‘Look, we’re going to do science for science’s sake’, which is amazing and that’s why I got into space in the first place, why I was interested, but it’s just a very different way.” (INTERVIEW 16)

(242) “We need to communicate the impacts of space in life, like the ATM: you know, ‘Do you realise when you go to the ATM, you couldn’t do that without space?’ I also think that we should engage the public with our stories of success. We have amazing role models of exploration.” (INTERVIEW 9)

(243) “The side I think is underplayed, actually, is the climate and environmental side. One of the things that has become clear to me that is a story that we don’t tell often enough is how space is a fundamental part of solving the environmental challenges that we have and how it’s not for the sorts of people that we want to attract into space, not just people who are interested in going to Mars, but we should also be telling the stories to people who are interested in how do you address climate change, how you deal with issues in the Great Barrier Reef. Space is a way that you do that too, and you could come and be an Earth observation data analytics expert and address these questions as well.” (INTERVIEW 22)

Others felt strongly about outreach and engagement being much more than a matter of information or inspiration:

(244) “Twenty years ago, the purpose of a science centre or a natural history museum was different than it is today. Then it was possible for those institutions to have access to experts that the public didn’t have access to and to expect knowledge that was a little bit harder to access for your general population. But today you can ask any question you want on your phone in your pocket in a second and have an answer or have a YouTube video that explains it perfectly. So knowledge and information has become much less valuable just by virtue of having more access to it. What this means is that they have to think more about where their value as an organisation

lies. It can't just be giving people information: it has to be more in things like skill-building and thinking about attitudes and behaviours. You can say that, yes, a better future for all Australians is increased economic prosperity, and you're not wrong. But that's not all of the story, and I think that there's a responsibility for cultural institutions to explore those other spaces, those other possibilities, those other imaginaries. I think it's not going to be either of them. We have no idea what the future's going to be. On the one hand we have trumpets blaring 'Rah, rah, to space'; on the other hand we have 'Whoa, Kessler syndrome, space junk. Deny access, go away and despoil Mars and it's going to be terrible'. And I don't know that either of those are true, but in order to move forward and reconcile some metanarrative that bridges that divide, we have to have the conversation, we have to engage in dialogue, and that's where I really see the value of a cultural institution: it's about acknowledging both sides and exploring both sides and then creating a safe space for the conversation." (INTERVIEW 31)

(245) "It's not just inspiration. We should prioritise asking people, they say a kid visits a museum, asking that kid to think critically, to think for themselves, and not just to accept the first narrative that comes to them. If they see Elon Musk on the news, I think Elon Musk is great, right? But what's the other side of that? Allowing kids to think about, exposing them to the fact that there could be another answer. And again, the challenge with that is, you get political because if you ask someone to think critically, then you might anger some people who are in the political sphere thinking that one thing is only right. So what I think is important in this day and age, when we are bombarded with information coming from all sides and when big social media giants are actually funnelling to us a narrative, a narrative that benefits them as a corporation, we need to be able to think critically about what is really the truth and how we seek the truth." (INTERVIEW 12)

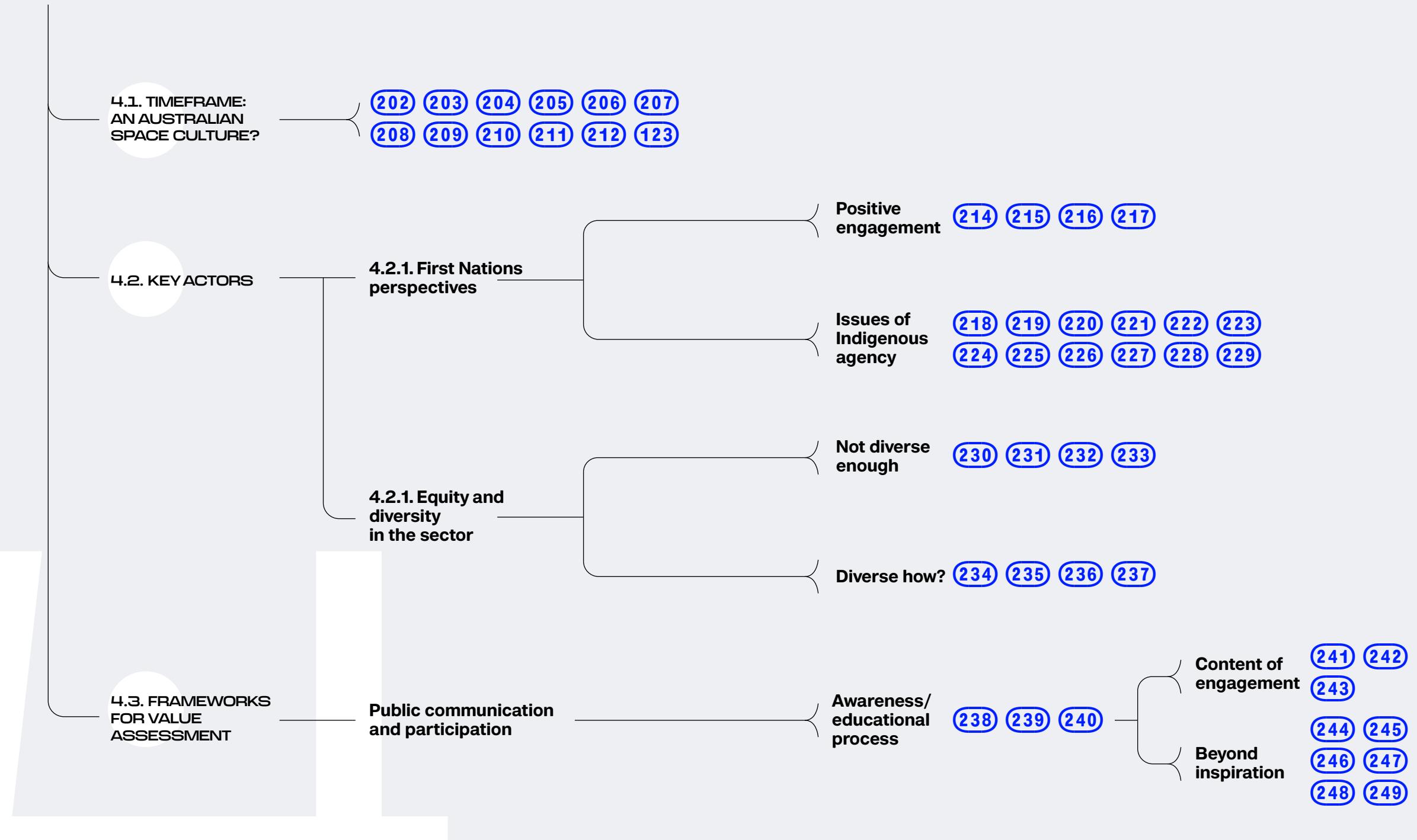
(246) The narrative around big rockets is very macho. And it actually, for me, detracts from the things that I'm trying to communicate, blowing up rockets and saying 'this was a great test, well done guys' (...). Okay, now we might have, they'll send some black women to the Moon and that's great, but again, it's still that colonial language that's used. Colonising the Moon, colonising Mars, a lack of respect for Indigenous knowledge, history, land, water, sky, these satellites filling the sky with so much light pollution that traditional knowledge can't be shared and gathered. Many Indigenous communities actually can't do their traditional sky knowledge properly anymore because of light pollution. I see space as this nasty thing, that's trying to ruin the universe, which is just firing rockets up there, polluting it, filling it with junk, not cleaning up after yourself, crushing things into the Moon, chucking human excrement everywhere, and just wrecking things. And then astronomy for me is about peace, about serenity, about connecting with the universe, about spending time quietly, reflecting about the meaning of existence. And that's how I try to communicate because that's how I feel it viscerally, and the rest is kind of pollution. But having said that, I still believe limited use of space and the responsible use of space for certain things is going to really help humanity. So I'm kind of in it for that." (INTERVIEW 6)

(247) "Most of the population either thinks that space is benign exploration and reiterating all of those 1950s tropes of displacing internal political discord onto this very benign idea of scientific exploration which is apparently inherently good, but we don't have very much education about the political stakes of what is going on (...). The level of general ignorance in the wider population prevents any kind of real democratic engagement in the political and economic stakes of what's going on, and I think that ignorance is being cultivated. I think that there are plenty of operators in the space who have no interest in the public understanding the long-term stakes of what's happening because it would be against their interests. All I see from the citizen science narrative is the 'get the kids interested' narrative." (INTERVIEW 11)

(248) "From my perspective, I think people are interested in the stuff out there; they are interested in the stuff that doesn't just relate to us here. But I think a big problem is that a lot of people who do talk about what's happening are people who are already interested and who are already engaged and who are already, you know, their ears are open (...). But this is something that affects everyone, Starlink is something that affects everyone, light pollution is something that affects us. I don't know, my belief is that people from all areas, whether you have a really high level understanding of it or not, should have a say in it, especially science, because science has such a big impact on society and where society's going and what it's doing. So all people should be concerned about this and should have access to it, but I think at the moment this broader conversation is not happening." (INTERVIEW 8)

(249) "The narrative we're all encouraged to believe is that satellites are good, they've brought us all this good stuff, and it's very hard to argue against that because most of the bad stuff satellites do is classified, so we can't really know if on the whole satellites have improved our world or not. They've also enabled new kinds of warfare – the kind of violence that they do is unquestionable – and so even that equation I would wonder about that narrative, and that's where I find that the satellite mega constellations just starting to be launched now for satellite broadband internet in very low Earth orbit, it's a step change. And so if we were talking about young people in Australia, how do cultural activists engage people? I think it's in getting a sense of urgency, that this is a whole new world in space, like we are going to have up to 100,000 of these objects in very low Earth orbit within sort of 10 to 20 years. So up to now, whatever we don't know about the military sites and what we do know about the benefits these other satellites at high orbits have given us, maybe it balances out, but this going to tip the scales so fully in favour of industry and surveillance, and so I think just for me it would be the urgency thing that if you could get involved now." (INTERVIEW 30)

04. CULTURAL DIMENSIONS OF THE AUSTRALIAN SPACE SECTOR



CHAPTER 5: AUSTRALIA'S FUTURES IN SPACE



Mosaic of the Valles Marineris hemisphere of Mars. © NASA/JPL-Caltech

In this final chapter we illustrate how diverse articulations about the future of space activities in Australia shed light on how the interviewees describe attainable futures and prescribe futures that ought to be attained. The interest lies in the politics of anticipation around space activities through a range of sites where varied and conflicting views are constituted and resisted. The question of how heterogeneous actors engage with ideas about the future, what intellectual and practical strategies they put into play, and what the implications of such strategies are (WILKIE ET AL. 2017) is crucial for understanding the space sector in Australia. The aim is to illustrate the multiple ways through which the anticipation of space futures has come to the fore as a developing field of expertise and practice. [\[1\]](#) [\[8\]](#)

In what follows we present the answers to the last question posed to all interviewees which focused on their visions of Australia's futures in space within the next two decades. In this question, we asked interviewees to paint a picture of space activities in Australia in 20 years from the time of the interview, in 2041. The question was posed in a deliberately open manner. Interviewees were prompted to articulate their response as an exercise in imagination, speculation, forecasting, informed opinion, or evidence-based projection. Unlike the previous four chapters where we selected excerpts from the interviews, in this chapter we have reproduced the full answers of all interviews.

Interviewees covered the range of statements about how Australia's space futures are anticipated and acted on in relation to a set of relevant recent events. For some these futures were problematised

[\[1\]](#) [\[8\]](#)

For related work around the politics of environmental anticipation see the special issue for the journal *Futures* edited by Céline Granjou, Jeremy Walker, and Juan Francisco Salazar (2017), which includes empirical investigations of a range of sites and infrastructures of environmental anticipation in order to examine the broad reconfiguration of research agendas, environmental governance, and technoinustrial innovation pathways toward anticipatory and security purposes regarding biodiversity, ecosystems, and the biosphere. They reveal insights into the complexities of anticipating the futures of entangled social-technical-ecological dynamics whereby scientific research, government, industries, markets, and civil society produce the future of nature and society in the same movement.

as a disruption, as indeterminate or uncertain, with some saying too much can happen in the timeframe of two decades and others saying that not enough can happen to mark a sharp contrast with the present.

It is important to note that responses combined the four frameworks for value assessment that we have distinguished analytically in previous sections of this report: commercial, sovereign, inquisitive, and caring. They do so in relation to a set of key areas: the space agency, the development of an Australian space market, future exploration and potential settlement on the Moon and Mars, and Australia's international stance.

Before delving into the responses, we provide a short overview of a few of the many significant social sciences approaches to the study of futures. We contextualise the interview responses by drawing from a range of literature that illustrates how the future has become a significant field of study across the social sciences in recent years in response to the escalating rise in and proliferation of uncertainties and unforeseen events brought about by the interplay between social-natural, techno-scientific and political-economic developments (WILKIE ET AL. 2017; OOMEN ET AL. 2021). One relevant approach to the study of futures is offered by the “sociology of expectations”, understood as wishful representations of things to be. This field has explored the ways in which hope, promises, and hype help construct the future as a resource to shape the present (BROWN & MICHAEL 2003). This approach is interested in showing that discourses about the future are generative, in that they “guide activities, provide structure and legitimisation, attract interest and foster investment” (BORUP ET AL. 2006, PP. 285–286). In their capacity to direct action, then, “expectation statements are not only representations of something that does not (yet) exist, they do something: advising, showing direction, creating obligations” (VAN LENTE & RIP 1998).

A third approach is offered by work on “sociotechnical imaginaries” which has been used extensively in social studies of science and technology as a framework to study those “collectively held, institutionally stabilised, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology” (JASANOFF & KIM 2015, P. 4). Imaginaries can be helpful to “reconfigure actors’ sense of the possible spaces of action but also their sense of the rightness of action, ranging from locality [...] to the planet” (IBID., P. 4). In addition, imaginaries are not necessarily constrained to any specific scale of action or actors but are often co-produced by shifting collectives. In her cross-national studies, Jasanoff concludes that “states have not always correctly discerned

the needs and wants of their own publics with respect to technological developments” (IBID., P. 4). It is important, however, to note, as David Hess observes, that “there is not a monolithic state imaginary of the public” (2015, P. 71). A plurality of publics, including social movements, industrial coalitions, and opposing political parties, formulates opposing visions of the future, for example, linked to new technologies and disruptive industries or visions of social justice. The responses we provide in full below illustrate some of the ways in which anticipatory action works. Drawing on geographer Ben Anderson, these could be further analysed in terms of styles – through which the form of the future is disclosed and related to; practices – that render specific futures present; and logics – through which anticipatory action is legitimised, guided and enacted (ANDERSON 2010, P. 777).

From the interview responses in the previous sections and in what follows, it is clear that some perspectives and narratives are dominant in the Australian space sector which are set to guide and galvanise the Australian space industry and shape the perceptions of the Australian public. On the one hand, there are “collectively held and institutionally stabilised” visions being developed, for instance, the visions crafted by the ASA through a series of roadmaps, which are publicly performed as visions of desirable futures (for instance through strategic documents or industry events and fora), by a range of actors. On the other hand, we also observed in the responses that other actors and collectives engage in formulating and developing differing views. In the Australian context, as is the case with other countries, for instance New Zealand, the rubric of NewSpace has emerged as a powerful imaginary of technological development, innovation, and commercialisation that inform the understandings of many key actors in the space sector and permeate the culture and politics of space in Australia. This does mean that a range of other perspectives and imaginaries do exist, or are relevant for considering the public value of space for a range of Australian communities. As has been mentioned throughout, this report considers that the creation of public purpose and public value for the sector lies in the meaningful linkage across those views, a task that entails a clear understanding of their underlying assumptions.

As is common across projections about the future in space, it is difficult to distinguish between what people “predict” based on criteria of viability and what they “hope” based on what they wish, imagine, or speculate. And both types of statements were present in all responses. In the combination of projections, most were hopeful and optimistic, or “cautiously optimistic”. The most contentious issues concentrated on three areas: the ambitions of the Australian industry to lead internationally, the likelihood of a human presence

on Mars, and the fundamental rationale to link space exploration with exploitation. Regarding the last point, whereas for some it appears as a given that exploration entails exploitation, others were quite critical of what this future entails and about the actual viability of these types of activities.

When mentioning the Australian Space Agency, interviewees converged around the idea that the future of Australia in space depends immensely on what the agency can achieve in the near future. Growing the Australian space industry is an explicit mandate for the agency, and it is a tangible indicator of where the sector can go in the future. Expectedly, interviewees from industry outlined optimistic futures of what their companies and the overall industry can achieve. All interviewees outside industry were more sceptical in terms of the position occupied by Australian industry, and others even predicted its failure. Most see the agency delivering on its goals and, more importantly, situating Australia as a mature, reliable partner for other nations in space. In this regard, with few exceptions that invoked the idea of “leading”, all responses that referred to this issue mentioned Australia as not taking on the leader’s role but rather acting as a valued and responsible partner for other nations in space activities.

The development of launch capabilities was quite pervasive amongst the hopeful accounts about the future. With very few exceptions, all mentioned launch in their accounts of Australia’s future in space. Launch is what gives a nation its “pedigree” when it comes to space activities, it is considered central in the creation of the supply chain that many actors in industry hope for, and even the condition of possibility for an Australian civil space program. Regarding satellites, space applications for everyday life, and Australia’s role in space infrastructures, these issues emerged as other concrete areas for activities both for exploration and for life on Earth.

Amongst the least mentioned issues were science, culture, and regulation. Only three interviewees mentioned the key role of regulation in the future of space activities in Australia. There were only single mentions to astronomy and the social sciences when envisioning the future of Australia in space, which illustrates that most accounts of “the sector” continue to be mostly centred on industry, launch, and technological capabilities. Again, as was mentioned earlier in this report, the importance of space science, humanities, and the arts for the Australian space sector is being overlooked.

In some cases, as part of the contextual conversations both during and after the formal interviews, references were made to popular

science fiction, from Arthur C. Clarke to the 1968 film *2001: A Space Odyssey* or, in two cases, to the Amazon series *The Expanse*. Further research could be interesting to illustrate the role that science fiction literature and popular culture plays in shaping and informing views of the key actors of the Australian space sector. For instance, sociologist Janet Vertesi has described how “NASA scientists refer frequently to science fiction in the course of their daily work. Fluency with the *Star Trek* series and other touchstone works demonstrates membership in broader geek culture. But references to *Star Trek*, movies like *2001* and *2010*, and *Dr. Strangelove* also do the work of demarcating project team affiliation and position, theorising social and political dynamics, and motivating individuals in a chosen course of action. As such, science fiction classics serve as local folk fictions that enable embedded commentary on the socio-political circumstances of technoscientific work: in essence, a form of lay social theorizing” (VERTESI 2019, p. 135).

From the responses we can see how, on the one hand, space futures are problematised as a disruption, as indeterminate or uncertain. On the other hand, we observe those positions that are quite the contrary. These distinctions can be analysed as between forms of engagement with space futures that provide “friction” and those that are relatively “frictionless” (GROVES ET AL. 2016). We argue that in both cases, these visions, narratives, and imaginaries of space futures are informing action in the present, as well as ways of knowing and actively anticipating future events that are rendered as crucial for the space sector, both in Australia and globally.

The following are all the responses from the interviews:

(250) “I used to write a lot about why we need an agency, how we’re going to build an industry, all this sort of stuff, and I would say at that time that the sectors of the industry or the ecosystem will emerge. Now, I didn’t fully believe it myself, but it has happened, right. So, in Australia at the moment we are developing space ports, we’re developing launch companies, we’re developing satellite companies, we’re developing payloads, ground stations, networking ground stations, software – the whole ecosystem. There’s little start-ups. If you were to break down the space ecosystem into boxes, there are start-ups in every box in Australia. So, what I see in a perfect world, if things go well, we will have a self-sustaining space industry here where Australian companies will – the whole supply chain, the whole supply chain will be here. So companies will contract to someone like Fleet to provide them with certain data. Fleet will then be able to go to Inovor, get their satellites built. If they need special sensors, they’ll come to someone maybe like us because we’re doing GPS or whatever, and they’ll be able to source their various bits and pieces around companies in Australia. They’ll go to Gilmour, Gilmour will put it onto their rocket, Gilmour will go to Southern Launch, send it up from South Australia; the whole supply chain will be operating. I do believe that there could be within that supply chain Australian

missions to the Moon. In 20 years, I don't see why we will not be doing things with asteroids that would be precursors to mining asteroids for water, I guess, to start but maybe for other things, depending on what goes on in the economy, ups and downs, but, you know, it may not be for use in space. Certainly, initially it probably will be. If you're going to paint that sort of [20-year] picture, I don't think you should be conservative. It's a funny thing. Now I said, 'OK, go back five years and see where the Australian space industry was and how radically it's changed in those five years', that is evidence of how fast it can change, but then if you go back five years from then, it didn't change much, right? It's really ramped up. And I think certainly at the beginning the agency was a symptom of that, not a cause, but I think it's starting to become a bit of a driver of that growth as well." (INTERVIEW 1)

(251) "Let us assume that there are no major conniptions on the part of government. For the moment let's assume that we get the current 10-year plan that the agency has put forward, all goes according to plan. Twenty years from now then I would expect that we might have a couple of Australian astronauts, perhaps, working with NASA or ESA, possibly even some commercial astronauts working with SpaceX or Bezos or one of the other commercial companies, potentially we could have Virgin Galactic using a port in Australia for some of their suborbital tourism, possibly even somebody using the same space port for point-to-point hypersonic suborbital transport, hopefully we'll have a number of well-founded SMEs, probably a handful of larger companies that have become space primes. I would like to hope that among that we would actually by then have that sovereign capability in launch and in being able to provide the necessary defence space capabilities through our own small satellite network, hopefully our own small satellite remote sensing and/or meteorological satellites. Again, maybe some constellations for a company like Fleet or Myriota, might have a small constellation again for their internet of things. You know, maybe this will be servicing New Zealand and perhaps New Guinea, some parts of Southeast Asia as well. Sadly, I don't think we'll have an Australian on the first mission to Mars. We might have an Australian or two on later missions to Mars. I'm hoping by then we will have had a couple of interplanetary probes." (INTERVIEW 2)

(252) "If you pose this question to lots of people in the Australian space industry, they will be unbelievably bullish and optimistic about space and that Australia will be a major player in the technology providers and we will be a partner of choice because we have this either game-changing or disruptive technology that nobody else has and so other countries will want to partner with us and be our allies. So, industry is incredibly optimistic. But if you ask the same of the space sector in any country in the world they'll also likely be incredibly optimistic in 20 years' time. I've experienced enough about industry to know that you have to take some of the publicised 'successes' with a grain of salt. On the other hand, if you speak to people who are opposed to space, they will say that this is a disaster, we should stop now because we're on a road to disaster. There'll be major accidents, launch accidents in Australia, humans will lose their lives, etcetera. And you probably expect me to say this: the answer is somewhere in the middle between the 'It's going to be unbelievable' and 'It's going to be terrible'. We do have some abilities and visionaries and some technologies that can do really good things. I think Australia will be a player, but still very much

in the second rank of space actors. As much as we'd all like to see them doing incredible things and being right up there, I think in the end the really big issues will be primarily driven by the really big players. Now, that's not democratic and we need to make sure that every voice is heard, but on the really, really big issues we're not the final decision makers, I don't think. We're important for what we can provide to our partners; that's why we've been in space. Our entire space history is not so much us being innovative and entrepreneurial in the sense that we're going to go out and create something and do it, it's what we can provide to our partners, and I think that's how we will be for most of the next 10 to 20 years. And we should strive to be that partner of choice. But I could be wrong: we could be major players in off-Earth mining; but just somehow I don't think we will be: I think we will be part of a cog in a wheel, but there'll be a lot more interest in space but I think it might be a fad as well (...). I'd hate for there to be disillusionment with space but it's really sexy in Australia because we're thinking 'Wow, we do all these things', forgetting that 1) we've got a heritage, but 2) all these other countries are wanting to do the same – or similar – things. They will also have clever people and interesting technical skills. You can't yet point to any clear, really big project that's happened in the last five years that has involved Australia. We have collaborations, we're partners, and I think we will need to find a really big Australian landmark project – it is not certain that this will happen, at least for the next 20 years, albeit industry says it will. So, I think we will be higher than where we are now in that there'll be a greater recognition amongst the populace about space, and we will likely be involved in interesting collaborative projects. So, I hope I'm wrong, but I'm not convinced we will be sitting directly at the main table on the really, really big issues; we'll be a support, I think we'll always be a support player, but that would still allow us to have views and a strong and respected voice." (INTERVIEW 3)

(253) "I suppose I've kind of got a little picture which is what I imagined years and years ago, in which an archaeologist goes to the moon, not 20 years from now but let's say 50 years from now, and they go to a particular mare or crater and they find a discarded jar of Vegemite left there. Australians have been on the Moon because Vegemite is the perfect space food, isn't it? Vegemite would be the perfect space food. So, I don't know, 20 years from now I would like to think, let's say there would have been an Australian astronaut and we would have had a deep space mission, an Australian deep space mission. Maybe that would just be the instrument on someone else's, but it would be a specific deep space mission. I would like to see Australia very – a personal vision of mine is that Australia would start to engage with Pacific Island nations in space and bring to them, given that we're not doing anything about them sinking below the waves, so I would like to think that we would put a lot of effort into capacity-building and collaboration and making them spacefaring. I even hate those terms. I'm starting to even abandon the term "spacefaring" and "non-spacefaring" because they're so problematic, but I would like to see that. I would like to see, I don't know, instead of random people one by one in different departments – I know that's changing a lot now. Like I know UWA is about to open a space centre as well, so like everybody's getting on the – but I'd like to see it not – like something that was coordinated, I guess, like from the science perspective, not just random things that rely on people's personal connections but something that was,

I don't know, genuinely discovering new things about the solar system. Twenty years from now, like we'd have a permanent space agency, we would have the most ethical space agency in the world. So, we would have made significant contributions to international relations in terms of addressing all of these things that we've been talking about just now. Like, we would have stepped up and shown leadership, leadership!, and, actually not just followed along but attempted to lead. Maybe in 20 years from now what would be nice is if we weren't just – if we rewrote the book instead of just. And I know it's not that easy and I know that's – but, you know, that would be really nice, it would be really nice if you took all the strengths that Australia had or could have and actually changed the way space was done – I think that would be amazing." (INTERVIEW 4)

(254) "I'm going to answer this with an image of mining Antarctica in 2041. In order for it to be economically and practically feasible for anyone to be wanting to mine oil out of Antarctica in 2041, the world would have to be in an entirely different place to where it is now. First of all, we'd still be using fossil fuels, which means that global warming will have accelerated to a huge rate, which means that there would have been sea level rise and all of our borders will have changed as a result and there will have been mass migration and huge instability in terms of the way that we're operating. As a result of that, the current major powers may not be the major powers in 2041, and we might have a completely different system of even internationally regulating if that's the case. So, if we get to a point where someone wants to mine Antarctica in 2041 because they think that there's profit and benefit in it, we're actually in such a worse place internationally that it almost doesn't matter. And that's kind of where I want to go with this space thing. I think that our activities and our operations in space in 2041 will actually be very similar to what they are now. I think that we will be doing probably a bit of exploration, a bit of science. I hope there'll be a swing-back towards science for science's sake, and I think there might be. I think there'll be a lot of robotic research going on. I think maybe we will have sent someone to Mars, but I don't think we're going to be colonising it any time soon because I think we just won't see the point. I think it's very possible that there will have been some sort of major cyber and space conflict that has occurred between now and 2041 and that as a result the landscape of low Earth orbit and geostationary orbit and the way that we use the internet and so on will have changed a bit. But fundamentally the progression I'm seeing is one towards being divided, towards being more connected, and we live in a world now where when there is a conflict between two neighbouring countries and one country is dropping bombs on the other, there are people on Instagram and Twitter and TikTok sending each other videos and saying, 'Hang on. Why are you bombing my friends?' and that in itself is hugely different to anywhere we've been in history in terms of the way that we see each other as being part of a global community. So, in 2041 I am cautiously optimistic that we will have sorted our stuff out, that we'll be doing collaborative research, that there will be some commercial activities in space but that the space rush of the 2020s will have moderated because we will have discovered that there's actually no demand for all of this stuff. There will be some activities going on, there will be some research going on, there will be a space sector that exists in Australia. We will be doing some launch, we will be doing some satellites stuff, but the vast majority of the space sector in 2041 will actually

be super-boring stuff like insurance and legal and consultants sitting and looking at spreadsheets and data analysis going on with the huge amounts of data that's coming back from all of the satellites and all of the research probes and all of the communications activity that's going on. We'll be communicating using laser communications maybe, and it'll be that much faster, so there'll be that much more data processing required, and there'll be loads of jobs in that kind of secondary area of the space sector. It's just like the boring office jobs will be what we're doing in space and no one will want to work in the space sector, they'll all want to work in whatever the next big thing is and it'll be something really cool but, yeah, I think space will be pretty mundane by 2041 and that'll be great – I'll be very happy with that." (INTERVIEW 5)

(255) "In 20 years we'll have a few Australian-owned satellites that are sovereign capabilities. We'll have, most of them will be secrets and military. I'm sure that already happens. And we will probably have three to five satellites that monitor Australian land, water, coasts and atmosphere. I suspect it will be very modest. We probably will have done some joint missions with other agencies, we'll have a launch capability, modest launch capability. It may be in two or three locations, which is really strange. And that will be a missed opportunity. Because again, different states are competing against each other. And I think we won't have gotten very far." (INTERVIEW 6)

(256) "Twenty years. Okay. I'd like to think that, by that stage, I'd like to think that we are sustainably setting up a base on the Moon. Australia has a pivotal part in that role. If you think of all the connections, we're going to need to have people living remotely in that way. An astronaut said this to me once: 'If you look at the Earth, if you're on the ISS, your entire window is taken up by us. Because you're so close to it, you can't see anything else really, it's the Universe or its Earth. And that's it, there's only two views. So even though you're outside the Earth, you're so close to it, you still feel tied to it. You take a picture from the Moon is very different – it's a blob in the distance.' And so, you know, I'm talking about communication as if it's something black and white, but it's not, it's *how we maintain that connection*, real time connection between the home and our people who are going to be living on, exploring, the cislunar environment. I think Australia will be that key point, that key funnel, which will enable that connection to be maintained. So, and I think 20 years is quite a long way for that, I think we'll be doing that before then. I'd like to think Australia is being part of some major missions at that point in time and whether it's exploring the universe or being part of the global need for us to understand what's happening on our planet and monitoring that and making sure we get back on the right direction. I like to think we're doing a lot of that too." (INTERVIEW 7)

(257) "My mind goes straight to sustainable ways of powering our lives. Potentially there's tech that might be developed that really just transforms the sustainable energy sector. We've seen a really gradual increase in uptake of certain technologies, but I think being able to connect those two, connect the sky to the land, is something really powerful from a human perspective. Surely there's a more sustainable way of harvesting energy off the land. I think also perhaps it might be a little bit different. Maybe things have been changed to get a bit of control over the climate. I know that

the sky and the atmosphere is one of those emerging spaces that is being looked at in order to change the climate here on the land, which is really scary, but hopeful at the same time – you've got to keep hope. So, yeah, there could be some climate altering technologies that are happening out there and maybe it's something that we can visit. We talk about visiting the Moon. I personally don't want to leave our atmosphere – I'm quite happy here – but how amazing would it be to look down and to see the planet and see a little bit of space in the background? So, maybe we don't have to go all the way to the Moon to get that for people; I think a lot of people would love that; yeah, they'd sell their leg for that. And no mining. I don't know what will be there to mine, to be honest. If it's water, I don't think there's enough, and it would be very expensive to do, but also hopefully our technologies here on Earth won't require us to do that." (INTERVIEW 8)

(258) "What I would envisage in 2041, if the space agency takes on board all the things that we've discussed, then we would have our full place in the international community, we'd be fully engaged in space exploration, maybe even among the astronauts who eventually go to Mars. An Australian or one or two Australians will be among them, which will be really inspirational for our country. I see that Australians are very good at innovation and that we will have begun innovation in the space area and just like the black box on airliners, things like that, that keeps us safe, that we'll have done those things, and when we plant a flag – flags, plural – on Mars, Australia will be among them." (INTERVIEW 9)

(259) "We are definitely launching a lot more. We probably have a few, four different launch sites, so we have this thing that everyone wants, which is sovereign launch capacity, and that is servicing government as much as it's servicing purely commercial clients. What I'd love to see – is this going to happen in by 2040? Maybe it will – is that we are also taking a role regionally. So, we're doing capacity-building for our smaller regional neighbours because there's a reciprocal benefit to that because of geography: we can have tracking stations on Pacific islands and, for security purposes, we can bolster the region if we perceive China to be a threat. So, there's a really great leadership role Australia could be playing and in the next 20 years I'd love to see us playing. Also, in terms of international space governance, if we are going to be talking about being custodians of governing space for future generations, and if we've done that right, that means that our burgeoning space industry is taking seriously the responsibility of long-term sustainability and safety and those kinds of things. So, there's no doubt in my mind we have a large and healthy and prospering space industry. Yeah, I want to put more thought to that question and come back to it later if I may. And I've mixed 'this is what I wish' with 'this is what's more likely'." (INTERVIEW 10)

(260) "There will be a bit of a reckoning in about two or three years' time between the US version and the China-Russia version of how these issues should be regulated. I see that coming quite soon. I don't know how that's going to play out, so without knowing how that's going to play out, I wouldn't dare to guess. I think it's equally likely that the Australian space industry will be a flop, an intransient part of a global supply chain. I think that the risks and the contingencies around it are so extreme that I wouldn't want to think beyond three years. So, there is no way I will go 20 years into the future. If we make it another two years here I'd be pretty happy." (INTERVIEW 11)

(261) "I would envision that we will build a spaceport in Australia. We have a lot of space here in Australia, a lot of land, and a lot of that can be put into use with a spaceport or two. Currently the only place humans have only launched for space has been the USA, Russia and China, but I'm not sure. And I would like to see something in the Southern Hemisphere, so maybe we can be the launching facilitators for the Southern Hemisphere. Putting my environmental hat on, we have made progress in a sustainable fashion, not just a fashion which showcases the advance in technology, but in a sustainable way that threatens life on earth the least possible. Whether that be sustainable rock fuels or minimising carbon emissions in some ways because one of the greatest concerns I have for the future is climate change and how that is going to affect everybody's life and health as well, so to link that back to space (...). For example I can see companies that pump leads that are used in space, reduce the number of trucks and cars that need to go out to pipelines to fix the pipelines that transport gas between big cities. Now they are just little sensors on the pipe to determine whereas it is a leak rather than having someone driving 500 km to that point to fix it. And I would like to see technology being used for good and I would like to see technology being used justly. To me, I believe nobody should have dominion of the sky or dominion of the Moon or Mars; that's what space law is about. But I hope that space law will catch up, because space law is important to determine things we are allowed to do and things we are not allowed to do, and I hope that law allows science and discovery to prevail over financial accumulation. And I hope Australia will be part of that, and I hope space will be part of every child's curriculum, and I would like to see some Australian astronauts launch from here." (INTERVIEW 12)

(262) "Twenty years? I don't know, three or four, I can probably have a good stab at that. Honestly, if all the risks that we're taking come to fruition, in three or four years, Australia will be conducting regular space launches from our shores, we will have companies building big rockets – big in relative terms, 10 to 20 metre tall rockets – in our very nation. Using supply chains that have been forgotten when we lost the car manufacturing industry. And so reigniting that, but inspiring that younger generation to go, 'Ha!, now that I've got the building blocks, with key building blocks to get into space, now I can start to hatch those ideas and really push us forward, be it you know, point to point, space travel around the globe that Elon Musk is talking, going to the Moon. This is our opportunity right here.' That then sets us up to move forward quite elegantly into the future. And then it's really up to us to decide what that looks like." (INTERVIEW 13)

(263) "When I look at what Australia's doing in space, I generally think of what am I going to do in space and what my company's going to do in space, because I think we will lead the way and we definitely want to have operations on the surface of the Moon. It'll be beyond ten years. We want to take people into space before ten years. So, I think it's optimistic for us to think that we're going to do a lot of activity on Mars in 20 years, but I think we're definitely going to be on the surface of the Moon and doing a lot of really good things. I have in mind astronauts, tourists, and I actually have this prediction that as we develop bigger launch vehicles that the government will be convinced to start a civilian space program and have Australian astronauts – that's my prediction. We already look like we're going to be operating in more than one state

anyway, so I don't know if I'm comfortable predicting what would be the centre of excellence for Australia. It could be two states: it could be Queensland and South Australia. As for conflict in space, to me is the same as nuclear war: I think it's mutually assured destruction. So, I don't doubt that there's already weapons in space and there will be more weapons that go into space, but I think the use of those weapons is really a last resort and very akin to a nuclear strike, so I hope it's the same and it never happens." (INTERVIEW 14)

(264)

"That's entirely up to us. It could be that we were a great place to buy American products instead of building locally – 'Thank you, President Biden, for your generous contribution to our space program' – that's where it could be. It's going to be one or the other. I'm going to be perfectly clear: it's either going to be a \$12 billion import of American space goods where US suppliers are all over the place and that we lie to ourselves and tell us how great we are in space, or it could be a place where Gilmour and Saber Astronautics and companies like that are building small satellites, launching small satellites, aspiring to do deep space missions and supply the market. You know, you've got a lot of robust mid-sized companies that are suppliers to primes and you've got room for maybe two or three primes in Australia itself. We've got enough room for that; I think we can do that. That's where it could go. So, it's really tough to predict. You don't know what's going to happen. A lot of these long-term kinds of changes are predicated on sort of national strategic directions as well. Who knows what this is going to look like? Maybe Australia will be a space superpower. We're top 10 in the world for academics; there's no reason why we can't be top 10 in the world for production. Twenty years is a long time to predict, right. I mean, what happened 20 years ago? Where were we at? We didn't have Virgin Galactic, we didn't have SpaceX 20 years ago. So it's really, really tough to predict. A lot of these long-term kinds of changes are predicated on sort of national strategic directions as well. Maybe Australia will be a space superpower." (INTERVIEW 15)

(265)

"I don't know if I could say where Australia is going to be. I could say where the world is going to be and I can tell you, I will be doing whatever I can to make sure that Australia plays a large role in that. I really do think that we'll have some missions on Mars, some activity there, not necessarily people at that stage. I don't think we're going to move as quickly as we are hoping – we're definitely not going to have astronauts there by 2026 – but we will start to develop more infrastructure there. I think that our infrastructure in Earth orbit in general will be incredibly increased (...). The idea of manufacturing things in Earth orbit will revolutionise some of the things that we're able to do here on Earth but also revolutionise our ability to easily manufacture spacecrafts up there – it's much cheaper then to be able to move out. So, I think that we'll have an incredibly large amount of telecommunications and observation infrastructure for other planets like Mars. The Perseverance rover that just landed, that's still quite a special thing. I think the ability for us to deploy robots to the Moon and to Mars is going to be quite big to the point where launching a single rover to Mars is not going to be seen as special at all. And I think, if we haven't by that stage, we will have the first human feet landing on both the Moon again permanently and also on Mars, at least temporarily. Hopefully, we'll have the ability to mine and manufacture some methane there for trips back, but that's a little bit further out, probably." (INTERVIEW 16)

(266)

"Twenty years from now – so this is 2040 – I can promise you [company] will have a constellation satellite, an Australian satellite, around the moon and Mars, so that's good. We would be like the infrastructure that connects everything. Hopefully, we will have a couple of good rockets that can launch from here, but more than anything I really hope that every single industry in this country uses space technologies in the way they operate. So massive satellite constellations on Earth, massive influence on Mars and Moon, particularly on the mining side. In communication and mining management and robotic management, we are the best in the world, so it can be done. So, we need to plant ourselves behind Elon and give him the infrastructure that he needs to achieve his dreams. I also hope to see a space culture. I hope that Adelaide will become Little Houston where people go there and love it. I hope that people learn a lot – it will change the culture of students if they want to work in space but, you know, more than anything it would be really good if we could have another astronaut in space that is Australian, and I think that would create a lot of pride in the community." (INTERVIEW 17)

(267)

"In 20 years' time, I see Australian launch being able to deliver payloads on demand for small spacecraft, for larger spacecraft being able to work with the large players to deliver equatorial and high-inclination orbit delivery. I see Australian industry being able to manufacture large parts of the launch vehicle, if not all of it. I see Australian industry being able to be a large part of the supply chain for the spacecraft itself. I see a rich and robust ground segment continuing from the present day, including not just test and evaluation but also ground stations for communications and receipt of data, especially for deep space. I see Australian niche capabilities coming to the fore, such as in remote asset management and operation as well as our deep knowledge in heritage and mining and mineral extraction, so prospecting and extraction of celestial bodies for various purposes, not just for return of high-value cargo to Earth but also for utilisation in space to support activities in space. I see Australia being a robust part of a global space economy." (INTERVIEW 18)

(268)

"We cling on to our linkages to the United States and the United Kingdom. I would like to see Australia play an absolute lead role in the Pacific and Asian region in collaboration with Singapore, Indonesia, all our neighbours and showing leadership in the Southern Hemisphere, looking after each other, and sharing data for purposes of climate change, security, managing fish stock. That's how we could really become more valued in the region we live in. For me, what I've noticed with a lot of Aboriginal people in Australia is that COVID showed us that healing can occur when you actually slow things down and do things differently rather than just doing the traditional way of continuing to roll out services. Aboriginal people can actually see and feel around the world that the Earth was actually healing through the process of COVID while everything stopped for 12 months. When I look around the world, Aboriginal Indigenous people provide the lungs for the rest of the world. We can find ways through space technology to help support other Indigenous peoples in the Amazon, and all these other places that are bringing a key component to the health of the Earth. That's what we'd like to see. And we saw a small glimpse of that through the world slowing down a bit through COVID. Waters started clearing up, and the

country became healthy. While there wasn't all the trucks and vehicles on the roads, there were no dead animals on any of the roads around here, you can see the difference in the, the colour of the sky, you can see the difference in everything around the place, then, ideally for us, we link into a global network of Indigenous groups to help provide leadership and support to help them heal their country, as well. That's what I would like to see in a personal sense, and that we can do that through these sorts of technologies and these opportunities in the space industry." (INTERVIEW 19)

(269) "I certainly see Australia looking up and knowing that there's Australian expertise, an Australian technology, there are Australians operating in space, and that they're proud of that. That is something that I think is so important. And that they also look at their daily lives, whether it's the sort of 2–3 centimetre positioning that they get, whether it's the emergency management that we're going to use during our bushfires is the same as what we're using on the Moon or Mars. They are going to get really excited about us participating in joint missions. So, I see those three things, I think the pride, that's a national pride in what we're doing there sort of restored. And I see their people's lives on the ground changed because of our role. And I can see the jobs that weren't here. I got a letter from a little kid, very early on in the agency. And it was really hard to read because she was like seven or eight. And she said, 'I never thought I wouldn't be able to do this, like work in space.' That was something she couldn't do because Australia wasn't doing it. And then she says, 'but now that we've got a space agency, I think I can.' I see this opportunity that Australian kids have been saying, 'well, that's not for me.' Several people say if I'm going to do this I have to go overseas, people like Thomas who wanted to be an astronaut and dedicate their life to live in the US and going through that. That's what I want to see. That would make me happy. And I think the other bit that people often perhaps don't mention, but sits on my shoulders, is that we've never lost anyone, we've never had a fatality, and Australia is respected for being a sustainable and responsible player in space. If we're operating in space, then we clean up after ourselves. And we worry about that and help clean up the issues of space junk, and we're this responsible player, we stand up even though we're a small player." (INTERVIEW 20)

(270) "Twenty years out is harder than 10 years out. Not because it's further out. It's more about where international collaborations go or not go. If you believe in – and even put a bit of conservatism on the Artemis schedules – that we should have, as a species, permanent establishment of life off our planet, besides the Space Station on the Moon and potentially Mars (...). What is the geopolitical climate around that? That is the fascinating question, and that will dictate what all nations of the world are doing in space. I think in terms of leadership, we will have by 2040, definitely sovereign capabilities to really do most things in space. Maybe not human crewed exploration missions to other bodies. But in terms of the things Australia needs, domestic launch, domestic satellite capability, domestic ability to track that data, domestic ability to control access to space and manage space, situational awareness, I think we will, by 2040, have a very important capability for the nation in space. Generally, I think we'll be part of international missions. I think we will have a thriving sector much bigger than the 20,000 jobs. But the hard thing with 2040 is what happens with the proliferation of all these small satellites in low Earth orbit? I think Australia will

play a leadership role. I think we will continue to be a responsible operator. And we have that seat at the table, through some of the things we're signatories to do that (...). As I think about 2040, the decisions we make in the next year in Australia are going to be absolutely key to that future. The investments we make, the companies that scale, the missions set that Australia as a nation, the government funds. The success of the Moon to Mars program, although relatively modest, you know, will be followed on by other programs, I'm pretty confident, if we're successful. Well, it's not billions of dollars, but 150 do that start. Doing that 10 times, that becomes a significant space program. So, if we can deliver on the projects we have now for government and continue to inspire the nation, I think there's a lot of endless possibilities." (INTERVIEW 21)

(271) "I think we would have a couple of reasonably thriving launch sites. We may also launch for space tourism, though I think that's open. Hopefully, we will have the best expertise in Earth observation, both on the data side and on the hardware side, originally driven by Australian-specific needs, but over time developing to address the needs of other countries too. I think we have a very strong research sector and so we will have technologies that have spun out of that which are specific to Australian innovation but then picked up, hopefully, internationally, and hopefully we'll have one or two or maybe more large-scale homegrown companies that have started from start-ups and grown. The other thing I would hope is that some of the primes have moved their space activities more to Australia, because most of the primes, I think, much of their activities have been much more aero-focused than space-focused, Boeing and Lockheed and things like this, in Australia, and so I think that's likely to evolve. The space agency will have 20 years under its belt; presumably it will be bigger, and we'll have some significant wins, and I guess we'll just be a more mature international player in the space sector. It'll be clearer where our expertise is. Australia will always be great as a ground station both for radio and optical communications. So, we've got a large continent in the Southern Hemisphere, politically stable, geologically stable; I can't imagine that that's not going to play a significant role as we evolve in the space sector – you saw that return of *Hayabusa*, right? And I think the Defence sector is likely to have played a significant role in the growth of the Australian space industry too. They have the largest projects, the most money, and they are keen to build sovereign capability, and I think that that kind of crossover between Defence and civil, that'll be really interesting to see how that evolves because I think maybe that's a bit closer in Australia than it might be in some other countries, that relationship." (INTERVIEW 22)

(272) "We have a manufacturing capability of small satellites, like the 400-kilogram class. We are very good at doing this. We are designing any mission here, we are building them here, we're testing them in Mount Stromlo in Canberra, we're launching them either in New Zealand from Rocket Lab or from southern Australia from an Australian-made rocket or not, and we operate all these missions here and we are the place of reference in APAC. Looking at the Five Eyes map, you can see that we are the only one from the Five Eyes in APAC and we are also their trusted ally in that vision. And while we are there, if it's 2040, we might also – yeah, actually, that's a big thing – we are also remote-operating most of the activities on the Moon

Lake Frome an endorheic landlocked lake in the Flinders Ranges, SA. Credit: Juan F. Sazari



and we are doing the 24 hours roll-outs during the day. That's NASA or America because they are looking at the right place and then we're taking over for the Southern Hemisphere. So, we are *the operator of an operation on the Moon.*" (INTERVIEW 23)

(273)

"The broader question is what does the future look like? What Australia should do is what it does well, which is use our geography and invest in ground infrastructure, to support deep space missions. We should capitalise on the advantages conferred by our geography – that is our differentiator. There would be sensors that we might sensibly design because we've made some bets about certain sorts of sensors. However, as computing and artificial intelligence technologies become commoditised, the advantages that Australia may have today in some areas of sensing, particularly around hyperspectral and some aspects of the use of edge computing, may well be reduced and even lost altogether. Social scientists, perhaps counter-intuitively, may come to the fore. If you can buy your sensor and you can repurpose a satellite and you can do all that stuff essentially from your laptop, the big questions are less likely to revolve around technology than around law and ethics. About the Moon Agreement – interestingly, as you know, Australia's one of the few signatories to that agreement. There has been some thought that Australia would be well placed to actually pull together the interested parties and host the conference that is provided for in the Agreement. Some who know a lot more about these things than I do have said to me that the time for such a conference may have passed. I'm not sure about that. Right now, it may have passed because the willingness to cooperate between Russia, China and America that was evident in the years before 2015 has dissipated. Terrestrial arguments between those three countries have come to the fore. If we find ourselves back in a more friendly relationship, then I think that a conference about the future of the Moon Agreement can come back on the table." (INTERVIEW 24)

(274)

"2041. We will certainly have established permanent lunar bases that will be quite sizeable in design. So I would imagine Australian astronauts working on the Moon alongside other astronauts of other nations in one of these bases on a daily basis. Certainly by 2041, if we're lucky, we'll have the first missions to Mars by then – it might be the late 2030s, it might be the early 2040s, but we're definitely on the point. So, maybe an Australian astronaut as part of that crew for the first mission to Mars. Certainly, an Australian launch capability that is on a daily basis launching payloads into space for Australia and for other countries on a regular basis and doing it extremely cheaply because reusable rocket technology is the future. So increasingly we'll be launching rockets – they'll be coming back, being reprocessed, and launched again and again and again – so you've got a vibrant launch sector. By 2040s, the possibility of aerospace plane technology emerging whereby you can get on an aerospace plane at an airport, it takes off under its own power like an airliner, flies into space, docks with a commercial space platform and then re-enters and lands under its own power like an airliner. So that's the next step beyond reusable rockets, at least for delivering people into space – that's a possibility. I think that taking it down to the societal level, if we've got all of that, Australia is a truly space-enabled society in every respect, so everything we do on a day-by-day basis depends on space capabilities in one form or another, in terms of the mega-constellations that are up there, the giving us internet of things, giving us 6 or 7G and giving us a whole range

of other services that we simply don't have now. When you go, for example, to Google Earth you see imagery that's maybe a few days old or a few weeks old. Well, by 2041 you should be seeing imagery in real time, sort of looking down on the Earth and you can see it, obviously, in virtual reality. So if we want to speculate about the technology, we can keep going, but I do think that society in the 2040s, if we can get around some of the security risks that we're now facing with major power competition, if we can get on top of climate change – which is a big if – I think it's a pretty good future, and space plays a big role in that. And by the 2040s if we're sending the first crew to Mars, we should also be starting to think about how do we send out a crew out to Sirius or how do we send out a crew out to the moons of Jupiter, because we shouldn't get stuck on Mars, we should be keeping on going. That's my vision: I suppose it's for a multi-planet species that is permanently in space and that is expanding across the solar system. There's a great short movie on YouTube called *Wanderers*, narrated by Carl Sagan, that is well worth a look and that kind of epitomises everything that I see over the next century and where we're going." (INTERVIEW 25)

(275)

"I am going to pick what I would consider to be the biggest changes and highlights. I think Australia will be one of the first countries to be a beneficiary of point-to-point transportation, and so I think we will have established space ports. They will be a cross between an airport and a spaceport – and I suspect we will have them on both east and west coasts of Australia, servicing our major domestic population centres. I think there will be Australian companies involved in off-Earth resource exploitation. I would like for Australia to be a leader in space-based solar power, and I think we have the potential to do that for a lot of reasons; I think it's very natural. And in the more mundane things around communications and GPS, I think they will be just more fully ingrained in everyday life and everyday industries. I do think there will be Australians participating in a cislunar economy, so whether that is transportation systems within the Earth-Moon system. I think there'll be Australians working on space stations and facilities on the Moon. By 2041 there'll almost certainly be Australians on Mars as well. So I see Australians participating throughout the economy of a multi-planet spatial system. I think we will have Australian companies as well as Australian individuals participating throughout that in the supply chains, researchers doing work in their fields of expertise, whether it's in microgravity in space station-type facilities, running growing crops or developing power systems on Mars, waste management on the Moon, or on a Martian settlement or in human habitats off Earth. One thing that I love to take people back to is the movie *2001: A Space Odyssey*, which was made in 1968 – and I've used this multiple times at the Space Settlement Summit – and you go back to one of those scenes where the space shuttle is flying up to the space station and the space shuttle is a Pan Am space shuttle, the big airline of the day, the space station's a Hilton in space, and until I saw this clip again about two years ago, I had not realised that they had seatback videos in the back of the seats of the space shuttle – this is 1968. And, of course, what you see are the people who are performing their jobs in space, so you have the flight attendant on the space shuttle flight, and then you have the pilot flying that, and then you get to the Hilton space station. It's just an extension of everyday life. So I think as people start to realise space is a location for work, it's not a discipline in the sense of 'I'm a career astronaut,' it will be a place that people go for aspects of their working

life, whether they are the bartenders or the doctors or the nurses or the mechanics that keep everything or whether they're the scientists or the merchants who work on that frontier. So, I think Australians will be dispersed throughout that, and it will be people from all walks of life who are participating as Australians." (INTERVIEW 26)

(276)

"I think Australia can be a leader in space, it absolutely can, not across a wide range of things but I think with some big, hairy, audacious goals around mining and medicine we could find ourselves being. Why can't we be the farmers of space, the first people to grow food, the first people or the first companies or organisations to extract minerals or resources? I mean, we have all the experience. Personally, I think the world does look to Australia and its experience around mining and remote mining as a potential leader in that area, and if we're willing to lean in on that we could find ourselves being at the very tip of the spear, which would be wonderful. I'm bullish around 2040. I reckon we should be leading in one or two key areas and be world-renowned for being the go-to nation with the go-to industrial ecosystem to support a mining or an agricultural outcome. We eventually have to grow food in space. Why can't we be the people that effect that? It's an interesting question because the space station's just turned 20, so you kind of think of that timeframe again. I think we'll certainly have really interesting infrastructure on the Moon and I daresay people with a permanent presence. There are a lot of challenges that haven't been dealt with, but I really think that people will travel to Mars by that time. I don't think it's realistic to say that there's any sort of scale to that; I think it'll still be quite minimal. If Australia plays its cards right, there's a role for Australia in both the exploration side and in continuing to understand the benefits on Earth as well." (INTERVIEW 27)

(277)

"I think we will be having frequent launches from Australia because Australia has quiet skies and we are a better place to launch from than the United States, for example, where you have to close down the skies for two hours every time you launch something. I imagine there will be people engaged in resource use on the Moon in some form. I think there will be some sort of economy around the Moon. We'll see whether it actually takes off in its own right, but I have a feeling that that is going to happen. There are complex systems forming around it – it's not just one or two. There are complex networks forming to make things happen around the Moon. I don't think we're going to be on Mars by that time. I think people will still just be looking at Mars, but I think it's a bit too hard; distances are too long. And I hope that, by that time, we have discovered uses for space that we haven't imagined today that help humanity and the environment and that enable us to understand the Earth and our solar system better. I hope there are benefits that come from using space in a clever and responsible way." (INTERVIEW 28)

(278)

"In 20 years of course I hope that the space agency has fulfilled its objectives of tripling the size of the sector and so forth. But I also hope that the Australian push has resulted in sufficient intellectual leadership that in the combination of the universities and the companies that there will be significantly more and significantly larger areas in which Australia has its focused lead, for example with the combined focus on quantum, that the quantum key distribution and ultimately entangled photon-distribution-based optical systems will be an area where Australia is neck

and neck with the US and with China in producing value. I'm hopeful of that anyway. Some of the others are a very small niche. Like the space medicine, you've got to have a human there before the space medicine makes a difference, but if we do have humans going to Mars, then space medicine will be an area where Australia can really outmanoeuvre most of its larger rivals because of its early lead. Australian companies know a great deal about mining and remote control and the AI-based autonomous equipment, and we've already taken underwater robotics funding porting it to space. My hope is that this area in Australian leadership can be made available to the mining of the Moon. The Chinese are already starting to prospect for lunar regolith helium-3, and several companies are looking at asteroids from which we're hoping to mine water ice outside Earth's gravity well for crewed Mars missions. So I'm not sure that's a very clear picture of Australia 20 years from now, but it's a few elements of it that I would be happy with." (INTERVIEW 29)

(279)

"I was trying to think of a fable for the satellite constellations. Imagining a world – sorry, this isn't your question – but imagine a world in the future where when you look up you see artificial lights with your naked eye and not stars, or you see more satellites than you can stars, and imagine somebody doing a school project where they were trying to reconstruct what their ancestors used to see when they looked up at the night sky, and something about that really kind of hit me hard. When it comes to Australia, I don't know. The worst part is we'll just be – I mean Starlink's already got approvals to build receiving stations here around Australia and ACMA's sort of given essentially what will be a licence and Starlink will be able to operate for Australian consumers. So, we're not doing anything to stop that. We'll just have been a lemming, I suppose. Like that's the fable of the future is that we were just a lemming that squandered any kind of chance we had to do something beautiful and interesting in space. We'll just have tried to do these dumb little businesses that will mostly fail because it's a failed system anyway economically and then we'll just be like the rest of the world, sort of trapped in this virtual reality of our own creation, yeah, and we won't even be on the record as having been a conscientious objector. That's really what we could do right now: we could be a conscientious objector." (INTERVIEW 30)

(280)

"I think that the Australian Space Agency vision is pretty realistic here, just in my opinion, and what I mean by that is the agency's vision is really being a small but valued contributor to a global space industry, and I think that that's probably where we're going to stay. And we talk all about how 'Well, we're going to invest and we're going to grow bigger' and so forth but everybody's doing that everywhere. We're just keeping up, we're just staying on the treadmill, I think. You've got to pump money in to stay competitive and I think that's all we're going to manage to do. I think that space – and this is, OK, we're going to assume that we avoid complete disaster here from one thing or another, right, so we're going to avoid Kessler syndrome somehow – I think space is going to become, I think it's a good chance space is going to become a bit boring for the public. And what I mean by that is I think it already is to some extent and especially what South Australia does in space I think is hard to excite people about, because I mean the classic Arthur C. Clarke quote, right, you know, 'Any technology that's sufficiently advanced starts to look like magic'. No, that's actually the opposite – I'm sorry, that's the wrong way to go – 'It's going to become

so integrated and so part of what we do every day that it just becomes invisible to us'. And again we already see that happened: so GPS on phones. People kind of know, 'Oh, yeah, that's space, there's something spacey going on there', but it's not exciting or interesting, and I think that when we think about precision agriculture and, you know, resource, Earth observations for resource extraction and all of those things, it's mostly invisible to the public. I think even in 2041 space travel for humans is still going to be incredibly limited and difficult to access, and if we do have off-world human habitation at that point, it's going to be harsh and unglamorous because it is so much harder than people think it is. We're trying to sell this narrative of a bright future in space, of 'We'll go and live on Mars' or whatever it is, and it's just so much harder than people think and I think the shine will wear off. I think that all the things that we use space for today on Earth, which is a huge number of incredibly important things, like to the point the modern economy, especially things like position navigation and timing Earth observations, without those technologies we'd be really struggling. I think if they were suddenly unavailable, it'd be a potential global economic disaster, but they are invisible to most people. Most people don't think about them as being something related to space, and I think that the way that we're going that's going to become more and more the case. We're going to do all of these amazing technical, difficult things – like the capacity and the capability is going to increase and increase and increase and it's going to become more and more invisible as time goes on. I think people are just going to take it for granted. And I think that the challenges of human spaceflight and all these promises of the Moon in 2024 and Mars by 2030, if we do achieve it, it's going to be so much – I think we're setting up for another space race, right, so when you think about public attitudes towards space interviews in the 1960s leading up to the Moon landing, amazing, exciting, the Moon landing happened, it's incredible. Everyone's cheering and waving and that lasts for a couple of years and then we realise, 'Well, actually, there's not much to do on the Moon, so we'll probably stop that and it's too expensive' and then everyone's like, 'Yeah, OK, OK, We're done with space for a while', and I think we're going to hit that – I don't know, sometime in the next 10 or 15 years that the shine will wear off, the difficulties of actually – yeah, there'll be a lunar base that, yeah, we'll have three people on there – it'll be like a space station. I think the space station's not a good example, but it was super-exciting and amazing and now most people kind of know it's there and they like seeing pictures taken from the space station, but they don't really know what it does. And when somebody goes to the space station or comes back or does a thing, broadly speaking people don't really care, and I think we're just going to see more of that." (INTERVIEW 31)

(281)

"In Australia's future there are things that I'd love to see. I think Australia's focus at the moment on telecommunications is going to expand into deep space communications further – that's an inevitability in this trajectory. I think Australia's maritime capability has a role to play that hasn't yet been expanded. Australian waters are pivotal, but also our capabilities in those waters are second to none, and just as we can demonstrate living underground in mining communities in Australia, I think we have a role to play in the habitation but also the essential service provisions for activities happening in outer space. I would love to see Australia's capabilities in film and television in virtual and immersive environments in storytelling coming

to the forefront – I think we have a role to play there, absolutely. We are strategic and we have the human resources and the technological capabilities for expanding on that. We also have supercomputing capabilities and things like that. Dare I say it? I believe – I don't know why but I believe Australia's cooperation with China should improve over the next 40 years. I think there's a great untapped resource there that as an actor China is quite independent, it's self-sufficient, but there could be a better and strategic view. I think they are part of a community that is looking for a peaceful purpose and cooperation, and they do believe in the essential treaties that I believe are fundamental for us as extraterrestrials and the success of our being better custodians of Planet Earth or any space that we enter. And my hope is that there's – we have a lot of capability for gathering data – and this is a planetary issue, but we are gathering data all the time but hopefully there are new service providers who are getting data, analysing it better and getting it to people, grassroots people, who can use it in real time. I think if that happens in the next 40 years that we can start to address bigger issues from food scarcity to other things, water management, and so the things that are creating and still historically have always created great political tensions for access to resources and the management of resources. So as things get increasingly extreme, I think we need to be better at using our data capabilities more responsively and responsibly to do a better job. At least the generations coming forward want that – their prime driver is to protect the planet and not to make the mistakes of our generation." (INTERVIEW 32)

(282)

"I think, to a certain extent, space might be boring, it might be routine. And we are kind of approaching that point already. The number of rocket launches we've had this year, internationally, space is becoming routine. I'd like to think that most people would know at least one person who's in the space industry in Australia. It's been fascinating seeing their reactions when I talk to people about my job. Most of the taxi drivers have asked me what I'm doing when I say I work in the space industry. They say it must be really tough leasing out offices in the CBD at the moment (...). I'd like to think that Australia might have more people who are known for their space expertise, whether that's scientists, or whether that's astronauts, or whether that's businesspeople. And I think space will be more pervasive into a lot of different parts of government, but also everyday life too. So, someone asked me the other day, in a panel discussion, do you think we'll have chief space officers in companies in the future, which is kind of an interesting thing to think about. I don't think so. But I kind of compare where space is at in Australia at the moment to where cybersecurity was four or five years ago. So, no one really knew what cybersecurity was, that it was important, but they didn't really know it was a thing. And then, all of a sudden, there's a lot of jobs in cybersecurity. So, now every company needs to have someone trained in cybersecurity. And then there was a journey happening in government as well. I think that's the journey we're going to go on with space in the next little while." (INTERVIEW 33)

(283)

"I would like to see Australia have one particular product in space that is immediately identifiable as Australia's contribution. Canada has robot arms. I'd like to see us have something, not a robot arm or something like that, perhaps a NewSpace suit,

revolutionary space suit, to be able to say that is Australia in space. I like to see that. I think that the Australian culture, because we are often generalists, you know, we've got, we can draw on people who have worked in the mining industry, in the parcel industry, exploring desert environments. We can contribute to that as well, and have a more practical approach than the super theoretical approach that happens in the US and Europe." (INTERVIEW 34)

(284)

"I think we have access to near real-time observations of the Moon or planet we're on. So, we've already sent the satellites, we're mapping that environment, we understand the systems and how that relates at a wide level as well as a local level. We have a presence, we have capacity to move off and on to that planet or moon, so freedom of travel. Yeah, that would be possibly the next step, I think. I'm not a cultural expert or anthropologist but I think in 20 years' time if we had legal personhood established, if nature had a voice, if we had ecocide established so had legal governance in place as well, I think our society then would have the real reverence, reverie, respect of nature in all its forms, from rocks to wind to sunlight – speaking of the Moon specifically so asteroid showers, seasons – and I think that awareness and intent and data-driven and legal framework around it would ensure that we really enable not only human life but the life of all living things in the universe as stewards of that success, and in relationship with it I should say, in dialogue." (INTERVIEW 35)

(285)

"Twenty years. That is a long time in technology. I think we've got three to five years to niche ourselves into this global market. Because there are a lot of players: India, China, Brazil, half of Southeast Asia. There are a lot of people vying for the NewSpace market. So, where I'd like to see us in 20 years would be designing, building, launching, managing spacecraft in order to get value back to Earth, back to Australia. Primarily in those other areas. We need our own weather services, but at the moment, we're totally dependent on foreign capabilities. We need to overcome the tyranny of distance in Australia. So, get away from copper and have ubiquitous communications. And we need to get away from rocks and crops, so kids aren't just selling fishing, wheat and dirt. But now hopefully, there's an industry for them to move into to actually do smart things. So, I think it's multifaceted. But in terms of the global market, I hope we're up, pushing towards the sort of 4 percent, 5 percent mark. At the moment, Australia, I think, globally only has 1 percent of the market of anything. So that would be pushing above our weight. I think the agency goals at the moment are about 1 percent. Very aspirational in the timeframe, but certainly a little longer time frame. Maybe a couple of percent of the global market, and doing really cool things." (INTERVIEW 36)

(286)

"I think we're definitely going to have our own sovereign launch capabilities. We'll have things like, for example, Gilmour Space Technologies, Equatorial Launch Australia, and Southern Launch Australia up and running and humming really smoothly. I also think that because of our location, our geopolitical scenario, our geology – not many big earthquakes – we're going to have a couple of really big investments here in terms of mega science projects. So the SKA Project will be up and running, we will probably have a space port, even two space ports, because, again, our location in the Southern Hemisphere means we've got a large land

mass which we should be able to service and utilise to our advantage. We've got a geologically stable location, so we may have a gravitational wave detector with lasers. And, of course, we've got dark skies, so we'll probably have some really nice optical observatories to look out into the universe. I feel like there probably should be – I'm hoping here – more tie-in with the storytelling part of things, so we'll be able to see a lot more platforms doing the storytelling aspect of space rather than just telling the news. So at the moment you'll probably notice things like Channel Nine, Channel Seven, SBS, they all have a news section about space or maybe technology that's buried seven clicks down if you look into their website, but I hope that those platforms start recognising that space is actually part of every market. Just as well as we tell sports, for example – we're obsessed with sports, we might as well be obsessed with space. And I hope again we have from the education perspective young people learning more about our space history and our space culture and our Indigenous space community as well. So, you'd look at things, examples like America and even Russia: space is their pride and joy. Obviously, they put people on the Moon, etcetera, but space is their pride and joy, and kids are taught about NASA and the moonwalk from primary school. We don't get that here. We learn about American space rather than learning about Australia space, and we need to integrate or we need to do an education curriculum around – and I hope this happens as well – around why has Australia's space history been important and what has Australia contributed to space." (INTERVIEW 37)

(287)

"If I was going to do my sort of big sky wishes – and I think they're fairly practical based on what we're doing at the moment – I would like to see a reliable launch facility that ELA is building in the Northern Territory. So having a reliable and trustworthy with lots of flight heritage launch facility in Northern Territory – the one at Gove that's been built – to have a larger satellite operation centre with Australian satellites and maybe even operating overseas satellites using Australian software and Australian operators for those. I would like to see space instrumentation, have mass manufacturing and space readiness certification and even basic components like satellite chassis and things like that that are super-easy to manufacture. So, more mass manufacturing and more regular manufacturing for the space industry, Australian-made sounding and orbital rockets; I know those are in development, but I would like to see those in 20 years and hope that they would be established. Space export: in 20 years' time, at least 50 percent of our revenue should come from space export if we're going to be a really serious space country – so that's a high goal, but I think it's achievable. In 20 years – well, definitely before 20 years but in 20 years, membership of the European Space Agency as a non-EU collaborating state, so the same as Canada and Latvia and Slovakia, for example. And building up our leadership and our capabilities so that we're equivalent to or better than Japan in the Asia-Pacific regional space agencies group. Human presence on the Moon is definitely going to be around as well. I think it's going to be driven a little bit still by the north, you know, the main space agencies that do the ISS, plus China who's a separate, independent actor. A really good extra point is that Australia toes the line constantly – and I know there's issues right now but in general we toe the line with being partners with America and partners with China at the same time, because one's our security ally and one's our economic ally, and I think we could also – you know, because we have

that precedent – collaborate with NASA and Europe and Japan but also collaborate with China, and that's not an option for a lot of places. And, yes, an established lunar base is a big thing that all the agencies are working on, so I think through international collaboration we could definitely have a foot in the door for that, yeah. We wouldn't take all the capital and risk impost ourselves, of course; there's no point. But, yeah, absolutely through collaborations and with the main group from the ISS that's doing a Moon base, then through China as well – why not do both in 20 years?" (INTERVIEW 38)

(288)

"I really think that remote asset management, robotics, autonomy, resource extraction, safe, sustainable resource extraction will be done in a safe, sustainable and reasonable way with a process behind it if you have Australians doing this. There is one good thing about that UK civil service culture: there will be a process around it. And so, I do think, though, that there's a strong science component to that when you get down to it, so to me it leverages some of those great strengths that Australia already has. I think for me the future is a little bit fuzzy, but there's one thing that I know – I have seen it in my head and I know it's going to come true and it's an Australian flag on the Moon. That will bring Australians together." (INTERVIEW 39)



Wall art in a restaurant in Alice Springs, 2021. Credit: Juan F. Salaza



Milky Way over the Pinnacles Desert, Western Australia. Credit: Trevor Dobson

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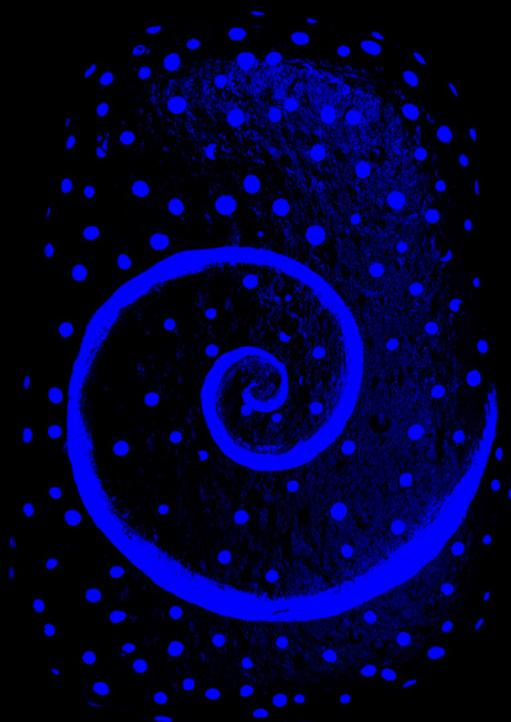
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The report identifies frameworks for value assessment in relation to the launch and first years of development the Australian Space Agency; the development of an Australian space market; future scientific, commercial and civil endeavours in Low Earth Orbit, the Moon and Mars, and Australia's stance in the global space sector. It aims to contribute to ongoing efforts to deliberate the futures of Australia in space by highlighting the cultural implications of the pace enterprise in Australia, to inform responsible research and innovation, the engagement with civil society and a diversity of publics.



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