Space security in the 21st century: roles, responsibilities and opportunities for Australia

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Space Security in the 21st Century
Roles, Responsibilities and Opportunities for Australia

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A thesis in fulfilment of the requirements for the degree of
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This thesis tests the hypothesis that Australia is obligated, in practical and moral terms, to invest in the security of the orbital space environment.

Since the late 1940s, Australia's involvement in activities in the orbital space environment has been framed largely by national security considerations. Space activities are the heart of Australia's alliance with the United States and have provided Australia insights into global space activities not available to other small and middle powers.

An economic development narrative, which has been poorly articulated over many years, also exists. Persistent calls by industry advocates and enthusiasts for a succession of Australian Governments to invest in a civil and commercial space industry have largely been ignored. The Australian Space Agency was established in 2018 with an economic rationale based on figures that are weak and ill-defined. The agency has been established, ostensibly, to encourage private investment in a domestic space industry that may come to represent about 1% of the global space industry. A domestic space industry is not essential to the dominant security narrative, but is dependent on assured and secure access to services and data that satellites provide.

Orbital space is a profoundly dual-use environment in which military and non-military payloads share orbits and technologies. Commercial interests, with proposals to launch very large constellations into Low Earth Orbit, are challenging the paradigm that space activity is the almost exclusive preserve of nation states.

To ensure ready access to orbital space in the future, the international community - including Australia - must deal with a range of threats including that of space debris in the Low Earth Orbits (LEO). The Space Agency could become Australia's lead organisation for space security matters, helping to protect economies, national and global, that are increasingly reliant on secure and assured access to the services provided by satellites.

The thesis focusses on the period from November 2007 to the end of March 2019. The evidence from this period appears to support the hypothesis that Australia is obligated to invest in the security of the orbital space environment.

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ABBREVIATIONS

AAAAI	Australian Association of Aviation and Aerospace Industries
AAS	Australian Academy of Science
AATS	Australian Academy of Technological Sciences
AATSR	Advanced Along Track Scanning Radiometer
ABC	Australian Broadcasting Commission
ACA	Arms Control Association
ACB	Adelaide Convention Bureau
ACC	Adelaide Convention Centre
ACMA	Australian Communications and Media Authority
ACS	Association of Consulting Surveyors
ACT	Australian Capital Territory
ADF	Australian Defence Force
ADFA	Australian Defence Force Academy
ADSCS	Australian Defence Satellite Communications Station
AEOCCG	Australian Earth Observation Community Coordinating Group
AIS	Automated Identification System [ship reporting system via satellite]
AITC	Advanced Instrumentation and Technology Centre
AGI	Analytical Graphics Inc
AGO	Australian Geospatial Organisation
ANU	Australian National University
ANZUS	Australia, New Zealand, United States [Treaty]
APAC	Asia Pacific Aerospace Consultants
APRSAF	Asia Pacific Regional Space Agencies Forum
APSC	Asia Pacific Space Centre
APSCO	Asia Pacific Space Cooperation Organisation
ARD	Analysis Ready Data
ASAT	Anti-Satellite [Weapon System]
ASB	Australian Space Board
ASC	Australian Space Council
ASD	Australian Signals Directorate
ASDC	Australian Space Development Conference
ASEAN	Association of South East Asian Nations
ASICC	Australian Space Industry Chamber of Commerce [since 2009 the SIAA]
ASIO	Australian Security Intelligence Organisation
ASKAP	Australia SKA Pathfinder
ASO	Australian Space Office
ASPI	Australian Strategic Policy Institute
ASRP	Australian Space Research Program
ATCA	Australia Telescope Compact Array
ATNF	Australia Telescope National Facility
AUSLIG	Australian Surveying and Land Information Group
AUSMIN	Australia/US Ministerial Talks
BIE	Bureau of Industry Economics
BMD	Ballistic Missile Defence
BoM	Bureau of Meteorology
BSA	Black Sky Aerospace
CD	Conference on Disarmament
CDSCC	Canberra Deep Space Communications Complex

CEODA	Continuity of Earth Observation from Space: Operational Requirements to 2015 for Lands, Coasts and Oceans
CEOS	Committee on Earth Observation Satellites
COAG	Council of Australian Governments
CME	Coronal Mass Ejection
ComSpOC	Commercial Space Operations Centre
COPUOS	Committee on the Peaceful Uses of Outer Space
COSSA	CSIRO Office of Space Science and Applications
CPD	Commonwealth Parliamentary Debates [Hansard]
CRC	Cooperative Research Centre
CRCSI	CRC for Spatial Information
CRCSS	CRC for Space Systems
CSA	Canadian Space Agency
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSIS	Centre for Strategic and International Studies
CSOI	Combined Space Operations Initiative
DEA	Digital Earth Australia
DFAT	Department of Foreign Affairs and Trade
DIAB	Defence Industry Advisory Board
DIIP	Defence Integrated Investment Plan
DIIS	Department of Industry Innovation and Science
DIISR	Department of Industry Innovation Science and Research [now DIIS]
DIISRTE	Department of Innovation, Industry, Science, Research and Tertiary Education
DIPS	Defence Industry Policy Statement
DITAC	Department of Industry, Technology and Commerce [now DIIS]
DITR	Department of Industry Tourism and Resources [now DIIS]
DLR	German Space Agency [Anglicised acronym]
DoD	Department of Defence [Australia]
DPMC	Department of Prime Minister and Cabinet
DSCF	Defence Space Communications Facility [Nurrungar]
DSCO	Defence Space Coordination Office
DSD	Defence Signals Directorate
DSP	Defence Support Program
DST Group	Defence Science and Technology Group
DSTO	Defence Science and Technology Organisation
DSGL	Defence Strategic Goods List
DTCA	Defence Trade Controls Act
DWP	Defence White Paper
EDTAS	Emerging Disruptive Technologies Assessment Symposium
EISSI	Excellence in Surveying and Spatial Information [awards]
ELA	Equatorial Launch Australia
ELDO	European Launcher Development Organisation
EMS	Electro Magnetic Spectrum
EOS	Earth Observations from Space
EOS	Electro-Optic Systems
ERC	Expenditure Review Committee
ERG	Expert Reference Group
ESA	European Space Agency
EU	European Union
FedSat	Federation Satellite
FIC	Fundamental Inputs to Capability

HGF	High Growth Firm
HPC	High Performance Computing
IAC	International Astronautical Congress
ICoC	International Code of Conduct
ICT	Information and Communications Technology
INSP	Integrated National Space Program
IoT	Internet of Things
ISAG	International Space Advisory Group
ISNSW	Institute of Surveyors, NSW
ISS	International Space Station
IT	Information Technology
ITR	Institute for Telecommunications Research [UniSA]
ITU	International Telecommunication Union
G-20	Group of 20 [wealthiest nations on Earth]
GA	Geoscience Australia
GAP	Global Access Partners Pty Ltd
GDP	Gross Domestic Product
GEO	Geostationary Earth Orbit
GFC	Global Financial Crisis
GGE	Group of Government Experts
GMT	Giant Magellan Telescope
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HCoC	Hague Code of Conduct
HEO	Highly Elliptical Orbit
HF	High Frequency
IAC	International Astronautical Congress
IAF	International Astronautical Federation
ICoC	International Code of Conduct
IDC	Inter-Departmental Committee
IDSA	Institute for Defence Studies and Analyses [New Delhi]
IGIS	Inspector General for Intelligence and Security
IPS	Ionospheric Prediction Service
ISAG	International Space advisory Group
ISNSW	Institute for Surveyors, New South Wales
ISS	International Space Station
ISU	International Space University
ITR	Institute for Telecommunications Research [University of South Australia]
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
JDFN	Joint Defence Facility Nurrungar
JDFPG	Joint Defence Facility Pine Gap
JDSCS	Joint Defence Space Communications Station [Nurrungar]
JDSRF	Joint Defence Space Research Facility
JORN	Jindalee Over-the-horizon Radar Network
JSpOC	Joint Space Operations Centre
LEO	Low Earth Orbit
LLGDS	Land Locked and Geographically Disadvantaged States
LOSC	Law of the Sea Convention
MEO	Medium Earth Orbit
MIKTA	Mexico/Indonesia/(South) Korea/Turkey/Australia [middle power group]

MTCR	Missile Technology Control Regime
MUOS	Multi-Use Operational Support System
MWA	Mileura Widefield Array
NAM	Non-Aligned Movement
NAS	National Academies of Science [US]
NASA	National Aeronautical and Space Administration [US]
NBNCo	National Broadband Network Company
NCI	National Computational Infrastructure
NCSRS	National Committee for Space and Radio Science
NEO	Near Earth Objects
NGTF	Next Generation Technology Fund
NICT	National ICT [Japan]
NOAA	National Oceanographic and Atmospheric Administration [US]
NORAD	North American Aerospace Defence Command
NRC	National Research Council [US]
NSC	National Security Committee
NSP	National Space Program
NSSA	National Space Society of Australia
NT	Northern Territory
OECD	Organisation for Economic Cooperation and Development
OST	Outer Space Treaty
OTC	Overseas Telecommunications Commission
PAROS	[to] Prevent and Arms Race in Outer Space
PIC	Priority Industry Capability
PMSEIC	Prime Minister’s Science Engineering and Innovation Council
PMG	Postmaster General’s Department
PNG	Papua New Guinea
PNT	Position, Navigation and Timing
PPP	Purchasing Power Parity
PPWT	[Proposed Treaty] on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects
OTC	Overseas Telecommunications Commission
QZSS	Quasi-Zenith Satellite System [Japan]
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RBA	Reserve Bank of Australia
RGS	Relay Ground Station
RF	Radio Frequency
RFI	Radio Frequency Interference
RoC	Record of Conversation
SA	Selective Availability
SASI	South Australian Space Initiative
SATCOM	Satellite Communications
SBAS	Satellite Based Augmentation System
SBIRS	Space Based Infra-Red System
SCO	Space Coordination Office (established in 2012 as a successor organisation to the SPU)
SDA	Space Data Association
SEATO	South East Asia Treaty Organisation
SEMCRC	Space Environment Management Cooperative Research Centre
SERC	Space Environment Research Centre (trading name of the SEMCRC)

SIA	Satellite Industry Association
SIAA	Space Industry Association of Australia
SIBA/GITA	Spatial Industries Business Association and the Geospatial Technology Association, Australia and New Zealand
SIA	Satellite Industry Association [US]
SIAA	Space Industry Association of Australia
Sigint	Signals Intelligence
SIIC	Space Industry Innovation Council
SKA	Square Kilometre Array Radio Telescope
SLOC	Sea Lines of Communication
SMH	Sydney Morning Herald
SOHO	Solar and Heliospheric Observatory [satellite]
SPAG	Space Policy advisory Group
SPU	Space Policy Unit
SSA	Space Situational Awareness
SSDP	Space Science Decadal Plan
SSN	Space Surveillance Network
SSSI	Surveying and Spatial Sciences Institute
STEM	Science, Technology, Engineering and Mathematics
STEREO	Solar Terrestrial Relations Observatory
STS	Space Transportation Services Ltd
SWF	Secure World Foundation
SWOT	Strengths, Weaknesses, Opportunities, Threats
TCBM	Trust and Confidence Building Measures
TLE	Two Line Element Set
TT&C	Telemetry, Tracking and Command
UK	United Kingdom
UCS	Union of Concerned Scientists
UHF	Ultra High Frequency
UN	United Nations
UNCLOS	United Nations Convention on Law of the Sea
UNGA	United Nations General Assembly
UNIDIR	UN Institute for Disarmament Research
UniSA	University of South Australia
UNOOSA	United Nations Office of Outer Space Affairs
UNSW	University of New South Wales
USAF	United States Air Force
USG	United States Government
USN	United States Navy
USSC	United States Study Centre [University of Sydney]
USSR	Union of Soviet Socialist Republics [now Russia]
VCDF	Vice Chief of the Defence Force
WEF	World Economic Forum
WGS	Wideband Global System
WPA	Woomera Prohibited Area
WRE	Weapons Research Establishment
WRESAT	Weapons Research Establishment Satellite

FIGURES

TABLES

Selected publications, articles and presentations that drew on this research

Monographs

Biddington B & Sach R H. *Australia's Place in Space: Toward a National Space Policy*, Kokoda Paper Number 13, Kokoda Foundation, 2010, Canberra.

Biddington B. *Girt by Sea: Understanding Australia's Maritime Domains in a Networked World*, Kokoda Paper Number 20, Kokoda Foundation, 2014, Canberra.

Waters G, Biddington B & Valli C T. *Building a Resilient Cyber Eco-System: National and Regional Considerations*, Kokoda Paper Number 21, Institute for Regional Security, 2016, Canberra.

Articles

2011
India, ASATs and the Regional Balance: An Australian Perspective, in India Review, Vol 10, Number 4, Oct-Dec 2011.

2012
Australia's Place in Space: Historical Constraints and Future Opportunities, in Morris L & Cox K J (eds), International Cooperation for the Development of Space, Aerospace Technology Working Group, USA.

2013
The Proposed ICoC for Outer Space: An Australian Perspective, in Rajagopalan R P & Porras D (eds), Awaiting Launch: Perspectives on the Draft ICoC For Outer Space Activities, Observer Research Foundation, New Delhi, India.

2019
An Australian Space Agency: Has the Country Woken Up? For the Observer Research Foundation, New Delhi, India.

Forthcoming
Strategy Geography, Space, Time and the Rules-Based Order: A Need for Some New Connections? in "Countering Extremism & Radicalization in the Age of Digitalization & Social Media: The Need for Paradigm Shift & Strategic Approach", published jointly by the Institute for Policy, Advocacy, and Governance (IPAG) and The Institute for Defence Studies and Analyses (IDSA), New Delhi, India.

Invited contributions about Australian space developments in:
The Conversation
The Interpreter, Lowy Institute
Australian Outlook, Australian Institute for International Affairs
The Strategist, Australian Strategic Policy Institute

Conferences

2018
Australian American Leadership Dialogue, Washington DC, 10-12 July

4th China (International) Aerospace Forum, Wuhan, China, 28-30 August.

The Zone Above Conference, Perth USAsia Centre, 5 October.

CHAPTER 1

INTRODUCTION

1.1 The Hypothesis

This thesis tests the hypothesis that:

> To defend and promote its interests domestically regionally and internationally, Australia, by virtue of its geography, extant capabilities, and commitment to the international rules-based order, is obligated to invest in the long-term safety and security of the orbital space environment.

The concept of obligation contains both practical and normative elements. The *Shorter Oxford English Dictionary*, in its discussion of the word, speaks about “bounden” or “particular duty” and also about a “moral tie . . . binding to some performance” (SOED, 1970). This thesis tests the idea that Australia has self-interested, practical and moral reasons to invest in space security.

1.2 Research Questions

The hypothesis is approached through five questions:

1. Why is a safe and secure orbital space environment important for humanity?
2. Is Australia capable of making a significant contribution to the security of the space environment?
3. If so, should the security of orbital space become a public policy priority for Australia that attracts funding and political attention beyond that devoted in the past?
4. Does the growth of a domestic space industry provide sufficient and compelling justification for the Australian Space Agency?
5. What are the implications for Australia’s commitment to space security of recent initiatives by Australian departments and agencies including the Australian Space Agency?

On 1 July 2018, the Australian Space Agency was established (Cash, 2018a). Does the agency’s creation represent policy continuity or policy discontinuity? Was the agency set up to avoid international criticism that Australia was one of the few developed countries in the world without a space agency? Or, is it a reflection of other developments related to the profoundly dual use of the orbital space environment? Is there a strategic impact of creating a space agency after decades of strong resistance which has yet to be understood? What might be the agency's contribution to the promotion of Australia's interests in space, especially as those interests relate to the safety and security of the orbital space environment? Is Australia merely interested in promoting selfish national interests in space, or does it have broader obligations to contribute to global space security on behalf of all nations?

1.3 The Australian Space Story: Divergent Narratives

A dominant theme in the past public narrative about Australia's approach to space appears to have been one of disappointment and lost opportunity. Dougherty in *Australia in Space* (Dougherty, 2017) exemplifies this view. She concluded her history of Australia's space journey with the following sentence:

> "Will Australia continue to remain 'lost in space', or will the government respond to the groundswell of support for a national space program, overseen by an Australian Space Agency, and launch this country into a new and vital phase of space engagement, enabling Australia to permanently become a spacefaring nation?" (ibid, p. 177).

There are numerous precedents for Dougherty's view. One of the more important is the report of the 2008 Australian Senate inquiry into the Australia's space science and industry sector. The title of the Committee's final report is, *Lost in Space? Setting a new direction for Australia's space science and industry sector* (Senate, 2008). The report concluded that:

> "…the Australian space industry is fragmented, there is a lack of clarity in organisation, confusion as to who does what and who is able to fund what…" (Senate, 2008, p. 65).

Whether the formation of the space agency has dispelled some of the disappointment remains to be seen. That aside, there are bifurcated narratives that have arisen about Australia's involvement in space activities and the need (or not the need) for a space agency. The first is a national security narrative and the second concerns economic development.

1.3.1 The National Security Narrative

A very small number of writers, most prominently Professor Desmond Ball (deceased, 2016), focussed their attention on the American satellite ground stations located in Australia, notably the signals intelligence (Sigint) ground station at Pine Gap near Alice Springs in Central Australia and the ballistic missile early warning ground station at Nurrungar, near Woomera in

South Australia that closed in 1999. In a series of monographs, Ball explained, as best he could from the public record, the roles these facilities played in verifying nuclear arm control treaties and in helping to balance the strategic interests of the West against the interests and ambitions of the Soviet Union during the Cold War (Ball, 1980, 1987, 1988, 1992, 1998). The principal benefit to Australia of the US Alliance, at the heart of which today is Pine Gap, is the implied nuclear guarantee or extended deterrence provided by the United States (Lyon, 2019).

Since the Cold War, and in response to technological changes, Pine Gap would seem to have acquired new roles providing direct targeting support to American and allied forces in theatres of military operations, notably in the Middle East (Rosenberg, 2011; Fraser, 2014). These capabilities have given cause for alarm (Fraser, 2014) and support (Beazley, 2016). Putting disagreements to the side (they are addressed in later chapters), the salient point is that satellite ground stations are a vital and substantial element in Australia's alliance relationship with the United States. Pine Gap remains fundamental to the security of the United States (Beazley, quoted in Wicht, 2018) and the NASA ground station, at Tidbinbilla near Canberra, is integral to US civil space activities as well (NASA, 2019). Known formally as the Canberra Deep Space Communications Complex (CDSCC), this is not a classified facility. US export controls, however, are stringently invoked to protect US-developed intellectual property, integral to the facility's operations, from falling into unauthorised hands (Biddington, 2017a).

These arrangements would seem to have provided successive governments in Australia with sufficient comfort that deliberate investment in a publicly-funded national space program, aimed at increasing self-reliance, has not been a security or civil national capability development requirement.

1.3.2 The Economic Narrative

The economic narrative is based largely on comparisons. Before the Australian Space Agency was established in 2018 the mere fact that one did not exist set Australia apart from all other OECD nations and was advanced by some as justification enough, with no further analysis needed, for an agency to be established (GAP, 2016, p. 26). Comparisons with other nations, notably Canada, have been made in an to attempt to strengthen the argument that Australia needed to establish a national space agency (GAP, 2017, p 10). Typically, high-level similarities are pointed out. In the case of Australia and Canada, references are made to their large landmasses, relatively small populations and their shared cultural and historical experiences. Circumstances unique to Australia, and to Canada ,that might explain why different space development pathways have been taken, are not addressed. Emphasis invariably is on comparative economic performance as if this is the only valid way to measure involvement with or commitment to space (Senate, 2008; SIAA, 2017).

Writing in 1990, Senator the Hon John Button, the Labor Minister responsible for civil space matters, wrote a lengthy introduction to a document called *Australian Space Industry Development Strategy* (DITAC, 1990). Somewhat paradoxically, given the document's title, he was unequivocal that the government would not give special treatment to space companies and laid the blame for the poor state of the space sector squarely at the feet of industry. He spoke of the government committing "certain resources" within an "agreed framework" to make "optimum use" of the resources that government was prepared to make available to assist with development of a space industry in Australia (ibid, p. 5).

In 2004, the document that served as the civil space policy for the Coalition Government led by John Howard was also blunt:

> "The market failures for the space sector are the same as for most other high-technology industries. These are addressed by generic Government industry programs and do not require a dedicated space program. The Australian Government does not support a centrally-funded "space office" or space program…" (DITR, 2004, p.3).

Since the Cold War, technological change, notably the miniaturisation of electronics, has led to what some writers are calling the "democratisation" of space (Baiocchi & Welser, 2015). As the costs of entry to space have come down, more nations have sought to design, build, launch and operate their own satellites. Some refer to this phenomenon as "Space 2.0" (Pyle, 2019). There are research organisations and start-up companies in Australia that are part of this movement. The principal stated role of the Australian Space Agency is to create an environment in which these ventures have every chance of succeeding, thereby forming the basis of a space industry in Australia (DIIS, 2018a).

1.4 In Space and On the Ground

Both narratives are complicated by the distinction between activities that occur in space and those that occur on the ground. The UK Space Agency has termed these activities respectively upstream and downstream activities (UK, 2010). Upstream activities include the design, manufacture, launch and operation of satellites. Downstream activities include the processing of data from satellites, insurance and financial services, and governance and policy roles (ibid). The economic narrative contains something of a contradiction because it focuses on encouraging Australian investment in upstream activities, whilst acknowledging that the most promising areas for growth and new jobs is mostly in the downstream domain (GAP, 2017; SIAA, 2017).

In the national security domain, Defence is heavily reliant on satellite communications provided by satellites (Henry, 2017a). Defence, and the national security community more broadly, processes data from satellites which are used to inform operations and planning (AGO, 2018). The Defence Science and Technology Group (DST Group) and the RAAF have invested in cubesat programs. One experiment seeks to further improve the performance of the Jindalee Over the horizon Radar Network (JORN), by characterising the ionosphere from above (DST Group, 2018a). The second is to assist with space debris measurement and monitoring research to improve understanding of the threat that space debris presents to future warfare in space and on the ground (Pittaway, 2018).

1.5 Changing Times

Since the end of the Cold War, China has emerged as a near-peer competitor to the United States (Allison, 2017). China is Australia's largest trading partner and the Australian Government seeks to maintain close relations with Beijing just as it does, through the alliance relationship, with Washington (DFAT, 2017a; Glenday, 2019). Australia is a middle power and a strong advocate for the international rules-based order, which China and Russia are challenging, for example in the South China Sea and the Crimea respectively, and in space as well (DFAT, 2017b; Chatham House, 2015). There are concerns that space, long militarised, will soon be weaponised and that already space has become the fourth domain of warfare (US DoD, 2019). President Trump's plan to create a space force as a separate branch of the US armed forces may be an indicator of such a development (ABC, 2018a; Rehm, 2018, USSC, 2018b). How should Australia respond to these challenges? Are there reasons that compel or oblige Australia to respond to these challenges? Are there initiatives that Australia might take, that may help to dissuade the major powers from fielding, if not developing space weapons?

1.6 Dual Use Technologies: A Problem and a Way to an Answer?

Space is a profoundly dual use environment meaning that ground infrastructure, launch systems, and satellites are often shared between military and civilian users (SWF, 2017). Elon Musk's commercial SpaceX, for example, conducts launches from Cape Canaveral, and the United States Government contracts to SpaceX to launch government payloads (ABC, 2018b). Core technologies, such as navigation and guidance systems, are common to both classified and unclassified systems and activities (DoD, 2019a).

The implications of the dual use nature of many space technologies and of the orbital space environment itself have been largely ignored by those who have contributed to the discussion about the role that Australia should play in space. The 2017 SIAA White Paper, *Advancing Australia in Space*, for example, has one reference only and that is contained in a quotation of UK experience. A deliberate discussion about dual use technologies may serve to synthesise the national security and economic narratives into a unified whole. This possibility is discussed in Chapter Two and also in Chapter Eight.

1.7 Definitions and Assumptions

Two definitions and three assumptions describe the boundaries of this thesis.

1.7.1 Definitions:

Orbital Space

The volume of outer space of interest to this thesis extends from approximately 100km to 50,000km above the Earth's surface and for the present purposes is called 'orbital space'. This is the realm in which satellites are operated by governments and commercial organisations for four principal purposes – communications, timing and navigation, Earth observation, and scientific discovery. Some reference is made to the further reaches of space that are the focus of solar and planetary science and astronomy, but only in so far as they relate to Australian space activities and aspirations more generally and to policy development.

The International Rules-Based Order

The phrase International Rules Based Order (IRBO) has acquired currency in recent years as a shorthand way of describing the international political and financial system that emerged, with American leadership, in the aftermath of World War 2. The IRBO embraces a range of international organisations, including the United Nations and its subordinate agencies, the World Bank, the International Monetary Fund (IMF) and the General Agreement on Tariffs and Trade (GATT). The IRBO speaks to principles of non-interference by nations in each other's affairs, and to respect for international law (Haass, 2017).

The IRBO is said to be under threat. Russia and China argue that they had little to do with the establishment of the core structures of the IRBO (Blackwill & Harris, 2016; Mearsheimer, 2018). It was imposed upon them and they are now challenging the legitimacy of some of the institutions and arrangements that are covered by the IRBO. Even the United States, under President Trump, is beginning to challenge aspects of the IRBO that the President now claims are harmful to US interests at home and abroad.

Australia played a part in establishing the IRBO, and remains strongly supportive, as will be seen in later chapters of this thesis. As a middle power, Australia seeks to exert international influence within the international system, which for all its faults, emerged in the 1940s.

How the IRBO adapts to changing geo-political realities may have important implications for the future of human activities in space.

1.7.2 Assumptions

The hypothesis looks to an indefinite future and, in this sense, is aspirational. However, the options available to Australia and the decisions to be taken, look to a much closer horizon – a decade or so from today. Three assumptions are made that are consistent with this shorter timeframe.

1. *The nation state will remain the fundamental building block of international order for the foreseeable future.*

A defining characteristic of nation states, and at the heart of the concept of sovereignty, is that that states use force to maintain domestic law and order within their borders and to fight wars against external adversaries (Crick, 1968). There are, however, limits that exist and that formally restrict a State's legal right to resort to force. Perhaps the most important is Article 2(4) of the United Nations Charter which expressly prohibits the threat or use of force and is a fundamental precept of international law. The use of force is only lawfully permissible in particular circumstances and is subject to specific limitations (Freeland, 2019a).

Physical borders remain but, as noted by Hathaway (2014), global supply chains and the pervasive nature of the internet are challenging the traditional concept of national borders as physical barriers to be crossed. The concept of sovereign prerogative was codified in 1648 in a series of treaties known collectively as the Peace of Westphalia (Holsti 1967). These Treaties signalled the end of the Thirty Years War in Europe (Tischer 2015). Richard Haass, a former senior official in the US State Department, has proposed that sovereign prerogative is no longer a sufficient concept to regulate relations between nation states that are now deeply connected and inter-dependent. He has proposed the concept of 'sovereign obligation' as a behavioural option for nation states.

> "Sovereign obligation [in contrast to Cold War containment and classical geopolitical competition] is designed for a world in which sometime rivals are sometime partners and in which collective efforts are required to meet common challenges" (Haass, 2017, p. 289).

The treaties and other instruments that regulate human activity in space assign important responsibilities to nation states. The international legal regime of orbital space is discussed in the body of the thesis on the basis that nation states will remain the principal arbitrators of war and peace and global economic and social organisation for the foreseeable future.

2. *Individuals, nations, and global processes (especially the international economy) will become increasingly dependent on assured and secure access to space-based utilities*.

This assumption is, in some respects, an extension of the first but with an emphasis on processes rather than institutional structures or frameworks. A corollary of increased dependence is increased vulnerability. Ajey Lele, an Indian Scholar based at the Institute for Defence Studies and Analyses (IDSA) in New Delhi, summed up the situation thus:

> "Satellite technologies have become endemic [sic] for human survival in every aspect of life from education to military. Naturally, keeping the space assets secure has become a major necessity for the states. Any damage to such assets would lead to excruciating consequences" (Lele, 2012, p. xvii).

In July 2017, an Expert Reference Group (ERG) was established by the Australian Government to provide advice about civil space matters. The Final Report of the ERG was passed to the government in March 2018. It echoed Lele's comment above and added an optimistic twist.

> "Every day, space provides essential data for everyday activities, from banking and internet access to simply knowing where you are. Space also provides critical data that supports emergency management, planning, and weather forecasting, and inspires young people to engage in science, technology, engineering, and mathematics (STEM) domains that are crucial to underpinning Australia's position as one of the most educated and entrepreneurial nations in the world" (DIIS, 2018a, p. 6).

The space environment is fragile and relatively easily disturbed yet global society is increasingly dependent on assured and secure access to data from and to services provided by satellites. The initiatives and activities that Australia might take to mitigate the risks associated with the vulnerabilities that stem from dependence are examined in the body of this thesis.

3. *Space launch will be dominated by conventional launch vehicles (rockets) for the foreseeable future*.

No breakthrough or substitute technologies to conventional rockets are on the immediate horizon for the launch of most satellites. Looking to the intermediate future, beyond 2030, new concepts might emerge. Today, some smaller satellites are launched from aircraft, but they are the exception and not the norm. The Pegasus system is one example of an aircraft launching capability (Orbital Sciences Corporation, 2016) and Virgin Orbit is developing a two-stage rocket, to be launched from an aircraft, designed to place small satellites into orbit (Virgin Orbit, 2019). Exotic technologies, such as space elevators, are being discussed, but are nowhere near the technology development stage (ISEC, 2018). The costs of launching satellites has reduced, perhaps by a factor of 20 in the past decade, in part because of competition from companies including, SpaceX and Blue Origin (Jones, 2018). The only known method of launching large payloads into space (those measured in tonnes rather than kilograms) for the foreseeable future will be by using conventional rockets. The international law of space, which is discussed in Chapter Two, assigns important responsibilities to nation states with respect to launch activities, particularly as they relate to questions of licensing and liability in the event of launch failure and subsequent injury and damage to property. Launching objects into space is difficult, opportunities are limited, although becoming more frequent, and they are carefully regulated by nation states. As space launches become more frequent, air traffic control agencies and space launch companies will need to synchronise activities around launch facilities and declared safety zones (Davenport et al., 2018).

Operational activities in space, in terms of investment, are dominated by the private sector. The evidence suggests that private investment is accelerating as new and emerging technologies become established in the space domain (Morris & Cox (eds), 2010; Davenport, 2018). Policy and regulatory responsibilities, for the foreseeable future, however, will rest with nation states. Their domestic laws and processes on the one hand, and the legitimacy they accord to international institutions on the other, can be expected to influence how the space environment evolves politically, legally and normatively, and the extent to which the space environment will remain safe and secure or one that is increasingly problematic and dangerous.

What Australia can, might and should do to ensure that human activities in space are necessarily and sufficiently safe and secure, within defined levels of acceptable risk, is explored in the chapters to follow. Australia has choices and opportunities in the commercial, civil and national security domains. A deliberate focus by all involved on the dual use nature of the space environment, the technologies placed into space and the processing technologies on the ground, might be a place to start.

1.8 Thesis Outline

Beyond this Introduction (Chapter One), the thesis has eight further chapters.

Chapter 2 addresses the first research question and provides the rationale for this thesis. It asks why a safe and secure orbital space environment is important to humanity by defining the elements of the environment that require protection from what threats and by questioning why a safe and secure orbital space environment matters to Australia and to the international community more broadly. The chapter describes the size of the space economy, places Australia within that economy, and notes the dependencies and associated vulnerabilities that nations have on assured and secure access to the services and data provided by satellites in orbital space.

Chapter 3 addresses the second research question. This is a discussion about the role and influence of a middle power in the high stakes world of peace and war in space. Set against China's emergence as a near peer competitor to the United States, the chapter asks whether any contribution that Australia may make to the security of orbital space is likely to be substantive or marginal?

Chapter 4 addresses the second and third research questions. The chapter examines the enduring attributes that are fundamental to any contribution that Australia may make to the future security and safety of the orbital space environment. Five attributes are discussed: (1) physical factors, (2) liberal democratic form of government, (3) traditional ties and the US alliance, (4) good international citizen, and (5) opportunity costs.

Chapter 5 addresses the third research question in relation to public policy and spending priorities. The impact of political ideology and economic policy on Australia's approach to space from the 1970s until the end of 2007 is emphasised. The Chapter examines the evidence for later comparisons about policy continuity and discontinuity in Australia's space journey.

Chapter 6 addresses the third research question in relation to public policy spending priorities in the context of the period from 2007 to 2018 when Australian policy makers were awakened to the importance and potentials of space both within and beyond the defence and national security realm. The evidence indicates ideology gave way to pragmatism and an element of opportunism as well. The decade opened with a Senate inquiry and ended with a space agency. Evidence for policy continuity and discontinuity is presented. Two themes were evident throughout the decade: the need for the space environment to be secure and advocacy for a space industry sector within the Australian economy. By the end of the decade, deliberate progress was made on the former and, also, more by accident than design, on the latter.

Chapter 7 addresses the fourth research question, which asks whether a domestic space industry is a necessary element of Australia's commitment to space security or a compelling reason for the formation of a space agency. Evidence is presented that at least some of the data about the size and shape of the Australian space economy, and on which the space agency has been justified, is not defensible.

Chapter 8 addresses the fifth research question and evaluates the implications for Australia's commitment to space security of recent initiatives by Australian departments and agencies including the new space agency.

Chapter 9 reviews the evidence presented in Chapters Two to Eight and, based on this material, looks to the future. The Chapter suggests that Australia is not only likely to become a more active and influential contributor to space security in the future but that it is obligated to do so to serve narrow self-interests as well as the broader interests of international society.

1.9 Sources

1.9.1 Literature

There is a vast international literature about space, much originating in the United States. By any measure, the United States is the world's predominant space power, a position it has occupied from the earliest days of the Cold War. The United States Government identifies 'leadership and freedom of action in space' as essential to the sovereign integrity of the nation (USG, 2017 p. 31). The US has invested considerably more than all other nations combined in military, civil and commercial space capabilities, including Russia and China. One estimate is that more than one of every two dollars spent on space activity today is spent in the United States (OECD 2014).

In contrast to American and International experience, comparatively little has been written about space in Australia from policy, national development, and national security perspectives. There are government reports, reports from consultants, a handful of PhD and Master's theses, and a small number of monographs and journal articles. Finally, there is material, of variable quality, which appears in the daily press and other media.

1.9.2 Personal Records and Notes from Interviews and Meetings

In the course of researching and writing this thesis many conversations have been held that are relevant to the research. Some of these conversations were arranged specifically to support the research. Others were initiated, for reasons as diverse as business, education and advocacy. The documentary record for these interactions is held in diary notes, emails and meeting minutes.

CHAPTER 2

THE IMPORTANCE OF A SAFE AND SECURE SPACE ENVIRONMENT

The purpose of this chapter is to test the hypothesis that Australia is obligated to invest in the long-term security of the space environment through an investigation of the question, "Why is a safe and secure orbital space environment important for humanity?" This question speaks to the level of priority, political attention and funding that future governments, including the Australian Government, might invest in space security.

This Chapter has three major sections

1. What needs to be kept safe and secure?
2. What are the threats?
3. Why does a safe and secure orbital space environment matter?

Later Chapters address the attributes that Australia can bring to the table, to contribute to the safety and security of the orbital space environment in its own economic and security interests as well as the interests of others.

2.1 What needs to be kept safe and secure: Orbits, Satellites, Spectrum and Politics

This section discusses the orbital space environment, considered as a physical and human construct. Four elements are addressed: orbital space, satellites, spectrum, and politics (the regulatory regime). Each element faces threats, which are addressed in the second section of this Chapter.

2.1.1 Orbital Space

In terms of the vastness of outer space and even the solar system, orbital space is nearby. Satellites in LEO occupy orbits between 500 and 2,000km above Earth – distances that people routinely travel on Earth for work, leisure and family reasons. Satellites operating in geostationary orbits are only 36,000km away, which is less than the Earth's circumference at the Equator (just over 40,000km).

A schematic of satellite orbits follows together with a brief description of the types of satellites that operate in specific orbits.

Figure 2.1. Schematic of Common Satellite Orbits.

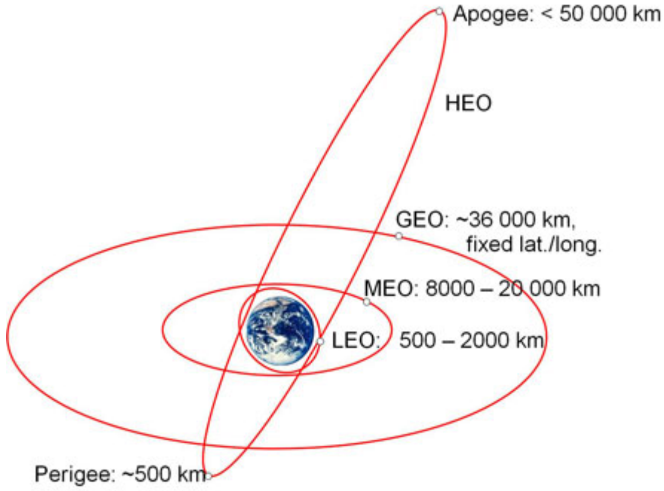


Diagram reproduced from SSA White paper published by Computational Physics Inc. http://www.cpi.com/capabilities/ssa.html.

Satellites are typically in four types of orbit around Earth.

- ***Low Earth Orbits (LEO)*** extend from approximately 500-2,000km above Earth. Many Earth observation satellites operate in LEO and most LEO satellites operate in highly-inclined orbits, which means that their orbits cross the polar regions on each orbit. LEO satellites orbit Earth every 90 minutes or so. One of the more useful highly-inclined orbits is the sun-synchronous orbit. Satellites in sun-synchronous orbits pass over the same part of Earth at the same time of the day allowing for ready comparison of what has been observed at a point on the Earth's surface from one day to the next. Weather satellites and reconnaissance satellites operating in the visual spectra are examples of satellites that exploit the advantages of such orbits (Poole, no date).

- ***Medium Earth Orbits (MEO)*** extend from approximately 8,000-20,000km above Earth. Many satellites that belong to global navigation systems, such as the US Global Positioning System (GPS) and a significant element of the Chinese Beidou system operate in MEO orbits (CSNO, 2013, p. 1).

- ***Highly Elliptical Orbits (HEO)*** have a perigee of approximately 500km, usually above Antarctica and an apogee of approximately 50,000km above the northern hemisphere. These orbits are also known as Molnya orbits, named after a series of satellites, first launched into these orbits by the USSR during the Cold War. HEO orbits permit satellites to dwell above places and targets of interest, especially in higher latitudes, for more extended periods than is possible for satellites operating in LEO and MEO. The functions performed by HEO satellites include intelligence gathering, augmentation for global navigation and communications (Poole, no date).

- ***Geostationary or Geosynchronous Orbit (GEO)*** is an imaginary ring around Earth, 36,000km above the Equator. Satellites in GEO appear to be stationary from the perspective of an observer on Earth. They occupy an orbital slot, which appears as a fixed latitude and longitude relative to Earth. There is a finite number of orbital slots and competition for them is intense, especially for those from which satellites can serve the large populations of Europe, Asia and the Americas. Many communications satellites, including those owned by commercial operators, are in GEO. Satellites in GEO also perform a range of vital Earth observation functions including intelligence gathering, ballistic missile early warning, treaty monitoring and compliance, and weather and climate monitoring (Poole, no date; Howell, no date).

The number of operational satellites in all orbits has grown progressively from one – Sputnik, in LEO in October 1957 - to approaching 2,100 today (See Table 2.1).

2.1.2 Satellites

Table 2.1 below, published by the US-based Union of Concerned Scientists provides a high-level summary of the satellites in orbit, their origin and whether they serve mainly military, civil or commercial purposes. 43% of the satellites in orbit today are owned and operated by the US Government or by companies based in the United States.

Table 2.1. Operational Satellites.

Satellite Quick Facts *(includes launches through 31 March 2019)*			
Total number of operating satellites: 2062			
United States: 901	Russia: 153	China: 299	Other: 709
Numbers in different orbits			
Low Earth Orbit: 1,338	Medium Earth Orbit: 125	Elliptical or Molnya Orbit: 45	Geostationary Orbit: 554
Total Number of U.S. satellites: 901			
Civil: 38	Commercial: 523	Government: 164	Military: 176

Source: Union of Concerned Scientists: https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database#.XGINVS1L1Bw. (add up left to right). Accessed 20 May 2019.

The number of satellites in orbit today is expected to multiply by at least one order of magnitude within the next five to ten years as several proposed mega constellations projects, of mainly Low Earth Orbit satellites, are implemented. These are discussed later in the Chapter. The anticipated rapid increase in the number of satellites has important implications for space security and the governance of human activities in space (Moltz, 2014). The growth trend is already apparent. In just 12 months between 30 April 2018 and 31 March 2019, the number of satellites increased from 1,886 to 2,062 (UCS, 2019).

Satellites share orbital space with many other objects. Some, such as comets, asteroids and meteoroids, are naturally occurring, others, are the detritus of human activities that has accumulated since the launch of Sputnik in October 1957.

Regardless of the number of satellites in orbit, all must be able to communicate with Earth, which is the subject of the next section.

2.1.3 Spectrum

Satellites must be able to communicate to Earth reliably and regularly to provide the services for which they have been designed. The principal communications method is via wireless communications (Richharia, 1999).

The electromagnetic spectrum (EMS) is a finite resource and a challenge for humanity is to use the EMS as effectively and efficiently as possible (ACMA, 2016a). Rapid developments in technology do allow much higher use of the EMS to be made today than in the past; however, the proliferation of wireless devices is placing increasing pressure on many frequency bands including those most valued by satellite operators (NAS, 2017).

Australia's national spectrum regulator is the Australian Communications and Media Authority (ACMA). ACMA, as do similar organisations around the world, has a technical and complex task in allocating spectrum is such a way that the competing needs of commercial and public good users of spectrum are balanced. Satellites require access to spectrum globally, so there is a need for international spectrum allocation and coordination agreements as well (ACMA, 2016b). This is achieved through the World Radio Conference, which is held every three to four years (ITU, 2019).

Since the earliest days of telecommunications, the need for international cooperation, coordination and regulation was foreseen. To this end, in 1865 the International Telecommunication Union (ITU) was established. The ITU is the world's first multi-national organisation. Since 1947 it has been a specialised agency of the United Nations. Among its many responsibilities, the ITU has the task of allocating spectrum for global users, including for satellite operators. The "About ITU" page of the ITU's website states the organisation's mission succinctly.

> "We allocate global radio spectrum and satellite orbits, develop the technical standards that ensure networks and technologies seamlessly interconnect, and strive to improve access to ICTs [information and communications technologies] to underserved communities worldwide" (ITU, no date).

As noted already, and discussed later in the Chapter, several companies have announced plans to launch very large constellations of satellites into LEO for remote sensing and communications purposes. These satellites need to communicate with the ground and with each other. Spectrum access requirements are considerable, and the ITU, as well as national regulators, are being pressured to relax constraints on the needed spectrum to permit the constellations to proceed (Selding, 2016).

Radio Frequency Interference (RFI) is a concern for all who seek access to the radio spectrum for any purpose (Hellbourg, 2015; Wyatt, 2018). Radio astronomers and others with interests in space-based remote sensing are concerned to keep free from interference frequencies that have been termed, aptly and elegantly, the "fingerprints of nature" by Dr Sue Barrel, a former senior official in the Australian Bureau of Meteorology (BoM). The proliferation of wireless devices connected to the internet is adding pressure both to the frequencies that matter to science as well as to some of the frequencies that have been allocated to satellite operators over many years by the ITU. The C Band (3.4 - 7.25 GHz) is one frequency band under much pressure (ACMA, 2017). The phenomenon known as the Internet of Things (IoT) is causing companies that serve the IoT marketplace to seek access to more and more of the C Band spectrum (Meola, 2018).

The ITU devotes considerable attention to reducing the likelihood of radio interference. It distinguishes between intentional and unintentional interference and has well-established reporting mechanisms (ITU, 2017). Where interference does occur, however, the ITU can do little more than 'name and shame' the perpetrator(s) in the hope that such publicity will cause the offender(s) to take corrective action and to 'cease and desist' (Biddington, 2016a).

Research into optical and quantum communications in various parts of the world, including Australia, aims to reduce the dependence of satellites on the radio frequency element of the electromagnetic spectrum. For the next decade, or so, however, the radio part of the electromagnetic spectrum is likely to remain the dominant medium for satellite communications.

2.1.4 Politics (the regulatory regime)

Expectations about how human activity in outer space should be conducted and for what purposes are established in a series of UN treaties, resolutions and supporting documents. The most important document, to use its common name, is the *Outer Space Treaty* (OST) of 1967. Formally, the treaty's title is the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* (UNOOSA, 2019a). Australian officials participated in establishing and later implementing this regime. Further details are provided in sections that follow.

The OST provides the basic framework for international space law and includes the following principles:

> "… the exploration and use of outer space shall be carried out for the benefit and in the interests of all countries and shall be the province of all mankind;
>
> - outer space shall be free for exploration and use by all States;
> - outer space is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means;
> - States shall not place nuclear weapons or other weapons of mass destruction in orbit or on celestial bodies or station them in outer space in any other manner;
> - the Moon and other celestial bodies shall be used exclusively for peaceful purposes;
> - astronauts shall be regarded as the envoys of mankind;
> - States shall be responsible for national space activities whether carried out by governmental or non-governmental entities;
> - States shall be liable for damage caused by their space objects; and
> - States shall avoid harmful contamination of space and celestial bodies" (ibid).

Except for forbidding the placement of certain classes of weapons in space the OST is silent about the military uses of space. Professor Freeland, however, argues that quite a number of the provisions of the Outer Space Treaty, as well as its preamble, have a limiting effect on the legality of certain military uses of outer space. Whilst it is true there is no other direct reference to 'military uses' as such, reading the Treaty in accordance with the customary international law principles in Article 31(1) of the Vienna Convention on the Law of Treaties, including a consideration of its object and purpose, would reinforce this view. On this issue, which goes to the heart of the regime that has been established, he maintains that it is important to read the Outer Space Treaty in totality rather than focusing on one provision only (Freeland, 2018).

The OST is a document that expresses noble and ideal sentiments about human activities in space. Yet, from the earliest days of human activity in space, military objectives have been paramount (McDougall, 1985; Dolman, 2002).

The OST, like all other international legislative instruments, only holds to the extent that states agree to be bound by its clauses. Corbett, for example, describes international law as:

> "…the complex of rules, principles, standards and procedures more or less observed by governments in their business with one another" (Corbett, in Sills (ed), 1968).

Professor of Strategy at the US Air Force Air Command and Staff College, Everett Dolman is uncompromising. He has written with respect to the international legal regime of space that:

> "The rhetoric of harmony and cooperation that attends most popular accounts of humanity's entry into outer space simply belies the historical record. . . expansion into near-Earth space came . . . as an integral component of an overall strategy applied by wary superstates attempting to secure their political survival. . . They established an international regime that ensured none of them could obtain an unanticipated advantage in space domination – for if any one nation did, the face of international politics might be changed for ever" (Dolman, 2002, p. 87).

In 2008, Moltz used the phrase "strategic restraint" to characterise the behaviour of the major spacefaring nations in the first 50 years of human activity in space (Moltz, 2008).

Professor Steven Freeland, Australia's foremost expert on international space law, notes that the principles of the OST remain necessary but now asks whether they are sufficient to encourage and permit orderly human conduct in space (Freeland, 2018; Blake & Freeland, 2017). Freeland makes the point that space is not lawless and that well-articulated and well-understood norms of behaviour exert considerable influence on the behaviour of spacefaring nations (ibid).

The basic principles of the OST have held for more than 50 years, whether through fear (Dolman) or because of commitment to norms (Freeland), or some combination of both. There is evidence, however, discussed in a later section of this Chapter, that the restraint that has mostly worked may be starting to wear thin, especially in respect to weaponisation.

If the current regulatory regime for outer space is at risk of failing, a question to ask is what might take its place and is there a role for middle powers?

2.2 What are the Threats?

This section of Chapter Two considers three threats to the orbital space environment: space weather, space debris and the potential for space to become weaponised. All three have the potential to adversely affect the access to the data and services provided by satellites with consequential adverse, potentially crippling, impacts on the national and global economies and on many facets of life. These threats are discussed in more detail below.

2.2.1 Space Weather

The sun continuously emits streams of charged particles. The sun's surface is dynamic and unusually large perturbations, known as solar storms or, more formally, coronal mass ejections (CME), release massive quantities of energy. The level of activity rises and falls on an eleven-year cycle. Space weather is the effect that these streams of charged particles have on Earth, and the other planets, as these particles travel through the solar system (NASA, 2011). Earth is protected against much of this radiation by the magnetosphere that deflects the charged particle streams around the planet (ibid).

The US National Ocean and Atmospheric Administration (NOAA) has an excellent website that describes space weather phenomena (NOAA, no date). NOAA also offers a space weather prediction and forecast service. Like weather on Earth, so in space, there are continuous processes with relatively minor perturbations, and there are also events that can have dire consequences on Earth. A large CME that releases energy directly towards Earth has the potential to wreak havoc because it would create power surges in electrical, electronic and computing equipment.

In 1859, the so-called Carrington Event was recorded as a significant solar storm (Bell & Phillips, 2008; Cain, 2017). A 2003 paper reports the result of ice core analysis which reveals this event as the most massive solar storm recorded on Earth in the past 500 years (Townsend et al., 2003). Damage to telegraphic equipment was recorded around the world. In 2008, the US National Research Council released a report that estimated, if a solar storm of similar magnitude were to strike Earth today, the recovery cost of such an event would be "US$1 trillion to US$2 trillion during the first year alone" (NRC, 2008, p. 4).

2.2.2 Australian Responses to the Threat of Space Weather

Australia has a long history in observing and forecasting space weather. The Ionospheric Prediction Service (IPS) is the lead agency and located within the Bureau of Meteorology (BoM). Accurate ionospheric prediction is essential to high- frequency radio communications, to astronomers and to the operation of Australia's advanced regional surveillance system, the Jindalee Over the horizon Radar Network (JORN).

In 2010, the Australian Academy of Science (AAS) released a decadal plan for space science that proposed three flagship research programs. One of these, called Sundiver, was a concept study for an Australian satellite that would conduct ground-breaking solar research (AAS, 2010, pp. 90-92). The project remains unfunded. An AAS document that effectively updates and replaces the 2010 document makes more muted reference to solar science. The 2017 document is called *A vision for space science and technology in Australia: Securing and advancing Australia's interests through space research* (AAS, 2017).

In December 2011, Ms Cloe Munro, an energy and climate change expert, delivered a report to Senator the Hon Don Farrell, the Parliamentary Secretary for Sustainability and Urban Water. The Report had a lengthy title: *Review of the Bureau of Meteorology's capacity to respond to future extreme weather and natural disaster events and to provide seasonal forecasting services* (Munro, 2011). One of the Terms of Reference of this review was to make recommendations about opportunities to reinvest or re-prioritise existing Bureau resources (ibid, p. 81). One re-prioritisation option proposed by Munro was to, "Cease or reduce the Ionospheric Prediction Service or offer it as a commercial service", which would save about AU$3 million annually (ibid, p. 13). In reaching this conclusion Munro noted, "There does not appear to be any general public value in this service, analogous to weather information" (ibid, p. 72).

Munro chose to measure the impact of the IPS on a first order figure, the number of customers it served. A more considered analysis might have revealed the contribution that the IPS makes to the safety and security of satellite systems, and data from those systems, that make vital inputs to the very matters she was employed to study – extreme weather, natural disasters and seasonal weather forecasting.

The government did not accept Munro's recommendation, pointing out in its formal response to her review that:

> "The IPS is recognised as the leading space weather service in the southern hemisphere. It provides space weather services that are essential for undertaking activities in defence and national security, emergency services, remote rural mobile communications, navigation, high-frequency radio and satellite communications and electricity transmission, as well as activities in the aviation, resource exploration and maritime industries" (BoM, 2013).

Instead, a more specific review of just the Ionospheric Prediction Service (IPS) was held (ibid). This review was conducted by two space weather experts; Professor Paul Cannon from the University of Birmingham in the UK and Dr Terry Onsager from NOAA in the US. Their report, a *Review of the Bureau of Meteorology's Space Weather Service,* was published in September 2014. In contrast to Munro's recommendation, this review came to a quite different conclusion.

> "The review has demonstrated that Australia needs a space weather services capability to support government, industry and the military. The military requirement is overwhelming on its own and security issues preclude shifting this capability offshore. Support to the electricity industry during major and extreme storms is another national security issue – with potentially severe economic repercussions. Moreover, we believe that remediation of space weather effects on the new technologies associated with precision positioning (i.e. Global Navigation Satellite Systems, GNSS) is sufficiently important that it too requires a sovereign capability" (Cannon & Onsager, 2014, p. iii).

Cannon and Onsager called for increased investment in the IPS to "improve the understanding of the criticality of space weather services" across the Australian government (ibid, p. iv). They note:

> "The general consensus is that an Earth directed solar superstorm is inevitable, a matter not of 'if' but 'when' " (ibid, p. 13).

The BoM and the USAF jointly operate a solar observatory at Learmonth in Western Australia (BoM, 2018a). The results from this observatory contribute to a global monitoring effort of the sun that provides early warning of solar activities, including CMEs, potentially harmful to satellites and Earth. Cannon & Onsager also note that several satellites that monitor space weather, including SOHO and STEREO, downlink data through the CSIRO Deep Space Tracking Network (Cannon & Onsager, 2014, p. 16).

The IPS remains in existence.

2.2.3 Space Debris

Space debris is principally a problem in LEO (ESA, 2018a). Nearly two of every three satellites are in LEO (Table 2.1) and most debris is in these orbits as well. The proposed mega-satellite constellations, discussed later in this Chapter, will operate in LEO, adding to the risks of collisions and the complexity faced by space traffic management organisations (NASA, 2018a; Grush, 2018). Modelling by the European Space Agency (ESA) suggests that an early start to debris removal, of large objects especially, would deliver significant benefits in the LEO environment (ESA, 2017).

Satellites and other space objects in LEO will eventually fall towards Earth under the influence of weak but persistent forces, notably orbital drag. For some objects, this may take hundreds of years. Most objects burn up as they enter Earth's atmosphere. Only the largest survive to impact the Earth's surface; such as Skylab and Mir, the American and Russian space stations, that preceded the International Space Station (ISS). Skylab broke up over south-western Western Australia in 1979 (O'Toole, 1979).

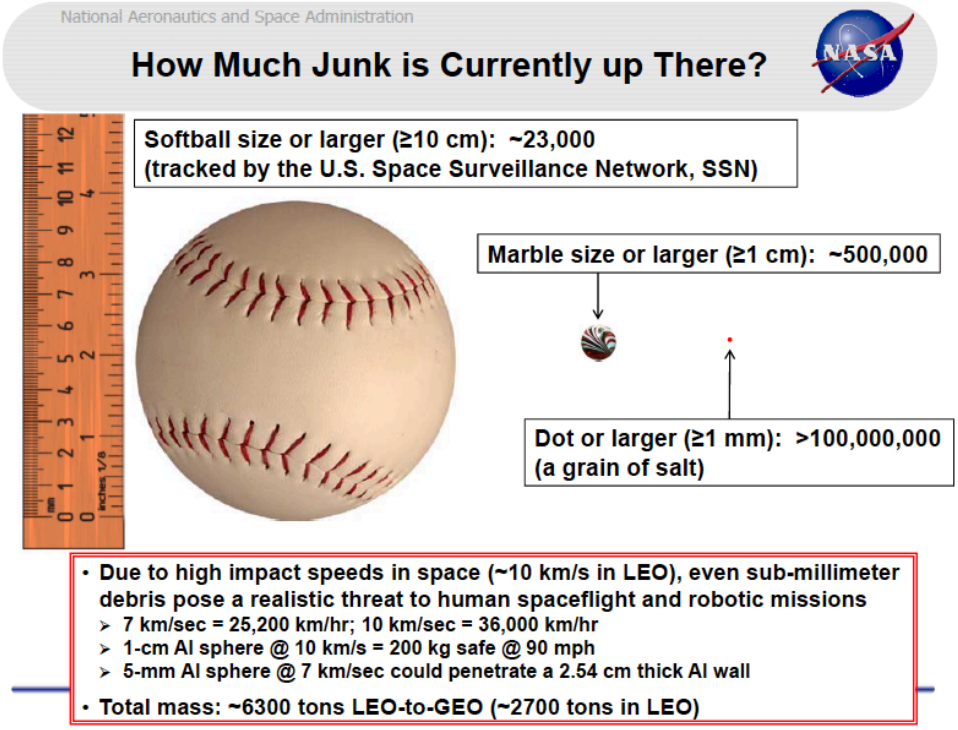
Satellites need energy to perform their designed functions. Most satellites have solar panels to generate electricity and batteries from which stored power can be drawn when the satellite is out of sight of the sun. Many satellites also carry fuel to power small thrusters that allow for station keeping, attitude control and collision avoidance (Intelsat, no date). Fuel, therefore, is often the factor that determines the useful life of a satellite (Teresciukas, no date). A corollary is that controlling agencies use fuel sparingly to prolong the lives of satellites to the extent possible. This is especially the case for larger, expensive satellites such as the many commercial communications satellites located in GEO.

The last reserves of fuel for GEO satellites are used to place them into a so-called graveyard orbit, further from Earth than the GEO ring, where they will remain forever as large and expensive pieces of space debris (Lewin, 2017). The final fuel reserves for satellites in MEO, HEO and LEO orbits are used increasingly to propel them into orbits that allow them to fall into the Earth's gravity relatively quickly (Henry, 2017b). Most burn up in the Earth's atmosphere.

Proliferation of Space Debris In 1978, Donald Kessler, a NASA scientist, published a paper with Burton G. Cour-Palais in the Journal of Geophysical Research with the title *Collision Frequency of Artificial Satellites: The Creation of a Debris Belt* (Kessler & Cour-Palais, 1978). The paper had a limited and cautious objective to demonstrate that at some point in the future collisions in low Earth orbits (LEO) between objects of human origin were more likely to occur than collisions between naturally occurring objects. Kessler's paper has acquired broader meaning over time and the Kessler syndrome, or Kessler effect, are terms now applied to the broader idea that collisions between space objects (of mainly human origin) could lead to a runaway chain reaction.

The figure on the following page provides some quantitative dimensions to the space debris problem in LEO.

Figure 2.2. Space Debris: A Visual Summary.



From: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150019428.pdf. Accessed 6 Jan 2018.

The United States Air Force (USAF) operates the Space Surveillance Network (SSN), which is the world's most complete and comprehensive system for tracking satellites and for monitoring and characterising space debris (Kennewell & Vo, 2011). The position of objects in orbit around Earth is expressed in a format, developed in the 1960s, called the two-line element (TLE) set. TLEs are published for many space objects by the United States Government via the internet (NORAD, 2018). Typically, data from United States classified missions are excluded. When the forecast locations of space objects indicate the possibility of two objects passing close to each other, a conjunction is said to exist. Satellite operators must then decide whether to expend precious fuel to move their satellite out of harm's way or whether to do nothing and hope that the objects, although passing close to each other, will not collide (Lindstrom & Muhlematter, 2017). Present sensors lack the fidelity to predict collisions with certainty. They can only indicate that a collision might occur leaving the satellite operator to determine how to respond on a case-by-case basis.

Figure 2.2 indicates that the SSN routinely tracks in the order of 23,000 space objects larger than 10cm in LEO. The objects tracked include active satellites, some of which can be manoeuvred, and space debris that is uncontrolled. A relatively small number of these objects, such as spent rocket casings, are quite large. The vast majority are small. Given that these objects are travelling at around 17,000km/hour the kinetic effect of collisions, even between small objects, can cause catastrophic damage and the creation of even more debris – the cascading or chain reaction effect first discussed by Kessler.

The diagram on the next page shows the disposition around the world of the ground-based sensors that provide data to the SSN. Some are dedicated sensors; others contribute on an intermittent basis.

Only three of the ground-based sensors are south of the Equator: a radar on Ascension Island in the mid-Atlantic Ocean (7^{o}56’S, 14^{o}22’W), an optical telescope on Diego Garcia (7^{o}19S,72^{o}24’E) in the Indian Ocean and a space surveillance radar at North West Cape (22^{o}13S,113^{o}57’E) on the western extremity of the Australian continent (DoD, 2016a; May, 2017). A space surveillance telescope is presently being installed at North West Cape and is due to begin operations in 2021 and not 2018 as indicated on Figure 2.3 on the following page (May, 2017). This small number of sensors means that many objects, as they traverse the southern hemisphere, are not continuously tracked, leaving perturbations in their orbits and the possible causes for these changes unnoticed and unrecorded.

Figure 2.3. The USAF Space Surveillance Network: Ground Sites.

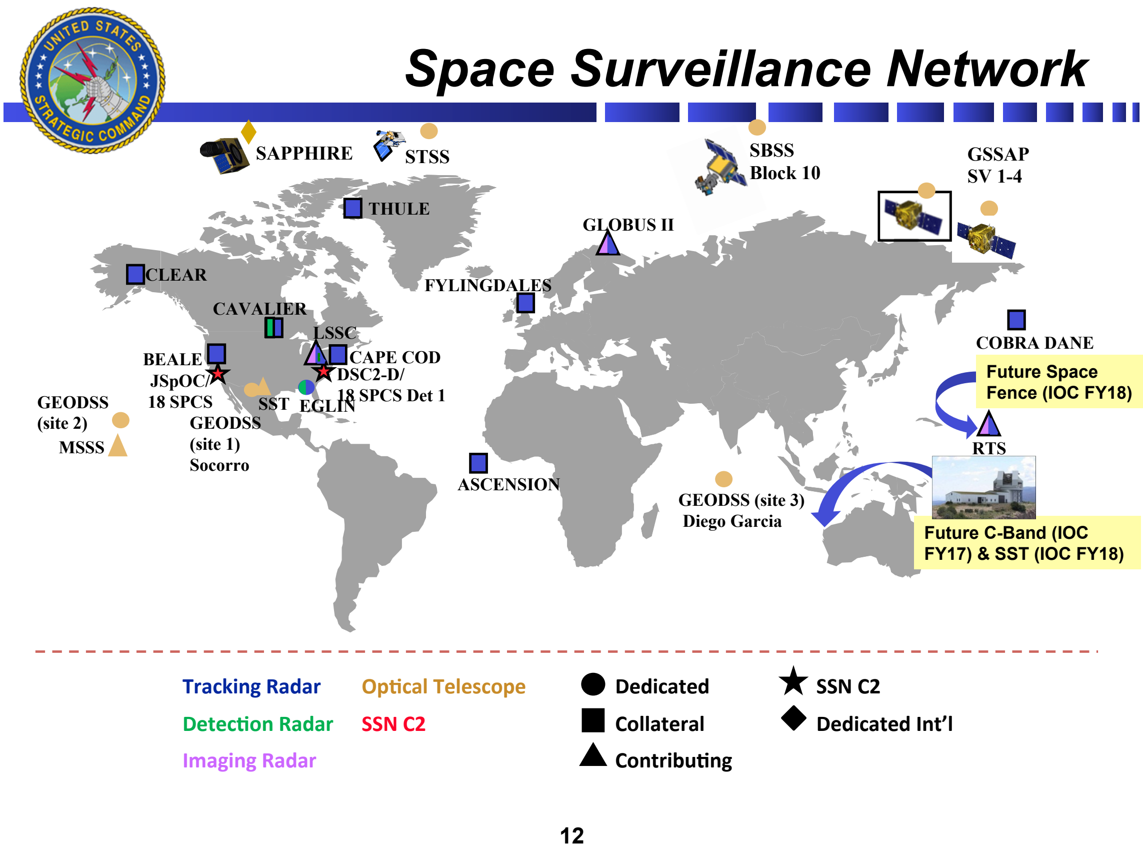


Diagram courtesy of Dr Peter Hayes, used in a briefing to COPUOS, February 2017.

Other nations, including Russia, China and Europe have, or are, developing systems similar to the SSN. Commercial operators have criticised the USAF for sometimes being tardy in providing alerts about conjunctions involving commercial spacecraft (Biddington, 2010a). To help mitigate this problem, in 2009 commercial operators established a not-for-profit entity, the Space Data Association (SDA) to:

> "…to support the controlled, reliable and efficient sharing of data critical to the safety and integrity of the space environment and the radio frequency (RF) spectrum" (SDA, no date).

Many major commercial satellite communications companies, including the Australian company Optus, are members of the SDA together with several commercial imagery providers and space agencies (SDA, no date).

Collisions and Their Environmental Impact In January 2007, the Chinese conducted an anti-satellite or ASAT test in which an aging weather satellite, Fengyun 1C, was destroyed with a kinetic weapon fired from the ground. The test created a debris field of unprecedented size and brought international condemnation, including from Australia (O'Malley, 2007, Hagt, 2007). Debris from the collision has had a significant impact on the low Earth orbit environment and some of the debris is expected to remain in orbit for hundreds of years (Kelso, 2007; SWF, 2010a).

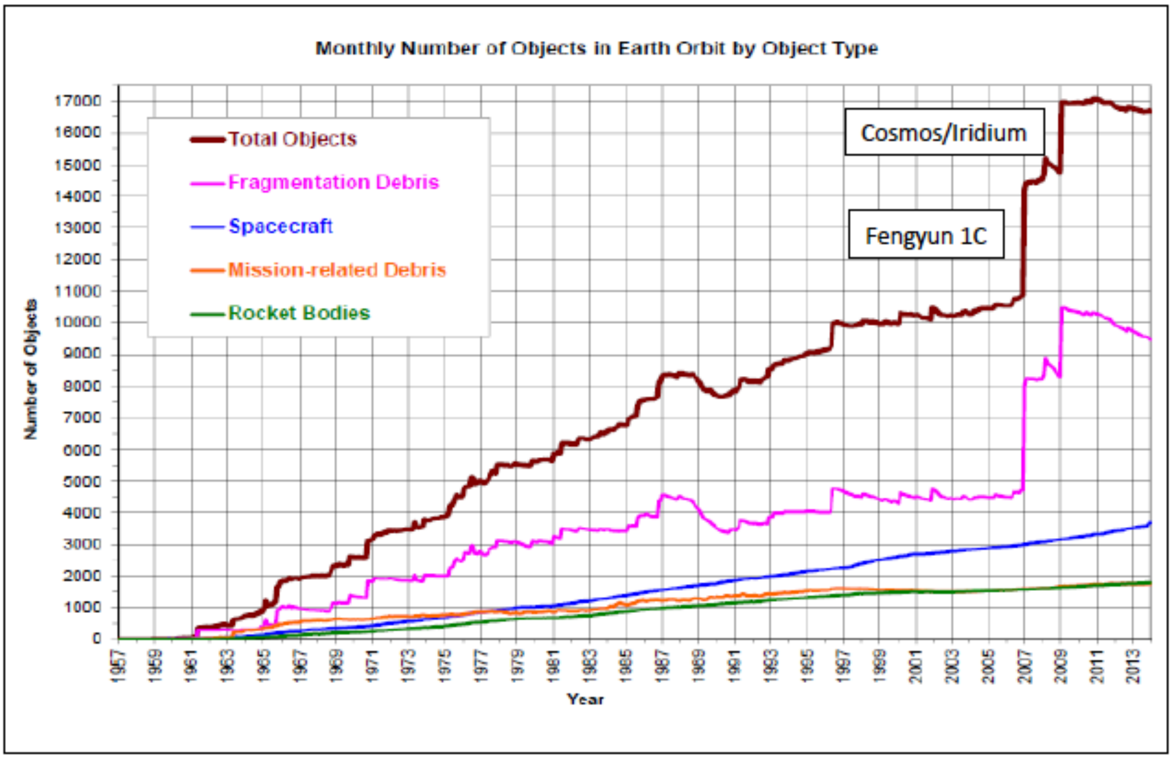
A year later, in February 2008, the United States shot down one of its satellites, an intelligence gathering satellite, that had not reached its intended orbit. The operation was carried out in such a way that the debris cloud was minimised with most pieces quickly falling towards Earth and burning up in the upper atmosphere (NBC News, 2008).

In 2009, a defunct Russian satellite, Kosmos 2251, collided with an operational Iridium communications satellite above Siberia. Iridium is a United States company with headquarters in McLean, Virginia. The collision created another large debris field (SWF, 2010b).

More recently, in March 2019, India conducted a successful ASAT test in which a defunct Indian satellite was destroyed by a missile fired from the ground. The Indian Government has been quick to point out that the debris created by this event will quickly fall towards Earth and not exacerbate the debris problem in LEO (Kuper, 2019).

The graph on the following page, prepared by NASA, shows how space debris has proliferated since the early 1960s and shows the substantial increase in the number of debris objects created by the 2007 and 2009 events described above.

Figure 2.4. The growth of the Catalogued Populations of Space Objects.



Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris" includes all objects dispensed, separated, or released as part of the planned mission.

From: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150019428.pdf. Accessed 6 Jan 2018.

Near Earth Objects (NEO) NEOs are natural phenomena, such as comets and asteroids, the trajectories of which potentially intersect with the Earth's orbit around the sun. Although the probability of any of these objects colliding with Earth is remote, it is possible and has occurred in the past. A large asteroid struck the Earth 66 million years ago near the Yucatan Peninsula in Mexico. The impact led to global climate change, the extinction of the dinosaurs and other fundamental changes to the Earth's environment (Hand, 2016). NASA and other organisations are paying more attention to NEO and the possibility of a catastrophic collision between a large NEO and Earth in the future. NASA has an office dedicated to the study of NEO (NASA, 2018b).

2.2.4 Australian Responses to the Threat of Space Debris

Australia's response to the threat of space debris has been mainly framed within the context of the Australia/US alliance. Each year Australia and the United States hold talks that discuss the state of the alliance. These talks, known as AUSMIN, are attended by the Australian Ministers for Defence and for Foreign Affairs and Trade and their US counterparts, the

Secretaries of Defence and State respectively. The communique issued at the end of AUSMIN 2010, under the heading "21st Century Security Challenges", referred to emerging threats in space and cyberspace. The communique noted:

> "Australia and the United States shared a deep concern about the increasingly interdependent, congested, and contested nature of outer space and acknowledged that preventing behaviours that could result in mishaps, misperceptions or mistrust was a high priority. Australia welcomed the US decision, reflected in the June 2010 US National Space Policy, to consider space arms control measures that are equitable, verifiable and in its and its allies' national interests. Australia intends to work with the United States to progress their shared goal of enhanced space security, with a particular focus on transparency and confidence-building measures" (DFAT, 2010a).

Two further documents relevant to space security were agreed at AUSMIN 2010.

- A Space Situational Awareness Partnership Statement of Principles (DFAT, 2010b), to "…enable further close cooperation on space surveillance to the benefit of both countries," was signed.
- A Joint Statement on Space Security (DFAT, 2010c), which "…highlight[ed] their shared views and resolve to cooperate with like-minded countries to ensure free and safe access to space," was endorsed.

The Partnership Agreement foreshadowed that joint SSA facilities may be constructed at some future point, possibly at the Naval Communications Station Harold E Holt at Exmouth, Western Australia (DFAT, 2010b).

A parallel in principle agreement was signed between Australia and the United States to boost civil space cooperation as well. No specific projects were mentioned, nor were funds allocated (Carr, 2010).

The communique issued at the end of AUSMIN 2011 said little of substance about space. However, the AUSMIN 2012 communique announced several commitments. Under the heading "Advance global security" Australia and the United States agreed to:

- "Continue to build on our 2010 Joint Statement on Space Security, in particular by working closely on pursuing transparency and confidence- building measures, such as negotiating an International Code of Conduct for Outer Space Activities aimed at promoting responsible behaviour and strengthening stability in space; [and to]

- Encourage greater regional engagement in space security issues, such as through the Australia/Vietnam initiative, co-sponsored by the United States, to hold an ASEAN Regional Forum Space Security Workshop" (DFAT, 2012a).

The two nations agreed to strengthen bilateral cooperation in space through the establishment of jointly operated SSA facilities that would feed data into the USAF Space Surveillance Network. They agreed to:

> "Relocate a US C-Band space surveillance radar to Western Australia in 2014, where it will track space assets and debris, contribute to the safety and security of space-based systems on which we rely and increase coverage of space objects in the southern hemisphere; [and]
>
> Complement the C-Band space surveillance radar capability by working towards the relocation of an advanced US space surveillance telescope to Australia and explore ways to better leverage Australian space surveillance capabilities for combined benefit, as next steps under the Space Situational Awareness Partnership signed in 2010" (DFAT, 2012a).

Beyond Alliance commitments, numerous civil SSA initiatives, involving both public and private investments are under development in various parts of Australia. These include:

- Commercial tracking and orbital characterisation of space objects, including debris, using ground-based lasers. The company involved, Electro-Optic Systems has a long heritage in these activities (EOS, 2018b).
- A Space Environment Research Centre (SERC), established under the long-running Cooperative Research Program of the Australian Government. The ultimate purpose of SERC is to demonstrate that pressure from a ground-based laser can be used to modify the orbit of a piece of space debris to prevent a collision (SERC, 2019).
- Construction at UNSW Canberra of a series of small satellites of different shapes to quantify and compare the effects of orbital drag on these structures (UNSW Canberra, 2018).
- Commercial development of a capability designed initially to track meteoroids with such precision as they fall to Earth that the material that reaches Earth (meteorites) can be found and recovered. Initially called the Desert Fireball Network and led from Curtin University in Western Australia, the potential of

the system for SSA purposes was realised when tracking meteoroids had been demonstrated (Defence Connect, 2018a).[1]

- Commercial development of a system that will allow certain radio telescopes, the first being the Mileura Widefield Array (MWA), to use passive radar techniques to track space objects, including debris. Radio astronomers, also based at Curtin University, realised that spurious signals being received by the MWA were from radio stations in Perth being reflected off orbiting space objects. (Tingay et al., 2013; News.com, 2018).

These initiatives all started from the bottom up. EOS, sensing the changing political mood as reflected in the AUSMIN announcements discussed above, initiated the CRC bid that led to the formation of SERC in 2014. UNSW Canberra, which is the academic provider to the Australian Defence Force Academy (ADFA), saw an opportunity to introduce Australia's future military leaders to space in all aspects – technology, science, policy, regulation and warfighting. The two projects from Curtin University did not set out deliberately to contribute to SSA capabilities. The dual use potential of both the tracking network and the radio telescope only became apparent later (Biddington, 2017b).

The initiatives were developed in isolation from each other and reflect the skills and interests of their inventors. There was no national plan, or dedicated SSA development and investment program to motivate or guide investment priorities.

2.2.5 Space Weaponisation

There is an important distinction between 'militarisation' and 'weaponisation' of human activities in space (Mowthorpe, 2004). Militarisation speaks to defence forces using satellites to more effectively conduct operations in the terrestrial warfighting domains - the sea, the land, the air and in cyberspace. Intelligence gathering and the use of satellites for navigation and communications are obvious examples. Weaponisation speaks to the space domain as a battleground where future military campaigns are conducted and where future wars may be won and lost. In such scenarios, the principal actors are taken to be nation states (Dolman, 2002; Sach, 2015).

[1] The Desert Fireball Network was designed to detect meteoroids as they fall towards Earth and that are within the field of view of an array of fixed sensors deployed across large areas of the Australian Outback.

Since the 1950s, the principal spacefaring nations have launched many satellites to support the terrestrial activities of their armed forces. These satellites are not considered by the international community to violate the principles of the Outer Space Treaty and its supporting documents (Grego & Wright, 2010). Using figures already quoted (Table 2.1 above), almost one in five of all satellites attributed to the United States serve military purposes. This number does not include commercial satellites that are used by the military under contractual arrangements for communications and other purposes. Professor Joan Johnson Freese, a space policy expert at the US Naval War College, was quoted in November 2018 as saying that around 95% of all satellites are 'dual use', meaning that they serve military and civilian purposes alike (Bartels, 2018).

In April 2018, the Secure World Foundation published a report with the title *Global Counterspace Capabilities: An Open Source Assessment* (SWF, 2018). The report defined counterspace systems as those that can be used to deceive, disrupt, deny, degrade or destroy satellites. Counterspace weapons may achieve their objective by kinetic, electronic, directed energy or cyber means. They may be held on the ground and only launched into space when needed, or they may be placed into orbits close to their potential or intended targets. Ground-based, direct ascent space weapons have been developed and demonstrated by the United States, Russia, China and India. Known as anti-satellite or ASAT weapons, these devices have the potential to cause considerable harm to the space environment as occurred with the Chinese ASAT test against the decommissioned Fengyun 1C communications satellite, noted above.

Any activity in space that involves one satellite operating close to another has military potential. Many so-called proximity operations are both necessary and benign. An obvious example is the routine transportation of astronauts to and from the ISS and the re-provisioning and sustainment of the Station as well. Other activities are not so innocent. A US-based company, AGI, operates an unclassified commercial SSA network and a commercial space operations centre (ComSpOC), where the sensor data are fused, analysed and displayed and from where alerts can be provided to satellite operators whose satellites might be at risk of collision with another space object (AGI, 2017). At its booth in the trade exhibition at the annual Space Symposium in Colorado Springs in March 2017, AGI demonstrated how, some months earlier, it tracked a Chinese intelligence-gathering satellite in close proximity to an Optus commercial communications satellite, and also how it tracked a Russian intelligence gathering satellite manoeuvring close to an American intelligence-gathering satellite. Seemingly, great care was taken by Chinese and Russian authorities to avoid having their satellites collide with the satellites about which they seemed to want to know more (Biddington, 2017c).

Had there been a collision, causing damage and possibly destruction, how would ground-based authorities know with certainty whether the action was due to a malfunction (concerning but forgivable), or deliberate (potentially an act of war)? The policy and practical dilemmas revolve around the determination of intent. In the space environment, comprehending intent is difficult and, in some situations, may be impossible to discern with any level of confidence.

A further example of proximity operations that has been discussed in the public domain concerns another Chinese satellite, Shijian 17, or SJ-17. Launched in 2016, this satellite has been observed conducting proximity operations with some Chinese satellites that are in GEO orbits (Spaceflight 101, 2016; Clark C, 2018). The references indicate that SJ-17 is an experimental satellite that appeared to be involved in SSA activities, using Chinese satellites as its targets of interest.

In March 2018, President Trump announced his Administration's America First National Space Strategy. A Fact Sheet issued by the White House explains that the core of the President's strategy is "Peace through strength" (White House, 2018a). The Fact Sheet, also notes:

> "President Trump's National Space Strategy recognizes that our competitors and adversaries have turned space into a warfighting domain.
>
> While the United States would prefer that the space domain remain free of conflict, we will prepare to meet and overcome any challenges that arise.
>
> Under the President's new strategy, the United States will seek to deter, counter, and defeat threats in the space domain that are hostile to the national interests of the United States and our allies" (ibid).

In June 2018, President Trump, ordered that a Space Force be created as a separate branch of the US armed forces (White House, 2018b). Only Congress can create a new branch of the military but planning to create a separate Space Force is under way (Greshko, 2018). The proposal has received a mixed reception, with opponents and those to be convinced citing mission uncertainty, cost and legal issues as important concerns. (Livingston, 2018; Greshko, 2018).

The statement quoted above from the White House asserts that space already is a warfighting domain. However, the thresholds that have been crossed to sustain this assertion, have not been made public.

2.2.6 Australian Responses to the Threat of Space Weaponisation

The position of the Australian Government regarding space security has been constant for some years and is expressed through Defence White Papers, and the Defence Integrated Investment Plan (DIIP). From a space capability perspective, these documents focus on Space Situational Awareness (DoD 2016b). There is no indication in the most recent Defence or foreign policy white papers that Australia is seeking to acquire offensive systems that could be used to damage or destroy satellites (DoD, 2016b; DFAT, 2017b).

A major objective of the Space Environment Research Centre (SERC), based in Canberra, is to alter the attitude of a piece of debris relative to Earth through photonic pressure from a ground-based laser. This is described as a demonstration of a collision avoidance system, not a space weapons program (SERC, 2018a).

The missiles and guidance and control systems developed for Ballistic Missile Defence (BMD) may be adapted to become direct ascent Anti-Satellite (ASAT) weapons (SWF, 2018, p. 3.8). The 2019 *US Missile Defense Review* notes that, in addition to trilateral meetings with Japan:

> "The United States and Australia meet annually to discuss bilateral missile defense cooperation. New areas of focus include joint examination of the challenges posed by advanced missile threats" (US DoD, 2019, p.xvi)

A complicating factor, for all nations, when addressing questions of space security is that the space environment is inherently 'dual use' as are many satellites. This topic is addressed in the next section.

2.2.7 Dual Use Technologies

Historian Walter McDougall's definitive account of the political history of the early decades of the space age makes abundantly clear that, since the 1950s, governments have recognised that space is a dual use environment. This means that satellites may serve military and broader national security interests as well as civil and commercial interests (McDougall, 1985). Initially the classified and unclassified elements of space activity were carefully and deliberately separated. The former was protected by rigorous security regulations and practices. Export controls, copyright and intellectual property protection laws and practices protected the latter. The major space-faring nations had the capability and capacity in their industrial base to design, build, test and launch satellites and space probes for national security, civil and commercial purposes.

Dual use technologies present challenges for large and small nations alike, especially when the export of these technologies is being contemplated (Johnson-Freese, 2007).

In the past decade or so, the distinction between satellites used for exclusively defence and national security purposes and those used for civil and commercial purposes has blurred. The United States military, for example, in the wars it has fought in the Middle East since 1991, has made increasing use of commercial communications satellites and imagery from commercial imaging satellites as well (Lee & Steele, 2014). High-resolution commercial imaging satellites now offer sub-metre resolution accuracy and timeliness once reserved for satellites operated by a small number of intelligence agencies around the world (Monmonier, 2002; Faust, 2014).

The US Global Positioning System (GPS), initially designed for exclusive military use, has since 1 May 2000, been readily available at a high level of accuracy to all who possess a GPS receiver. On that day President Clinton signed an order to turn off the Selective Availability (SA) capability of the system. This decision permitted GPS to become a virtual global utility that supports myriad civil and commercial applications where timing and location matter, across all nations (USG, 2018a). Some nations and groups of nations, to reduce their dependence on GPS, have invested in their own GPS-like Global Navigation Satellite Systems (GNSS). These nations include Russia (the GLONASS system), China (Beidou), the European Union (Galileo), Japan (Quasi-Zenith Satellite System -QZSS), and India (IRNSS).

One example of an operational dual use imaging system with which Australian land management agencies and researchers have some experience, is the Cosmo-Skymed Synthetic Aperture Radar (SAR) satellite system operated by the Italian Government. The Italian Government uses information from this system for national security and for civil purposes (Stanglini & Mocci, 2008). A difficulty arises in the tasking and priority setting process. The Italian defence and security community seeks to preserve a level of confidentiality around its specific tasking requirements and priorities. Civil agencies also have requirements, some of which can occur at short notice, especially when imagery is needed of natural disasters such as earthquakes, fires and floods. In the case of Cosmo-Skymed, the military and national security community is the final arbiter.

The requirements setting and tasking system for Cosmo-Skymed is shown in the diagram on the following page.

Figure 2.5. Cosmo-Skymed Remote Sensing Satellite System: Tasking and Data flows (simplified from Stanglini & Mocci, p. 67).

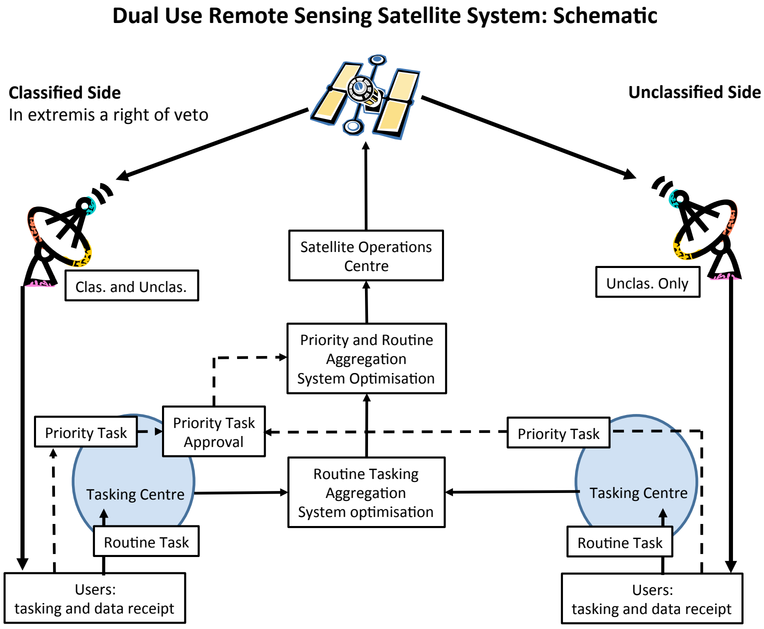


Diagram first published in Biddington & Sach, 2010, p 60.

2.2.8 Australia and Dual Use Technologies

Since Sputnik, the Australian Government has funded the construction and launch of four small scientific satellites. The most recent of these, called M1, was funded by the Royal Australian Air Force (RAAF) and built by the Space Centre at the University of New South Wales in Canberra (Gunter, 2019a; Spacewatch, 2019). This satellite was launched in December 2018 and seems to have failed. The penultimate satellite to be launched, called Buccaneer, was launched in November 2017 for the Defence Science and Technology Group within the Department of Defence (Seidel, 2017).

The Commonwealth, through two wholly-owned business enterprises - Aussat and the NBN Company (NBNCo) - has also funded the purchase of advanced communications satellites. Aussat was established in 1979 and sold as a going concern to a commercial enterprise, Optus, in December 1991 (EOAS, 2010). The NBN Skymuster satellites, built by Space Systems Loral, substantially contribute to the government's aim to make broadband connectivity available to all Australians, including those living in remote and regional locations, at affordable prices (NBNCo, 2018).

In the late 1990s, the Department of Defence co-funded a hybrid commercial and military satellite with Optus, the company that purchased Aussat. Defence and Optus shared the cost of the satellite, which is operated by Optus (Optus, 2013; Optus, 2019). Defence, however, controls a communications payload on the satellite independently of Optus. Defence determines the traffic that will be passed on the Defence payload, the relative priority to be accorded to traffic, the encryption standard and the configuration of the transponders (Hill, 2003).

In 2007, the Australian Government arranged with the United States to pay for the construction and launch of a sixth satellite in the USAF's Wideband Global System (WGS). The WGS is a capable and secure SATCOM system with coverage of most of the Earth's surface (Davies, 2015). Effectively, by paying for one satellite, Defence has achieved access to the entire constellation. An objection to this arrangement is that Australia lacks sovereign control over the WGS. In a *force majeur*e event, the US may take all the bandwidth available in the WGS constellation for its purposes, leaving Australia without the means to pass vital information to its forces via WGS. As with the Optus case so with WGS, successive Australian governments have negotiated high-level assured access and quality of services agreements. In the case of WGS, the Australian and US governments at AUSMIN 2008:

> "…signed a Statement of Principles establishing a military satellite communications partnership. Both governments committed to taking forward the partnership in a manner which benefits the defence capabilities of the Australian Defence Forces and the U.S. military" (AUSMIN, 2008).

In 2012, showing further flexibility, Defence arranged to place an Ultra High Frequency (UHF) communications as a hosted payload on a commercial satellite, Intelsat 22. This satellite is in GEO at 72^{o}East, and the UHF payload provides reliable UHF communications to the Australian Defence Force across the Indian Ocean and littoral states (Aerospace Technology, 2018).

For remote sensing, Australia has been content to rely on data from satellites that are owned and operated by other nations and by commercial entities. There is evidence that this approach is changing, including in the Defence realm, discussed in Chapter Six.

2.3 Why does a safe and secure orbital space environment matter?

Numerous reasons exist for nations to invest in the safety and security of orbital space. The Australian Government's 2017 *State of Space Report* (DIIS, 2018c) noted:

> "Australia is increasingly reliant on space-enabled services, in particular those that use satellite information in applications that protect and advance national interests. Key benefits derived from Australia's use of space applications include:
>
> - **Improved Productivity:** space capabilities such as satellite imagery and high accuracy positioning deliver information that brings about greater efficiencies and encourages innovation.
> - **Better Environmental Management:** satellite information enables effective environmental management across Australia's extensive and often inaccessible land and ocean territory.
> - **A Safe and Secure Australia:** space capabilities are important inputs to national security, law enforcement and to the safety of all Australians during disasters.
> - **A Smarter Workforce:** space capabilities help transform existing industries and build new ones that provide quality jobs.
> - **Equity of Access to Information and Services:** satellite communications enable high-speed, universal access to TV broadcasting, internet and telephone services." (ibid, p. 11)

These points and some others related to them are discussed in four sections that follow with the headings:

- The space economy
- Treaty verification and monitoring
- Monitoring the space and Earth environments
- Industry transformation: Space 2.0.

2.3.1 The Space Economy

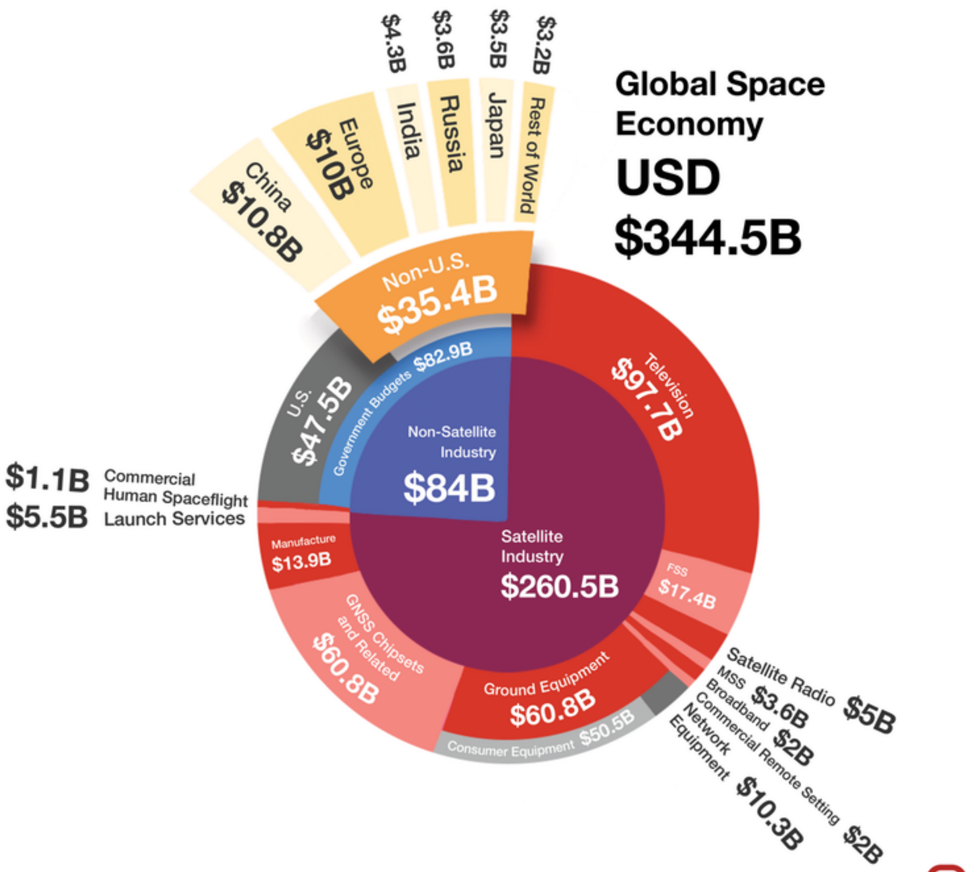
Satellites, in concert with the internet, have been essential to globalisation and the creation of global supply chains (Linton et al., 2017). The US Global Positioning System (GPS) system, and similar systems operated by other nations provide precision navigation and timing services across the planet. Producers and sellers, manufacturers and buyers can track materials and goods as they cross the world from their sources to markets.

From the late 1940s until the 1980s, space activity was the preserve of a very few nation states. During the Cold War, the United States and the USSR were pre-eminent. More recently China has become a third member of this exclusive group, and now spends more on space activity than does Russia (OECD 2014; Bryce 2017a). There is a second group of influential but lesser players including Europe (including France), France (on its own account), India and Japan. A third group, which either possesses space capabilities or is developing them, includes Brazil, Canada, Germany, Iran, Israel, Italy, New Zealand, Pakistan, South and North Korea, Taiwan and the United Kingdom. All other nations follow (OECD, 2014; Harding, 2013; Harvey et. al., 2010; Morris & Cox (eds), 2010).

The World Bank estimates that the overall size of the global economy to be in the order of US80.7 trillion dollars (World Bank, 2018). The space component is US$334.5 billion (Bryce, 2017a), a tiny proportion of the overall figure; in the order of 0.4%.

The space economy is expected to continue to grow and to treble by 2040 to be worth US$1.1 trillion (Bryce, 2017a). The figure below is adapted, for purposes of clarity only, from the Bryce study (ibid, p. 1). It summarises the state of the global space industry in 2016.

Figure 2.6. The Global Space Industry at a Glance.



The global space economy at a glance. Figures are from 2016 and shown in US$.
Source: Marcella Cheng for The Conversation, adapted from *Global Space Industry Dynamics Research Paper*, Bryce Space and Technology, 2018.

The points from Figure 2.6, relevant to Australia's place in space, are summarised below.

- Private investment and activity accounts for 76% (US$260.5B) of the total space economy with investment by governments accounting for just 24% (US$82.9B) of the total.
- Of the 195 nations in the world, eleven account for 96% of the total expenditure by governments in space activities. These include the United States, China, Russia, India, Japan, South Korea, Canada and the nations of Europe (primarily France, Germany, Italy and the United Kingdom). The governments of the remaining nations, including Australia, account for the remaining 4%.
- The US Government accounts for more than 50% of the investment made by governments in their space activities and more than 50% of the US Government's investment in space is for defence and national security activities.
- The 'downstream' elements of the space economy are much larger than the 'upstream' elements.
- Launch activities account for just 1.6% (US$5.5B) of the global space economy.
- Launch services and commercial human spaceflight together amount to just 1.9% (US$6.6B) of the global space economy.
- A final point is the relatively small investment on human space flight and space exploration – in sum, somewhere between 2% and 3% of the total.

Data published in a series of reports published by the Organisation for Economic Co-operation and Development (OECD) reinforce these points.

OECD Reports Since 2004, the OECD has published a series of reports that chart the course of the global space industry and make predictions about its future. The first two reports, published in 2004, looked forward to 2030 and foreshadowed how human use of space would change in the intervening quarter of a century (OECD, 2004a; OECD, 2004b). The OECD published editions of the *Space Economy at a Glanc*e in 2007, 2010 and 2014.
In 2012 a report with the title, *OECD Handbook on Measuring the Space Economy*, was published. The report discussed the challenges involved in making accurate measurements and predictions about the size of the space economy.

The 2014 edition of *The Space Economy at a Glance*, revised and updated information provided in earlier reports. Table 2.2 below is reproduced from the 2014 OECD Report and indicates the money that national governments spent on space activities in 2013 in Purchasing Power Parity terms[2]. The figures differ from those quoted in the Bryce study, above, however, the ratios, even when expressed in PPP terms, remain about the same. Peeters has cautioned that the OECD figures are based upon official figures, not upon the real budgets and that conversion to PPP can lead to further distortion (Biddington, 2019a). Allowing for these caveats, the table shows the enormous disparity in expenditure on space activities between the three major powers, larger powers, and some middle powers.

Table 2.2. Space budgets in PPP (Purchasing Power Parity) for selected countries.

Space budget in USD millions PPP 2013

Nation	**US$m**
USA	39,332.2
China	10,774.6
Russia	8,691.6
India	4,267.7
Japan	3,421.8
France	2,430.8
Germany	1,626.6
Italy	1,223.3
South Korea	411.5
Canada	395.9
United Kingdom	338.9
Spain	302.9
Brazil	259.2
Belgium	244.8
Indonesia	142.0
Switzerland	133.0
Sweden	122.0
Netherlands	110.5
Turkey	104.3
Norway	89.6
Israel	89.3
Poland	80.7
South Africa	76.4
Austria	73.0
Finland	53.9
Denmark	38.2
Portugal	32.2
Greece	30.3
Czech Republic	25.4
Ireland	25.3
Australia	**24.9**
Luxembourg	17.0
Hungary	8.9

[2] To quote Hall (2019), "One popular macroeconomic analysis metric to compare economic productivity and standards of living between countries is purchasing power parity (PPP). PPP is an economic theory that compares different countries' currencies through a "basket of goods" approach.

According to this concept, two currencies are in equilibrium—known as the currencies being at par—when a basket of goods is priced the same in both countries, taking into account the exchange rates".

Mexico	8.5
Estonia	5.4
Slovakia	4.8
Slovenia	2.9

The table indicates the dominant position of the United States, followed by China and Russia. India, Japan and Europe as a whole, are in the next tier. A summary of points from this table that are relevant to Australia's place in space follows. In 2013, in PPP terms:

- The United States Government was, by far, the largest spender on space activities of all national governments.
- The ten nations that spent most on space, accounted for all but a few per cent of the global space expenditures of national governments.
- The 11th highest spending nation, the United Kingdom, accounted for less than 1% of the money spent by governments on space activities in 2013.
- Middle-ranking and small powers (South Korea and those listed below South Korea in the table) accounted for around 4% of total investment by governments in space activities.
- Australia spent more than one order of magnitude less money on space than does the United Kingdom.

The locations of capital cities of the top ten spending nations are north of the Tropic of Cancer[3] and all major launch facilities, including the Space Centre at Kourou in French Guiana, are north of the Equator. A reasonable inference is that space investment and space activity is overwhelmingly concentrated in the Northern hemisphere.

A question that follows is whether nations located south of the Tropic of Cancer have any realistic possibility of exerting influence in the space economy, except as buyers and users of services and data provided by others. Can nations located in the southern hemisphere contribute usefully to the global space enterprise? Might location attract investment and form the basis of new industries?

The 2016 OECD report, *Space and Innovation*, explores the role of innovation as it relates to the space sector. Many innovative technologies were spawned in the space sector from the 1950s to the 1990s. This innovation fell away towards the end of the 20th Century, as

[3] Washington, Beijing, Moscow, New Delhi, Tokyo, Paris, Berlin, Rome, Seoul, Ottawa.

entrepreneurs and innovators focussed on computing technologies. The report, however, provides evidence of a resurgence in innovation in the space sector, especially in applications development, as commercial investment in space projects displaces government spending (OECD, 2016).

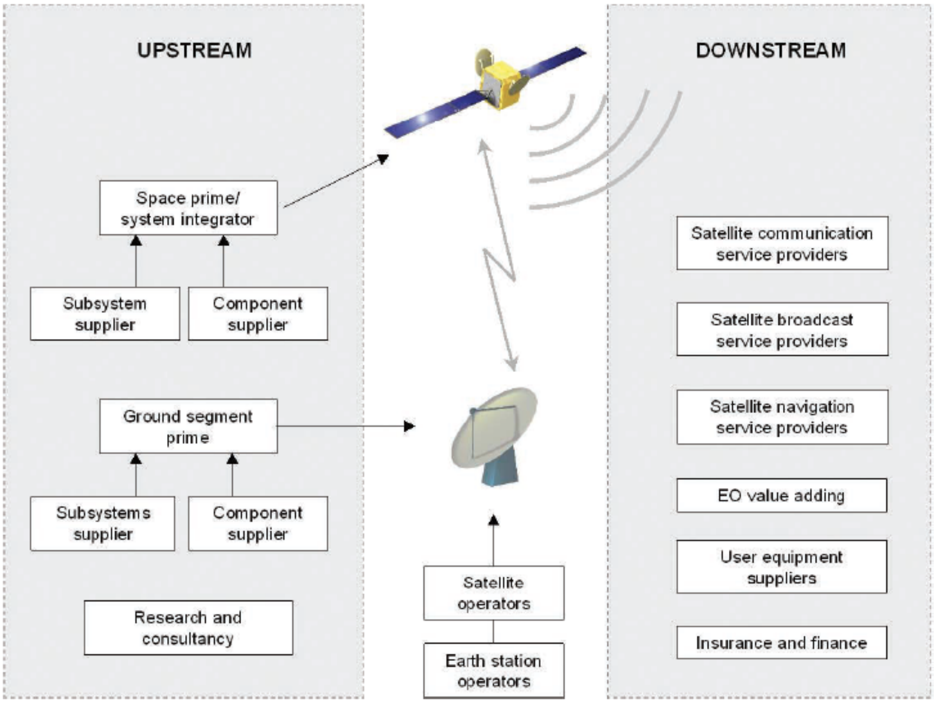
Is there an emerging nexus between location and innovation upon which Australia and other nations in the southern hemisphere may be able to capitalise?

Measuring the Space Economy: Challenges with Data and Definitions The 2012 edition of the *OECD Handbook on Measuring the Space Economy*, discusses the challenges involved in making accurate measurements and predictions about the size of the space economy and warned that methodologies may vary over time and may be subject to numerous constraints (OECD, 2012). This report acknowledged the difficulty of determining the boundary of the space economy. Which aspects of economic activity should be counted as belonging to the space economy and which aspects should be excluded is not always self-evident and can be open to interpretation? The OECD was concerned to avoid the situation where economic contributions were counted twice. The OECD's definition of the space economy is as follows:

> "The space economy is the full range of activities and use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space. Hence, it includes all public and private actors involved in developing, providing and using space-enabled products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities. It follows that the space economy goes well beyond the space sector itself, since it also comprises the increasingly persuasive and continually changing impacts (both quantitative and qualitative) of space-derived products, services and knowledge on economy and society" (OECD, 2012, p.20).

Upstream and Downstream Space Activities In the past decade, the United Kingdom has made deliberate efforts to establish a self-sustaining space industry. An important document in this journey is a report, *The Size and Health of the UK Space Industry*, published by the UK Space Agency in 2010. This report made an important distinction between 'upstream' and 'downstream' activities. The types of companies and the products and services they deliver are divided into those that directly support activities in space and those that provide ground services are enabled or made possible by data and services provided by satellites, as illustrated overleaf.

Figure 2.7. Differentiating Upstream and Downstream Space Activities.



Source: *The Size and Health of the UK Space Industry* UK Space Agency: 2010, p2.

Dr Henry Hertzfeld is the Director of the Space Policy Institute in the Elliot School of International Affairs at George Washington University. He is an economist who specialises in the economics of the global space sector. In an article published in 2013, he wrote:

> "Space is a small economic sector, accounting for less than half of 1% of the estimated gross domestic product (GDP) of the world and approximately 1% of the U.S. GDP, the largest single nation investing in space activities" (Hertzfeld, 2013, p. 23).

The small size of the sector is one of several reasons cited by Hertzfeld for the "very poor quality" of economic data that exists about the global space sector. Space activities are not captured under a single industry classification. Rather these activities are,

> "…spread among many sectors (e.g., transportation, instruments, communications equipment, navigation equipment, software, and business services)" (Hertzfeld, 2013, p. 23).

The OECD figures quoted above (Table 2.2) indicate that Australia's share of the global space economy represents 0.33% of the total. Other figures, presented in Chapter Seven, indicate that Australia's share might be closer to 1%. The numbers are less than convincing and are discussed in more detail in Chapter Seven.

2.3.2 Treaty Monitoring and Verification

Military activities dominated the early days of human activities in space and continue to be vitally important (Dolman, 2002). The world's first intercontinental missile was the German V2 terror weapon, 3,500 of which were fired from the Continent towards the United Kingdom in the latter months of World War 2 (Neufeld, 2013). Although these weapons had no direct impact on the outcome of the war, the Saturn 5 rocket of the Apollo era and Soviet launch vehicles can trace their lineage to the V2 missile. As World War 2 drew to a close the United Kingdom determined to develop long range weapons of its own to deter the Soviet Union. Australia was a willing partner and the Woomera test range was established in 1947 to enable the United Kingdom to pursue its ambitions (Hasluck, 1970; Morton, 1989)

During the first decade or so of Cold War, the United States and the Soviet Union sought to understand the development of each other's nuclear forces. In July 1955, President Eisenhower proposed the so-called Open Skies initiative at a summit meeting in Geneva with his Soviet counterpart, Premier Bulganin. This policy envisioned US aircraft overflying Soviet sovereign territory and Soviet aircraft overflying US sovereign territory to permit each nation, through an agreed and transparent process, to gain a verified understanding of each other's developing nuclear capabilities. Eisenhower was looking to avoid strategic surprise and to reduce the prospect of a nuclear war by accident or miscalculation. Although Bulganin seemed responsive to the suggestion, Khrushchev who was present at the summit and seemingly the Russian with real authority, rejected the proposal out of hand. According to a first-hand account by American presidential adviser, Walt Rostow, Khrushchev told Rostow "…that the idea was nothing more than a bald espionage plot against the U.S.S.R" (Rostow, 1982, p. 8).

Nevertheless, the United States used the extremely high-flying U-2 reconnaissance aircraft to conduct a series of overflights of the Soviet Union between 1956 and 1960. These came to an abrupt end when one such aircraft, piloted by Gary Francis Powers, was shot down near Sverdlovsk (today's Yekaterinburg) on 1 May 1960 (Richelson, 2001).

These were precursor activities to a series of space reconnaissance programs that originated in the late 1950s and came to fruition in the 1960s. The first American satellite reconnaissance program, codenamed Corona, became operational in 1960 (Richelson, 2001). Corona was an imagery intelligence gathering system. Space-based signals intelligence and missile early-warning programs, focused initially on Soviet nuclear capabilities, followed. As noted earlier, ground stations located in Australia, at Pine Gap, near Alice Springs and at Nurrungar, near Woomera, were vital to the treaty monitoring and verification capabilities of the United States.

The importance of the ground stations to the development of Australia's space activities are discussed in more detail in Chapter Four.

2.3.3 Monitoring the Space and Earth Environments

A third reason for Australia to take an active role in securing the space environment relates to the vantage point that space offers for monitoring the Earth and space environments.

The Space Environment As already noted, space is a harsh environment that is easily disturbed. It presents considerable technical challenges to those who design, build and operate spacecraft. Environmental risks are magnified by political and strategic competition between the major spacefaring nations and by the fundamental dependencies that all satellites have on access to radio spectrum to communicate with control stations on Earth (Hitchens, 2004).
Noted already, and discussed in more detail in later chapters, the Australia continent offers a vantage point for ground-based or downstream activities that are directly relevant to monitoring the orbital space environment.

Observing Earth The Committee on Earth Observation Satellites (CEOS) in conjunction with the European Space Agency (ESA) publishes annually the *Earth Observation Handbook* (CEOS, 2018). This is a comprehensive annual survey of the Earth observation satellites in operation, their technical characteristics, the tasks they perform and the principal users of their data. Case studies, that vary from year to year are also included.

To summarise the *Earth Observation Handbook*, many nations operate Earth observation satellites. Some of these are optimised to collect information about natural phenomena and others seek to collect information about human activities. Some collect data about the atmosphere that aims to improve the timing and accuracy of weather forecasts. Others monitor soil moisture to predict crop growth and yields, and changes to vegetation and forests. Others monitor the oceans, measuring water temperatures, circulating currents, pollution and the health of estuaries and coral reefs. Finally, there is a group of satellites that provide data about natural disasters – floods, forest fires, earthquakes and the impacts of large storms. Myriad users benefit directly and indirectly from the data collected by satellites.

Australia operates no Earth observation satellites of its own. Australian Government agencies receive data from numerous satellites and government to government sharing arrangements or through commercial arrangements. Late in 2018, CSIRO began to receive data from a UK satellite, NovaSAR-1, in which CSIRO has purchased a 10% stake (CSIRO, 2018a).

Australia is responsible through sovereign jurisdiction or obligations under international treaties for approximately 15% of the surface area of Earth. Data from satellites makes an essential contribution to the discharge of these responsibilities (GA, 2011). The Australian Bureau of Meteorology (BoM) processes weather data the results of which are fed into global weather and climate models thereby increasing their fidelity and predictive accuracy (AMOS, 2017). These contributions deliver economic and social benefits nationally and internationally and are discussed in more details in Chapter Six.

2.4 Dual Use Technologies

Dual use technologies and advanced manufacturing have two important consequences for the global space economy and for regulation, cooperation and competition in space. Tables and charts that segment the space economy into component parts to which dollar figures are attached (e.g. Figure 2.8 above), do not capture vital co-dependencies and inter-relationships between the segments.

First, is the 'dual use' nature of many space-based technologies and the economic consequences of the interdependence between military and non-military systems. Two examples follow.

- The Global Positioning System (GPS), owned by the US Government, is operated by the USAF. GPS is the best known and most widely used Global Navigation Satellite Systems (GNSS) in existence. As already noted, GPS is effectively a global public utility paid for by the US taxpayer. Other GNSS systems are operated or being developed by Russia, China, Europe, Japan and India (the latter two with regional and not global coverage).
- The US military, since the first Gulf War in 1991, has become increasingly reliant on commercial satellite systems to support its warfighting activities, notably in Afghanistan and the Middle East.

If the US Government did not provide the GPS space segment, the substantially larger non-government ground segment may not exist. Conversely, the US Government has met increasing demands for bandwidth and has strengthened the resilience of satellite communications in and out of theatres of military operations by undertaking commercial contracts with satellite communications companies.

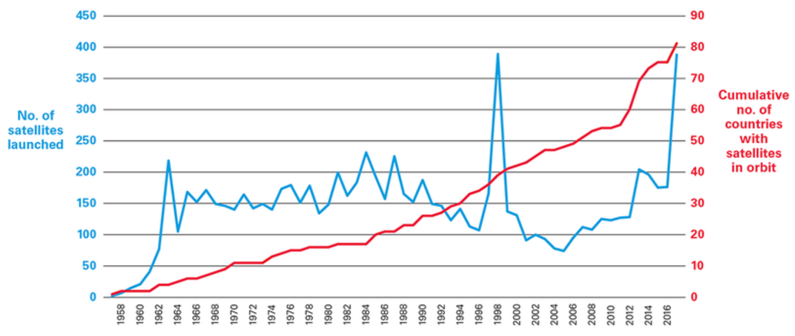
Second, is the disruption to the *status quo*, notably in the launch services and satellite manufacturing sections of the industry, because of advanced manufacturing techniques, including 3-D printing and the invention of new materials. Launch providers are proliferating, and launch costs are coming down. Satellites are also becoming smaller, yet more capable and less expensive. Important parts of the global space industry are in transition presenting both risks and opportunities for countries, including Australia, that are seeking to capitalise on these developments.

According to the Washington-based Satellite Industry Association, in 2017, 59 nations operated satellites representing well over 300 billion dollars of direct investment (SIA, 2017). Satellites have become, in effect, critical global infrastructure on which the international, national and regional economies and societies depend.

2.5 Industry Transformation: Space 2.0

Space is no longer the preserve of a handful of superpowers and rich nations. More countries are choosing to invest in space systems and there are numerous commercial entrants as well (Bryce, 2017b; Harding, 2013). Space is being 'democratised'.

Figure 2.8. Number of Satellites Launched and Countries Launching Them (from Wicht, 2018).



Note: spike in launches in 1998 due to several commercial satellite "constellations" (series of related satellites) being launched. Sources: Center for Strategic and International Studies, "Escalation and Deterrence in the Second Space Age", 2017; space-track.org; Timeline of First Artificial Satellites By Country, wikipedia.org, https://en.wikipedia.org/wiki/Timeline_of_first_artificial_satellites_by_country

A consequence of more satellites and more stakeholders is a more complex operating environment in space and a more complex policy landscape on Earth.

Risks and costs associated with launching satellites are reducing and technological change, notably the miniaturisation of electronics, the invention of new, strong materials such as carbon fibre and advanced manufacturing techniques, means that small satellites are quite capable of performing operationally useful tasks at prices that new entrants can afford.

Space 2.0 is a phrase that the space community borrowed from the internet to imply transformational change (Fort, 2009). Old space (Space 1.0) is characterised by government-funded space programs working through well-resourced space agencies supported by large companies. There were billion-dollar projects, huge launch vehicles, and very big, highly sophisticated satellites. New space (Space 2.0) is characterised by private investors building smaller systems made possible by the changes in technology noted above (Farwell, 2017). The business models of the new entrants are characterised by entrepreneurship and agility. New companies, such as SpaceX and Blue Origin have entered the market and old companies, of which Boeing and Lockheed are examples, are re-inventing themselves (Alleven, 2017).

Nations that are now seeking to become space capable are middle ranking and even quite small (Harding, 2013). Australia is one of these. These nations are seeking to own and operate satellites for a mix of reasons including to:

- Develop local industry and strengthen the technology base of the national economy.
- Gain a share of a rapidly developing global market
- Reduce the sovereign risk they perceive by being dependent on data and services from satellites that are owned and operated by other nations.
- Demonstrate commitment to education and research, especially in the areas of Science, Technology, Engineering and Mathematics (STEM), to both domestic and international audiences.
- Gain prestige both domestically and internationally that flows from being a spacefaring nation.

The values stated in the Charter of the Australian Space Agency are similar to the first four of the five points above (DIIS, 2018c). Prestige is not being sought. However, the space programs of some other nations, do contain prestige elements. The Chinese human spaceflight program and the United Arab Emirates' mission to Mars are examples (CSIS, 2018; UAE, 2015).

Euroconsult is a Paris-based consulting firm that specialises in the analysis of space markets. In July 2016, it released a report, *Trends and Prospects for Emerging Space Programs*. Euroconsult predicted that by 2025 the number of countries with emerging space programs will almost double from 24 to 47. The number of large satellites launched is also expected to almost double and the value of these investments to more than double (Euroconsult, 2016a).

In a separate report, *Prospects for the Small Satellite Market*, also released in 2016, Euroconsult predicted that more than 3,600 small satellites (with a mass of up to 500kg) will be launched in the decade 2016-2025 with a value of US$22 billion (Euroconsult, 2016b). This forecast of rapid acceleration in the numbers of satellites of all sizes and in the numbers of operators and nations involved in the coming decade all point to an industry on the cusp of fundamental change. Networking technologies, miniaturisation of components, advanced manufacturing techniques such as 3-D printing, and the emergence of global supply chains are combining to create opportunities for new entrants into many parts of the space marketplace. How nation-states and the international regulatory system will respond to the challenges that these new entrants present is an open question.

Large and small companies are joining in. Several have announced plans to launch constellations of hundreds and even thousands of satellites into LEO to provide internet on demand to all corners of the earth and to provide Earth observation data that are updated continuously. These constellations present challenges from both spectrum allocation and space traffic management perspectives.

2.5.1 Mega-Constellations

As noted earlier in this Chapter, presently almost 2,100 operational satellites are in various orbits around Earth. Several companies have announced that they intend to increase this number substantially by launching mega-constellations into LEO. In two cases the companies involved are planning to develop constellations each of more 4,000 satellites. In total, within the next five to ten years, there may be in the order of 12,000 new satellites in various low Earth orbits if these constellations are built and become operational. This figure is three to four times larger than that quoted above from Euroconsult. It is also much less than some other estimates that suggest that 20,000 or more satellites might be in orbit by 2025 (Scoles, 2017; Messier, 2019). The variances point to the fluidity of the market and its unknowns. The table on the following page, from the European Space Agency, provides some additional details.

Table 2.3. Announced Mega-Constellations.

Announced constellations

esa

Constellation	OneWeb	Boeing	SpaceX	Samsung
Satellites	720	2960	4000+	4600
Altitude	1200 km	1200 km	1100 km	1400 km
Sat. Mass	150kg	> 100kg	390kg	< 200kg

ESA UNCLASSIFIED - For Official Use

B. Bastida Virgili | 21/03/2017 | Slide 3

European Space Agency

Source: Slide drawn from a presentation by M Bastida Virgili to a meeting of the Space Security Committee of the International Astronautical Federation, Paris, March 2017.

If these constellations become operational, the implications for space traffic control and collision avoidance are profound as are the forecast demands on the radio spectrum. Considerable research is being undertaken to use light as a communications medium between satellites and Earth (Son & Mao, 2017). If this succeeds, some of the current and anticipated pressure on radio spectrum may ease.

2.5.2 Cubesats and Nanosats

Very small satellites have captured the attention and imagination of governments, policy-makers, technologists, entrepreneurs and research organisations across the world. Cubesats are now being designed and built in many countries, including Australia.

The standard dimension for a single unit (1U) cubesat is 10cm x 10cm x 10cm. These individual modules can be joined together to make 3U (30cm x 10cm x 10cm) satellites or even 6U satellites (30cm x 20cm x 10cm). The 1U designs have limited operational utility (Bugryniec, 2016). However, they are useful for testing satellite components and software in the harsh space environment and as educational and training devices as well. The 3U and 6U systems have sufficient space to house sensors that have operational utility. Some are launched by conventional means, being ejected directly into orbit from launch vehicles. Others are being transported to the International Space Station (ISS) as cargo and ejected into space from that platform (NASA, 2017).

In April 2017, three Australian-built cubesats were launched to the ISS for later deployment into LEO to perform various experiments. Three universities, the University of Adelaide, the University of New South Wales and the University of Sydney, each built a satellite (Dempster, 2017; Harris, 2017).

Planet (formerly Planet Labs) is a company based in San Francisco, California. It is presently deploying a constellation of 160 small (5kg class) satellites into LEO (Safyan, 2015). Known as Doves, these satellites will constantly image Earth at a resolution of 3-5 metres. The first 'flock', comprising 28 Dove satellites was launched from the ISS in 2014. Further 'flocks' were launched in March and June 2016. One of the founders of Planet Labs is an Australian, Dr Chris Boshuizen (Wall, 2014).

Planet's business model is to continuously replenish and upgrade the entire constellation (Safyan, 2015). A small percentage of the satellites (5%) are expected to fail on launch. The Dove satellites do not have propulsion systems. Because these satellites are in a relatively low orbit (less than 600km), by altering their attitude relative to the direction of flight, atmospheric drag can be used to slow them down (Foster et al., 2015).

In summary, the technologies, operating concepts and private sector funding sources that form the basis of Space 2.0 offer possibilities and potentials that could not be envisaged with the hand-crafted, government funded large satellites that were characteristic of the Space 1.0 era. Space 2.0 satellite systems may disrupt some established Space 1.0 markets and businesses. However large satellites, performing long-duration missions, are not likely to be replaced for functions that are critical to the interests of nation-states such as treaty monitoring and verification, some intelligence gathering missions and communications and navigation and timing. From an Australian space industry development perspective, the opportunity for Space 2.0 capabilities may lie, above all, in creating new markets and in providing products and services to new customers with new requirements that complement the services of the larger legacy systems (Davis, 2018).

The World Economic Forum has a project called 'Mapping Global Transformations'. It describes the importance of the space domain and its potential in the following way:

> "Space is more relevant to our daily lives than ever before. It offers the potential for a future economy, enhanced social and cultural development, international peace and security, and natural resources. The orbits around Earth provide critical satellite infrastructure for communications, networking, imaging, weather monitoring, and navigation - and related commercial and defence-related opportunities promise to

launch a new space race. Greater collaboration in the global commons of space can help to ensure a peaceful future for humankind" (WEF, no date).

2.6 Chapter Summary

This Chapter sought to derive an evidence-based answer the question "Why is a safe and secure orbital space environment important for humanity?" The first section of the Chapter identified four elements of the orbital space system that need to be safe and secure: orbital space itself, the satellites in orbit around Earth, radio spectrum needed for satellite communications, and the regime that regulates human endeavours in space. The second section of the Chapter identified a series of threats to the orbital space system that need to be countered or mitigated if a safe and secure environment is to be established and maintained. The third section was a discussion of a series of human activities that are dependent on secure and assured access to service provided by satellites in orbital space which demonstrated that many human activities on Earth depend on access to the data and services of satellites. Critical infrastructure and national economies have fundamental dependencies and the global space economy itself is growing rapidly, creating new job opportunities.

The research question speaks to the level of priority, political attention and funding that future governments, including the Australian Government, might invest in space security.

Based on the evidence presented, a case exists for governments in Australia and elsewhere to invest more political attention and to allocate more funds to space security than has been the case in the past. Although three nations, the United State, Russia and China, are dominant in national security, defence and commercial aspects of space activity, smaller nations, including Australia have vital national security and economic interests in ensuring that the satellites which provide data on which so much of modern society depends, may operate safely in an environment that is assured as secure (Morris & Cox (eds), 2012; Harvey et. al., 2010). This points to the question of obligation.

Threats and hazards need identification, risks quantified, and decisions made to ensure that access to space is secure and assured for space-faring nations as well as for those many others who use the satellite-based services provided by others. This can only be achieved through international cooperation. The changing geo-strategic dynamics of the world, especially the rise of China and the growth in the economic and strategic importance of the Indo-Pacific region, are already affecting the behaviour of nations in space. Just where a middle power, such as Australia, might fit into this emerging world order and how it might assist in making the space environment safer and more secure for all users is the subject of the next Chapter.

CHAPTER 3

MIDDLE POWERS AS SPACE ACTORS IN AN ERA OF GEO-STRATEGIC CHANGE

This Chapter addresses the second research question of the thesis which asks:

> Is Australia capable of making a significant contribution to the security of the space environment?

The lens through which the question is addressed in this Chapter is that of Australia's status in the international community as a middle power. The research question is explored from three perspectives. These are:

- Distinguishing features of middle powers from other nations within the pantheon of nation states.
- The influence that middle powers have in international politics generally and in the space domain specifically.
- Contributions that Australia may make to space security that derive from its status as a middle power above other factors.

Both Australian Labor and Coalition governments have used the phrase 'middle power' to establish Australia's place in the hierarchy of nations (Cotton & Ravenhill (eds), 2011, p. 2). Australia considers itself to be a middle power. Such status, whether self-assigned or assigned by others implies a degree of influence, with associated responsibilities and obligations.

The Chapter has three sections, one devoted to each of the perspectives listed above.

3.1 The Middle Power Concept

The purpose of this section is to test whether the phrase 'middle power' has theoretical as well as descriptive value. If the phrase has more than descriptive value it may allow for generalisations to be made about a group of states, of which Australia is one, regarding their general and even specific approaches to the governance of outer space.

In 1984, Carsten Holbraad published *Middle Powers in International Politics*, the basic research for which was completed at the Australian National University in Canberra (Holbraad, 1984).

Holbraad defined middle powers as:

“…states that are weaker than the great powers in the system but significantly stronger than the minor powers and small states with which they normally interact” (ibid, p. 4).

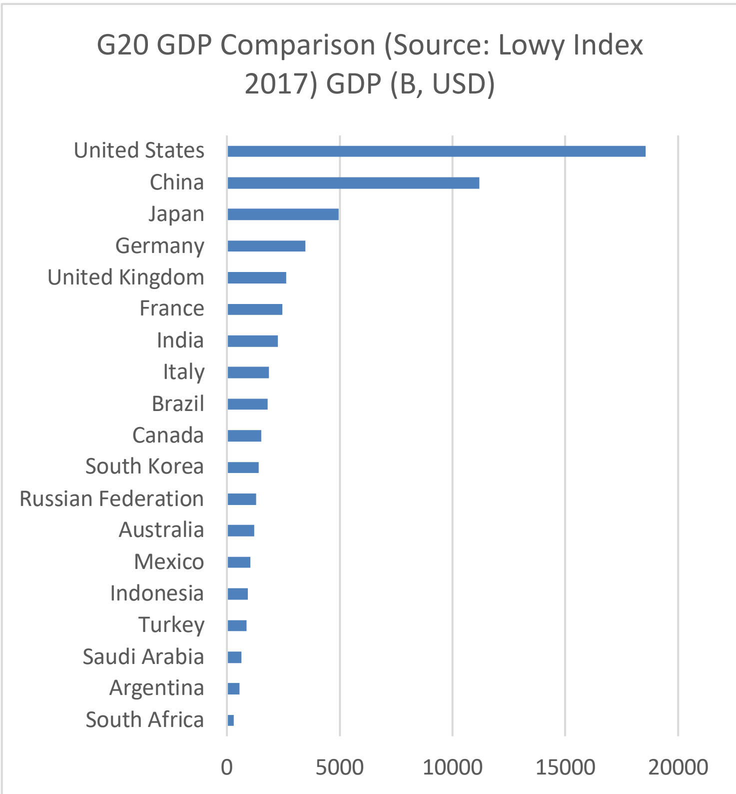
He also noted that middle powers tend to play prominent roles in their own regions where their “immediate interests usually lie” (ibid, 1984, p. 4).

Cotton & Ravenhill, also note that the middle power concept:

“…refers principally to aspects other than size, but most definitions refer, in one way or another to capability or ‘capacity’” (Cotton & Ravenhill (eds), 2011, p. 2).

When considering ‘capacity’, a place to start is the relative sizes of national economies. OECD figures were quoted in Chapter Two. Figure 3.1 below, published by the Lowy Institute, conveys similar information just for the G20 group of nations. In 2017, Australia was ranked the 13th wealthiest nation within the G20 which comprises the world’s 19 wealthiest nations plus the European Union considered as an aggregated whole.

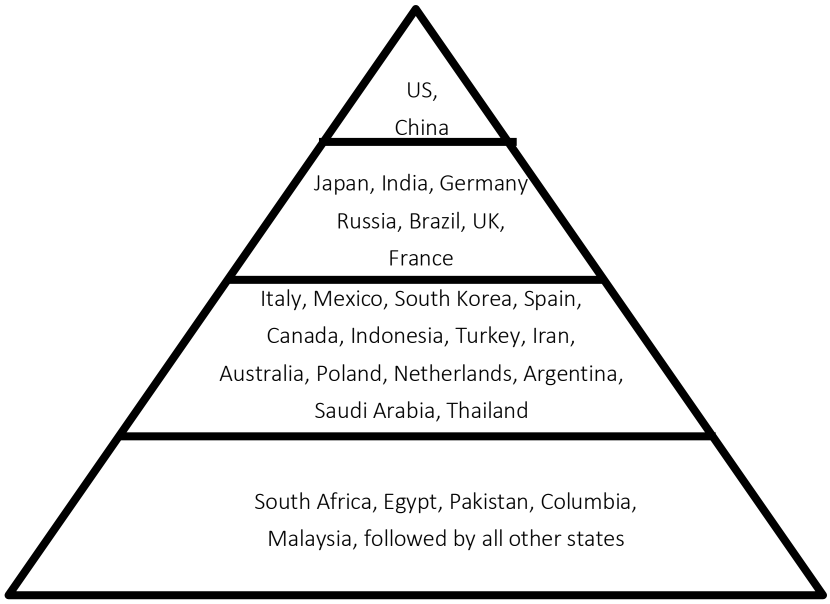
Figure 3.1. Relative Sizes of the G20 economies (US$ bns).



Note: The EU is a member of the G-20, however, it is excluded from this chart because it is not a nation state but an accumulation of states.

Drawing on data gathered in 2010 and published in 2012 about the relative sizes of economies, Gilley and O'Neil (2014) used a cluster analysis approach to devise the following hierarchy of states.

Figure 3.2. A Hierarchy of States: Middle Powers.



From: Gilley B. and O'Neil A (eds). 2014, p 5.

This approach revealed 14 nations, in the third tier from the top in Figure 3.2, that could be considered as candidate middle powers. Considerable overlap with the nations in the bottom half of the G-20 ranking table (Figure 3.1 above) is noted. Russia sits just above Australia in the G-20 ranking yet is accorded considerably greater overall global standing than the size of its economy, taken as a single data point, might suggest is warranted. Russia's vast geography and nuclear status add dimensions to its power that compensate for its relatively weak economy and elevates it to high status.

3.1.1 What Middle Powers are Not

Following from the comment about Russia, middle powers lack three attributes that are the preserve of the major powers. Middle powers:

- *Are not permanent members of the UN Security Council*. The permanent members are China, France, the Russian Federation, the United States and the United Kingdom. All possess nuclear weapons.

- *Do not possess nuclear weapons*. Four nations, not members of the Security Council, do possess nuclear weapons. They are India, Israel, Pakistan and North Korea. They have developed these weapons as deterrents against threats they consider to be existential: India – Pakistan, Israel - the Arab World, Pakistan - India, and North Korea - the United States. The paradox of nuclear weapons is that their value as instruments of national power is in the deterrent effect of their non-use (Morgenthau, 1973).
- *Are not capable of initiating major wars*. The armed forces of middle powers, although generally well-trained and equipped, are relatively small (SIPRI, 2018). These forces may conduct operations that contribute to regional stability and they may become involved with international peacekeeping and peacemaking activities that have been sanctioned by the international community, usually through the mechanisms of the United Nations. They do not have the capability or capacity to initiate and sustain major war.

The major powers, especially the United States, China and Russia, as discussed in Chapter Two, are heavily invested in all facets of space activity to advance their economies, to strengthen their security and self-reliance and for purposes of research.

Middle powers are significantly less invested in space than the major powers.

3.1.2 What Middle Power Are

Beyond the question of capacity, mentioned above, is a question of behaviour. Do middle powers display similar behaviours on the world stage?

Research Fellow Eduard Jordaan has observed that:

> "All middle powers display foreign policy behaviour that stabilises and legitimises the global order, typically through multilateral and cooperative initiatives" (Jordaan, 2003).

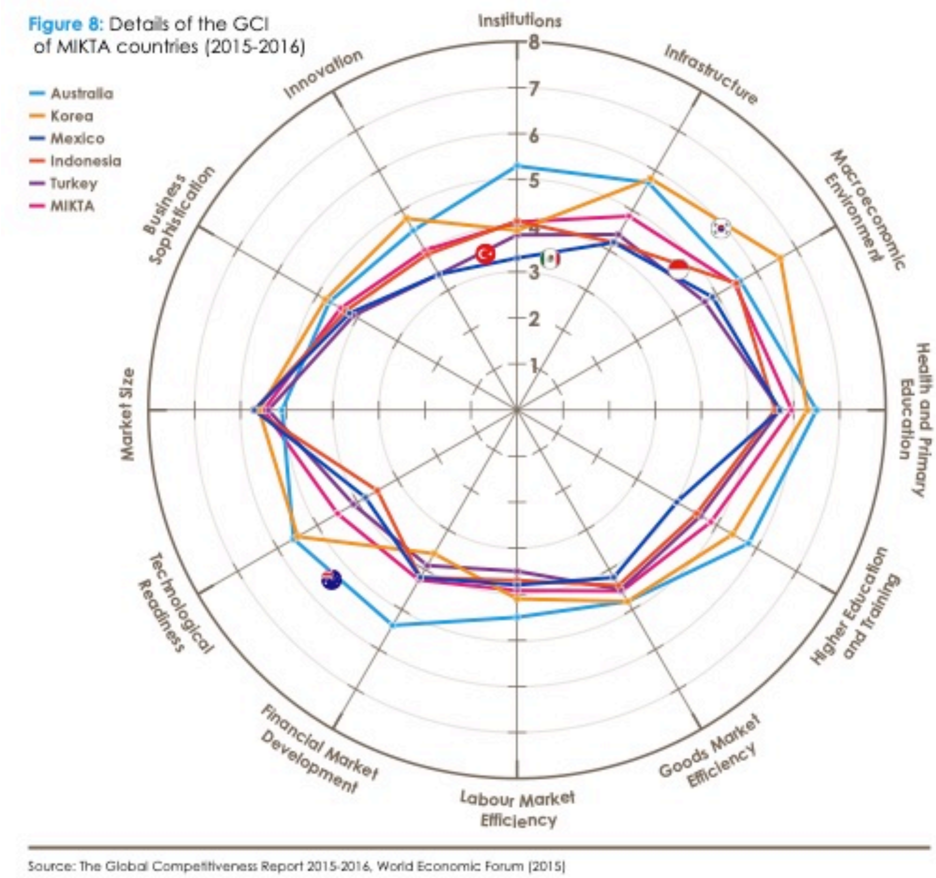
Outer space has fallen within the ambit of the United Nations as a domain of human activity since the late 1950s. The General Assembly of the United Nations passed its first resolution concerning the peaceful uses of outer space in December 1958 (Resolution 1348 (XIII)) at which an *ad hoc* committee was established to advise the General Assembly on how best the United Nations might assist with promoting human access to and use of space for peaceful purposes. Australia was represented on the *ad hoc* committee (UNOOSA, 2019b).

The role of middle powers in the space domain is varied and is discussed below through two sets of relationships. One is an informal linkage of states known as MIKTA – Mexico, Indonesia, South Korea, Turkey and Australia (DFAT, 2018a). The other is an assessment of the approach to space taken by Canada.

3.1.3 MIKTA

In 2013, the foreign ministers of a disparate grouping of the five nations comprising MIKTA, including Australia, agreed to meet regularly to discuss matters of common interest as middle powers. At first glance, this is an unlikely grouping of nations, given their different places in the world, histories, cultures, religious affiliations and domestic circumstances. However, on a series of indicators, they do share some similarities and equivalence as the Figure below suggests.

Figure 3.3. Details of the Global Competitive Index of MIKTA Countries (2015-2016) (reproduced from Flake & Wang, 2017, Figure 8).



The stated purpose of MIKTA is:

> "…to bridge divides in the multilateral system and build consensus on complex and challenging issues, drawing on the diverse perspectives of its members and their shared interest in an effective, rules-based global order.
>
> Since [2013] our exchanges have grown to encompass collaboration between academics, diplomats, journalists, parliamentarians, and experts in areas ranging from trade to international security, gender equality, governance and sustainable development" (DFAT, 2018a).

The MIKTA Vision statement, adopted in 2013 by the participating states, states in part:

> "We have both the will and the capability to contribute to protecting public goods and strengthening global governance. Working together, MIKTA can play a constructive role in the international agenda and exert greater influence" (MIKTA, 2013).

Ministers of the MIKTA nations have met regularly since MIKTA was created and other meetings and workshops have been held under MIKTA auspices as well (MIKTA, 2019).

A 2016 review of MIKTA, published by the Perth USAsia Centre, concluded that:

> "…these five nations have the capacity, will, and intent to influence global issues beyond their immediate regions – something which an uncertain world will certainly welcome" (Flake & Wang, 2017).

This desire to influence global issues stands in contrast to Holbraad's finding, noted above, that middle powers tend to look to exert influence in their immediate region. In an increasingly connected world, the distinction between at least some regional and global issues appears to be more theoretical than practical.

There is no evidence from a review of the MIKTA website that space security has been discussed, although informal conversations about the suitability of this topic for MIKTA consideration, were held in 2016 and 2017. The topic was not considered suitable because, according to Mexico's Ambassador to Australia at the time, MIKTA was a "work in progress" and no member wanted to set back MIKTA's development by pushing into areas that might prove to be controversial too soon. By inference, space was considered to be potentially controversial or divisive, at least by some MIKTA members (Biddington, 2017d).

As indicated in Chapter Two, determining what is and is not included in assessments of the amounts of money that countries allocate to space activities is difficult. In 2016, Mr Steve Bochinger, from Euroconsult, briefed a United Nations conference about the global space economy. Euroconsult is a company that specialises in space industry analysis (Euroconsult, 2019). Mr Bochinger presented one chart which listed the expenditure by governments on civil space programs in 2014. The amounts for the MIKTA nations, with Canada also included as a reference point, have been extracted from the Euroconsult data and are shown in the table below.

Table 3.1. Expenditure by Selected Nations on Civil Space Programs in 2014.

Country	US$m
Mexico	125
Indonesia	59
South Korea	459
Turkey	58
Australia	297
Canada	325

Source: Euroconsult, 2016. reproduced at http://www.unoosa.org/documents/pdf/copuos/stsc/2016/symp-01E.pdf.

Euroconsult did not explain the methodology adopted in reaching these figures.

Brief comments on the space activities of the MIKTA nations follow.

Mexico. In his 2013 monograph, *Space Policy in Developing Countries*, Robert Harding characterised Mexico as a third-tier space actor, the third tier being the lowest level in Harding's schema. Harding summed up the evolution of Mexico's space activities as "not smooth" (Harding, 2013, p. 155). He noted that Mexico established a space agency in 2010 with an initial operating budget of US$800,000 (ibid, p. 156). Since 2010, the space agency's budget has grown modestly and, in 2018 was in the order of US$6 million (Pesce, 2017).

The Mexican Space Agency hosted the 67th International Astronautical Congress in 2017. The Agency places considerable emphasis on skills development and in using space as a vector for STEM education (Volkov 2017).

***Indonesia*.** Harding (2013) characterises Indonesia as a third-tier space actor. He notes that Indonesia established a space agency in 1964 and has used satellites since the mid-1970s to provide reliable communications to many of the 17,000 islands in the archipelago. He also points out that the space agency (LAPAN is the anglicised acronym) maintains close ties to the Indonesian military. LAPAN operates several small remote sensing satellites to assist with disaster monitoring across the archipelago. LAPAN's budget has been in the order of US$20 million in the past. The Agency is reported to have asked for US$61 million in 2018 (Goh, 2017a).

South Korea (the 'K' in MIKTA). Of the five MIKTA nations, South Korea has the most highly developed and comprehensive space program. Harvey et al., in their monograph *Emerging Space Powers* (2010), devote a chapter to space developments in South Korea. Moltz, in his 2011 monograph, *Asia's Space Race*, does the same. Moltz states that South Korea's civilian space budget in 2009 was US$256 million which he described as a "potential limiting factor" to growth (Moltz, 2011, p. 148). Moltz concludes his chapter on South Korea with this passage:

> "…Seoul will be forced to "run faster" than its Asian competitors in space. For this reason, those elements of South Korea's space strategy aimed at integration, cooperation and efforts to prevent the emergence of aggressive foreign military activities seem most likely to serve its interests as a newly capably "middle" space power within Asia" (ibid, p. 157).

Turkey. Turkey has been involved in space activities since the late 1960s. Presently, Turkey operates some communications and Earth observation satellites and has ambitious plans to develop the ability to design and build its own satellites (Gurcan 2016). Yilmaz (2016), in an article in the *Open Journal of Political Science*, details Turkey's space journey. Yilmaz notes the ambition of Turkey to become more self-sufficient in space technologies and for a space agency to be established. He also acknowledges tension between civil and military space interests (Yilmaz, 2016). Gurcan also mentions civil/military disagreement in the context of his discussion about the need for a Turkish space agency (TUA):

> "Yet the bill has been delayed, once again because of major problems in determining how the military and civilians will share authority and responsibility. Arguments on the functions, relations with universities and the defense industry, and the budget might also help explain why Turkey has not been able to set up its TUA for 26 years" (Gurcan, 2016).

Gurcan, quoting Euroconsult, noted that Turkey spent US$67 million on civil space activities in 2013.

Australia. Figures presented in Table 3.1 above indicate that, of the five MIKTA nations, Australia spends more on civil space than do Mexico, Indonesia and Turkey and less than does South Korea. Australia's circumstances are detailed in later Chapters. In the present context, one obvious difference between Australia and the other MIKTA nations is Australia's alliance with the United States which, as noted in Chapter Two, has a vital space element.

All five MIKTA nations have mostly cordial relationships with the US and deal with the US on a range of issues, including, at times, thorny security issues. The existential threat that North Korea presents to South Korea is one example, another is the question of Kurdish autonomy on the border between Syria and Turkey and a third is the "Wall" that President Trump seeks to build along the Mexican/US border. Of the MIKTA nations, only Australia has a deep intelligence sharing relationship with the US.

In summary, the funds allocated by MIKTA nations for civil space activities are modest, especially in Mexico, Indonesia and Turkey. The focus of space investment of the MIKTA nations is on capabilities that are designed to strengthen economic security and broader national security, including satellite communications, remote sensing and education.

3.1.4 Australia and Canada

Reports and commentaries that have advocated for Australia to become a more active participant in the global space economy have made comparisons with the experience of Canada. A recent example is from a report produced in 2017 by a Sydney-based group called the GAP Space Taskforce:

> "Canada, a nation of comparable size, population and technological sophistication, generates CA$5.3 billion in annual space revenue, of which CA$1.6 billion come from exports – thanks, in part, to its associate membership of ESA. Overall, the space sector contributes CA$2.7 billion to Canada's GDP and supports over 24,000 jobs in the greater national economy" (GAP, 2017, p. 10).

The figures quoted by GAP above are drawn from the 2015 Euroconsult report that is the basis for Table 3.1 above (Euroconsult for CSA, 2015).

Another example is from a report prepared by Mr Gabriele Lania who was seconded to the space section of DefenceSA in Adelaide in 2016. His report, *An International Comparison of Space History, Policy and Industrial Capability,* concluded:

> "Perhaps the most suitable reference model for Australia is the Canadian one. Canada's geographic features are similar to Australia: a vast country with scattered population" (Lania, 2016).

The comparisons stop at this first order level of analysis and imply that Australia could and possibly should emulate Canada's experience because of the high-level similarities between the two nations. The question that has not been asked is why these similarities have not translated into similar space sector development trajectories, but, instead, have been so different.

The Canadian Space Agency (CSA) was established on 1 March 1989 (CSA, 2018a). Australia's agency only stood up in 2018. Canada is an associate member of ESA, which is said to allow Canada access to space technologies that are not available to Australia (Biddington, 2019b). Australia, as is discussed in Chapter Six, has been invited to join ESA as an associate member and has respectfully declined these invitations (Dougherty, 2017). Canada has participated in upstream elements of US human spaceflight programs, the robotic arm, known as the Canadarm, on the Space Shuttle is a celebrated example (CSA, 2018b), and Canada has supplied a steady flow of astronauts to the International Space Station (CSA, 2018c). Two Australian-born men have flown in space; both became US citizens to do so (Burgess, 1999). Canada has some well-established space companies (Euroconsult for CSA, 2015). Australia does not. Canada has built and operates a suite of capable satellites, notably RadarSat 1 (now inactive) and Radarsat 2 (CSA, 2014). Australia, although it has access to RadarSat data, has no comparable industry capability.

Canada's location to the immediate north of the United States helps to explain the different space sector development pathways taken by Canada and Australia. Two points seem especially pertinent.

- During the Cold War, Canada's very existence was tied to that of the US and vice versa. The North American Air Defence Command (NORAD) is a combined American/Canadian organisation that was formed in 1957 with antecedents that developed in World War 2 (NORAD, 2013). As its name suggests, NORAD was integral to the defence of continental North America, embracing both Canada and the United States. Sensors in northern and central Canada provided early warning in the event of Soviet air and missile attacks against the United States and Canada from the earliest days of the Cold War (ibid). The growth of the Canadian space sector indicates that defence and civilian activities were interleaved (CSA, 2018a). This stands in contrast to Australia's experience where military and civil space activities were bifurcated as will be discussed below in Chapters Four and Five. In summary, the fundamentals of Canada's threat environment, including threats from space, and its security responses have been quite different to those faced by Australia.

- The space industry sectors of the US and Canadian economies are closely integrated (Euroconsult for CSA, 2015). A Canadian developed sensor was launched from the US in 1960 and Canadian components were on the Apollo moon lander. There is a long-standing history of cross-border space industry cooperation. Proximity would seem to have worked to the advantage of Canadian companies (CSA, 2018a). There is no equivalent Australian experience.

Those who encourage Australia to emulate Canada's commitment to space activities do so on the basis of similarities, including geographical similarities. Overlooked is that the different space development trajectories of the two nations may also be explained by geography and its intersection with Cold War politics. Canada's proximity to the United States led to a common nuclear defence and to an integrated space economy. Australia's location led to ground stations being hosted that were vital to the nuclear defence of the United States and to civil space activities, including the Apollo Program, that was of immense symbolic importance in the Cold War. The equipment installed in the ground stations located in Australia was designed and built in the United States and flown in to Australia. There was no incentive or imperative for a local industry to develop.

Synchronised or collective approaches by middle powers, including Australia, on international issues of importance, in principle, can amplify or add weight and legitimacy to the arguments they might put. One Canadian study, however:

> "…tentatively concluded that the collective influence of the middle powers . . . had not been commensurate with either their capabilities and their stakes [because] they have rarely acted in concert . . .in pursuit of shared goals" (Wood, 1987).

Summarising this section, middle powers do have shared characteristics in terms of their size and influence. With respect to space activity, they behave in similar ways through a general commitment to uphold the international rules-based order whilst also pursuing their individual sovereign interests. This does not necessarily differentiate them from many other states that are both larger and smaller. Evidence of concerted space diplomacy, by Australia and other middle powers, working together, is limited.

3.2 The Influence of Middle Powers

The purpose of this Section is to determine whether the status of being a middle power bestows any benefit or authority on nations to which the middle power moniker is applied. Do middle powers have access to sources and processes of influence not available to larger powers on the one hand and to smaller and weaker powers on the other?

The first part of this section asks whether the actual status of being a middle power confers influence, in general terms, in the international system. The second part considers whether middle power status confers particular or special influence in international discussions about space security.

3.2.1 Middle Power Status in General

Hedley Bull was a highly regarded Australian international relations scholar. One of his most influential works is *The Anarchical Society: A Study of Order in World Politics* (Bull, 1977). The title is paradoxical. How can any set of relationships be simultaneously anarchical and orderly? Bull looked beyond treaties, laws and regulations that can be difficult if not impossible to enforce in the international domain to norms and unwritten rules by which nations choose to abide. Middle powers help to reinforce and uphold norms in the knowledge that a stable system generally serves their selfish interests better than does a system that is unstable and contentious (ibid).

Gilley and O'Neil hypothesised that middle powers display three behavioural dimensions outlined in the table below.

Table 3.2. Three hypothesised behavioural dimensions of middle powers.

Security	• Peace initiatives • Conflict mediation roles
System	• Counterhegemonic • Pro-multipolarity • Uniting for consensus
Rules	• International institutions and processes • Rules-building and adherence • Regional institutions

From Gilley & O'Neil (eds), 2014, p. 13, Figure 1.2)

The behaviours listed in the table imply support for the institutional framework and informal arrangements and understandings that emerged after World War 2. Middle powers serve to ease the friction at those points where the tectonic plates of the great powers intersect (Gilley & O'Neil (eds), 2014).

More formally, roles that middle powers can, and do, play in international affairs include:

- Acting as conduits and even informal mediators between the major powers, drawing on extensive diplomatic experience to remain impartial and fair-minded.
- Bringing a moral or ethical dimension to bear on the realpolitik considerations of the major powers by pointing out how struggle between the great powers, unless mitigated and mediated, may hurt the innocent bystanders - the small and middle powers (Gilley & O'Neil (eds), 2014).

3.2.2 Does Concerted Action Work?

Australia and Canada emerged from World War 2 on the side of the victors. Both nations took an active role in the San Francisco conference that settled the Charter and organisational details of the United Nations and its related institutions. Both countries argued for special recognition and involvement in the international security fabric that eventually emerged because of the blood and treasure they had invested in helping to win the war and make the peace. (Chapnick, 2005) The great powers of the day ignored these arguments and neither country succeeded in being granted any favoured status (ibid).

At the San Francisco conference Australia earned the reputation as the leader of the middle powers and Dr Evatt, Australia's chief negotiator, was singled out for praise as the "great champion of the smaller nations" (ibid, p. 143).

Another example of medium (and small) powers acting in concert to achieve a desired common result comes from the Third United Nations Law of the Sea Conference (UNCLOS) that met over a period of nine years from 1973-1982. The Law of the Sea Convention (LOSC) was concluded successfully in 1982 and came into force in 1994. The question in UNCLOS was how to account for the interests of the landlocked and geographically disadvantaged states; the LLGDS as they became known.

Rothwell & Stephens (2010), in their detailed commentary on the LOSC state that the "specific interests" of LLGDS "received serious and detailed consideration," because they were "able to form a negotiating bloc" that advanced their "collective interests" in the three UNCLOS committees. Further:

> "The Group of LLGDS numbered 55 states, over a third of the participating states, and therefore wielded considerable influence because under the UNCLOS Rules of Procedure such a 'blocking third' could veto proposed rules" (ibid, p. 190).

Rothwell & Stephens also noted that:

> "The Group of LLGDS at UNCLOS III was remarkable in so far as it brought together a diversity of developed and developing states such as Switzerland and Nepal, all of

> which had limited or no access to the sea but otherwise shared little in common". (ibid, p. 190).

Rothwell & Stephens concluded that the LLGDS enjoyed "few hard and fast guarantees under the LOSC" (ibid, p. 190). In summary, the cooperative behaviour of the LLGDSs helped their cause but was not decisive.

These examples suggest that when middle (and small) powers work together, they can achieve outcomes not likely to have been achieved had they acted alone. However, even when acting in concert, middle powers lack the capacity to change the basic architecture or structure of the system. They can, however, improve these structures in ways that are accepted as helpful and legitimate. Middle and small powers in 1948 in San Francisco achieved improvements to the UN Charter. In UNCLOS III, a similar result was achieved with an entire section, dealing specifically with the interests of the LLGDS, being added to the LOSC (ibid, p. 190).

3.3 Middle Power Levers and Space

This section is a discussion about the approach that middle powers take to space policy development and space investment decisions. Can general principles or modes of behaviour be discerned that are common to middle powers in regard to space? Do middle powers act in concert, within the international community, to make the space environment more secure in the interests of all humanity? Or, are their endeavours dedicated to the achievement of more narrowly defined national objectives? These questions are discussed in this section. First is a discussion about divergent, perhaps irreconcilable views of the legal standing of outer space and what nations lawfully may and may not do in outer space.

3.3.1 Spacepower and the Global Commons.

The exercise of political power in outer space, as in every other domain of human activity, has two faces like the Roman god, Janus (Duverger, 1966). One face points to the achievement of self-interested ends through cooperative and collaborative activities. Shared objectives, negotiation, discussion and compromise characterise these activities. Altruism need not be a driver although others may derive benefit as a corollary or consequence of such activities. The second face points to competition, conflict and the more or less naked threat of force by an actor to enforce compliance by others (ibid). James Oberg in *Space Power Theory*, published in 1999, in a discussion about space warfare, drew the distinction thus:

> "At its core, the notion of weapons in space pits military pragmatists against idealistic futurists . . . It is a conflict between those that espouse the immutable nature of human beings against those that believe they are slowly, but definitely and

> irreversibly, moving toward an era of greater cooperation and unity: it is the idealists versus the realists . . ." (Oberg 1999, pp. 146-7).

Joan Johnson-Freese is a professor at the US Naval War College, Newport Rhode Island. She has published extensively about US space policy. In her 2017 monograph *Space Warfare in the 21st Century: Arming the Heavens*, Johnson-Freese argued that a more nuanced spectrum than the dichotomy presented by Oberg has emerged. Writing from a US perspective, she identifies four schools of thought along a continuum:

- US reliance on space for both military and civilian purposes is so great that space dominance is essential. Space represents the ultimate high ground.
- Weaponisation is simply inevitable and the United States would be remiss not to prepare.
- Space is important militarily but there should be limits to militarisation.
- Finally, there is the space sanctuary school that argues for space to be accorded an international status like that of Antarctica (Johnson-Freese, 2017, p. 57).

Writing 15 years earlier, Everett Dolman, a professor at the US Air Force Air War College in Maxwell, Alabama, published *Astropolitik: Classical Geopolitics in the Space Age* (Dolman, 2002). Dolman explains that he chose the title *Astropolitik* to be provocative, to focus on the geography of space and its importance to the ambitions of nations, notably the great powers. In drawing attention to the realpolitik of space he expressly acknowledged the dangers inherent in any "geopolitical-based *Realpolitik* strategies of dominance" (Dolman, 2002, p. 3). The ultimate purpose of *Astropolitik* would seem to be to demonstrate that American dominance in space is in the interests of all humanity and, ultimately, is a force for good. Dolman proposes a three-step strategy that would have the US shatter the present international treaty regime for outer space and would assert US primacy in LEO through military means. Space would:

> "…transition to an *Astropolitik* regime and ensure that the United States remains at the forefront of spacepower for the foreseeable future" (Dolman, 2002, p. 158)

Dolman insists that, at every turn, human endeavours in space have been driven by competition and competitive behaviour and not by a desire for cooperation.

About the Outer Space Treaty (OST), the key principles of which were outlined in Chapter Two above, Dolman writes:

> "The highly touted international cooperation that produced the 1967 Outer Space Treaty was not in truth evidence of a newly emerging universalism; rather it was a reaffirmation of Cold War realism and national rivalry, a slick diplomatic manoeuvre that both bought time for the United States and checked Soviet expansion" (Dolman, 2002, p. 8).

The Latin phrase *res communis* (common heritage of humankind) provides some guidance but its meaning is contested and has been subject to interpretation and re-interpretation over time (Dolman, 2002). This point is developed below in context of the Moon Treaty.

A further difficulty with any commons is the disjunction that can occur between rational self-interest and the common good. The former speaks to the maximisation of individual benefit and the latter to environmental and societal sustainably; the optimisation of benefit to a broad community over time. Garret Hardin captured the essence of this argument in his classic paper, *The Tragedy of the Commons* (Hardin, 1968). Critics of Hardin, such as Beryl Crowe, argued that technology would solve the scarcity problem that lies at the heart of Hardin's argument (Crowe, 1969).

3.3.2 Space Treaties, Regulations and Norms

The international legal framework for outer space was established in the 1960s. There are five treaties and a series of additional principles, resolutions and other instruments that have been endorsed by the United Nations.

Of the five treaties, the first, commonly known as the Outer Space Treaty (OST), is the most important. As noted in Chapter Two the OST enshrines a set of principles to which States that have signed the treaty agree to adhere when conducting activities in outer space.

The core principle in the OST is that human activity in outer space is restricted to peaceful purposes for the benefit of all humanity. As noted already, precisely what this principle means, when the question of application arises, is not always clear.

The Treaties are:

- The *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies* [the 'Outer Space Treaty', adopted by the General Assembly in its resolution 2222 (XXI)], opened for signature on 27 January 1967, came into force on 10 October 1967, 107 ratifications and 23 signatures (as of 1 January 2018);

- The *Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space* [the "Rescue Agreement", adopted by the General Assembly in its resolution 2345 (XXII)], opened for signature on 22 April 1968, came into force on 3 December 1968, 96 ratifications, 23 signatures, and 2 acceptance of rights and obligations (as of 1 January 2018);
- The *Convention on International Liability for Damage Caused by Space Objects* [the "Liability Convention", adopted by the General Assembly in its resolution 2777 (XXVI)], opened for signature on 29 March 1972, came into force on 1 September 1972, 95 ratifications, 19 signatures, and 3 acceptances of rights and obligations (as of 1 January 2018);
- The *Convention on Registration of Objects Launched into Outer Space* [the "Registration Convention", adopted by the General Assembly in its resolution 3235 (XXIX)], opened for signature on 14 January 1975, came into force on 15 September 1976, 67 ratifications, 3 signatures, and 3 acceptances of rights and obligations (as of 1 January 2018);
- The *Agreement Governing the Activities of States on the Moon and Other Celestial Bodies* (the "Moon Agreement", adopted by the General Assembly in its resolution 34/68), opened for signature on 18 December 1979, came into force on 11 July 1984, 18 ratifications and 4 signatures (as of 1 January 2018).

The texts of the treaties and further details are available on the UNOOSA website (UNOOSA, 2019a).

The fifth agreement, known commonly as the Moon Treaty, has not attracted the broad support of the four earlier treaties. It has not been ratified, by any of the major space powers. Australia, Mexico and Turkey are three of the 18 nations to have ratified the Treaty (UNOOSA, 2019c).

According to Dolman, the Moon Treaty re-interprets the definition of *res communis* from meaning ‘equal access’ to meaning ‘equal benefit’ (Dolman, 2002, pp. 100-101). A US Senate Committee considered the treaty and noted a series of issues including that it may discourage commercial investment in space by creating uncertainty around the meaning and application of the ‘common heritage’ principle (USG, 1980, pp. 78-80). Did the ‘equal benefit’ definition of *res communis* mean that profits from mining the Moon and other celestial bodies, for example, should be shared amongst all people and nations and not confined just to those entrepreneurs and pioneers who took the risks and made the capital investments? The question is unresolved.

The Moon Agreement came into force in 1979, more than a decade after the Outer Space Treaty in 1967. Freeland has noted that many new countries had come into being in this period because of decolonisation and that numerous developing nations were demanding their share of bounty of the commons, whether in space or in the oceans and irrespective of how or by whom these commons would be developed (Freeland, 2019). In the 40 years that have passed since the Moon Agreement was signed the Soviet Union has collapsed, China has emerged as a near peer competitor to the United States and there have been enormous advances in computing and other technologies relevant to space exploration and space development. Freeland's view is that humanity has the wit to create a scheme that would distribute benefits generated by mining or related activities on the Moon equitably (Freeland, 2019). The legal question to be addressed is the principle of non-appropriation which is stated in Article 2 of the Outer Space Treaty:

> "Outer space, including the Moon and other celestial bodies is not subject to national appropriation by any claim of sovereignty, by means of use or occupation, or by any other means" (UNOOSA, 2019a).

Article 11 of the Moon agreement repeats the principle of non-appropriation, with specific reference to the Moon, word for word (UNOOSA, 2019a).

There is provision in the Moon Agreement for a conference to Review the efficacy of the Agreement. Australia acceded to the Moon Agreement on 7 July 1986 (CPD, H of R, 1986), although literature explaining the decision has not been found. Freeland's has expressed the view that Australia, being one of the larger powers to have ratified the Moon Agreement, would be well-placed to play a prominent role in such an activity (Freeland, 2019; Listener, 2011).

3.3.3 Stalled Initiatives

Within the United Nations, responsibility for space matters is split between two of the main committees of the UN General Assembly (UNGA). The First Committee (Disarmament and International Security) considers space security matters and is advised by the Conference on Disarmament (CD), based in Geneva. The Fourth Committee (Special Political and Decolonisation), considers the humanitarian aspects of space and is advised by the Committee on the Peaceful Uses of Outer Space (COPUOS) (UN, 2019). The First Committee and the CD are concerned with disarmament and with preventing warfare and the proliferation of weapons, including in space. The Fourth Committee and COPUOS are concerned to ensure that space remains open and accessible to all of humanity under rules and norms that are universally accepted and adhered to.

The international community continues to struggle to reconcile the dichotomy that exists between realist and liberal perceptions of human behaviour in space. Within the UN, in 1985, an *ad hoc* committee of the Conference on Disarmament (CD) was established to consider how to prevent an arms race in outer space (PAROS). The *ad hoc* committee made little progress and has not met since 1994 (NTI, 2017). In 2008, Russia and China proposed a new space treaty to complement the Outer Space Treaty that, they claimed, was designed to prevent the placement of weapons in outer space. The draft, called a *Treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects* (PPWT), was rejected by the United States. The basic objection was that the treaty was not capable of being verified. The CD operates on the principle of consensus and the United States has simply blocked negotiations and refused to allow the draft treaty to proceed, assessing that to do so would compromise its ability to defend and advance its vital interests in outer space (Huntley, 2009 p. 147).

Russia and China reintroduced the PPWT into the CD in 2014 to provide a legally binding form of regulation that stood in contrast to the non-binding International Code of Conduct (ICoC) in space, discussions around which had gathered momentum in the previous years (Beard, 2016). The ICoC was initially proposed to the international community by the European Union (EU) in 2008 (SWF, 2014a). It gathered support and its work was paralleled by a Group of Government Experts (GGE) on Transparency and Confidence Building Measures (TCBM) that was established under UN auspices in 2011 (SWF, 2014b). The GGE provided its report to the Secretary General of the UN in July 2013 (UNOOSA, 2013). This report made a series of recommendations that summed to encouraging all states to adhere to the treaties and other instruments already in place and to be more explicit in disclosing their space activities to the international community (UNOOSA, 2013, pp. 21-22). The GGE also recommended that a joint session on TCBM in space be held between the First and Fourth Committees on the UNGA. The first joint session, which was unprecedented, was held in 2015 and a second was held in 2017 (UN, 2018).

The ICoC made progress until 2015 when, at the United Nations in New York, Russia and China, with the support of some smaller states, including Brazil, India and South Africa, as well as nations from the Non-Aligned Movement (NAM), essentially killed the initiative (Listener, 2015; Meyer, 2015; Krepon, 2015). Australian officials participated in the ICoC discussions and expressed private disappointment at the 2015 outcome noting how the spirit of cooperation between the United States, Russia and China that had characterised earlier meetings had soured. (Biddington, 2015).

Listner and Rajagopalan have suggested that the principal reason for Russia and China introducing a revised draft of the PPWT in 2014 was to:

> "…to breathe life into the Conference of Disarmament, preserve their soft-power advantage among third-world nations in the UN, and to take the spotlight off the ICoC and the effort to utilize transparency and confidence-building measures in the Group of Government Experts to address outer space security issues" (Listner & Rajagopalan, 2014).

The effect of these diplomatic manoeuvrings is that both the ICoC and the PPWT would seem to be dead in the water at a time when the orbital space environment especially, would seem to be coming under increasing pressure as more states launch more satellites, leading to increased political and physical risks (the prospect of collisions and radio frequency interference).

3.3.4 Other Agreements, 'Soft Law' and Norms

In addition to the five main treaties there are 11 further instruments that the United Nations considers relate to the regulation of outer space (UNOOSA 2019a). One of the most important relates to the International Telecommunication Union (ITU) which, as was referred to in Chapter Two, allocates radio spectrum to satellite operators across the world. Through this mechanism, the ITU, *de facto*, allocates the location of satellites in orbital space, especially slots above the Equator that satellites occupy in GEO. This is a highly technical activity as indicated by the complexity of the space services area of the ITU website (ITU, 2018).

Beyond these instruments are further guidelines, resolutions and protocols some that relate specifically to outer space and some that have more general application but include or embrace space activities. The Guidelines that have been adopted by the UNGA to minimise the rate of growth of space debris are an example of the former (UNOOSA, 2019a). Three examples of the latter are:

- The Wassenaar Arrangement is an export control regime that seeks to, "promote 'greater responsibility' among its members in exports of weapons and dual use goods and to prevent 'destabilizing accumulations'" (ACA, 2017a).

- The Missile Technology Control Regime (MTCR) is an export control regime that "aims to limit the spread of ballistic missiles and other unmanned delivery systems that could be used for chemical, biological, and nuclear attacks" (ACA, 2017b).
- The International Code of Conduct Against Ballistic Missile Proliferation (ICOC) is also known as the Hague Code of Conduct (HCOC). This has been described as a "political initiative aimed at globally curbing ballistic missile proliferation" (ACA, 2002).

Australia is a signatory to these agreements. With respect to ballistic missiles, the position of the Australian Government, summarised on the website of the Department of Foreign Affairs and Trade, is clear:

> "The development and proliferation of cruise and ballistic missiles, in particular long-range missiles, is of great concern to Australia and many other countries. Missiles with a range of 300km or greater, capable of carrying a load weighing 500kg or more, are suitable vehicles for the delivery of weapons of mass destruction (nuclear, biological or chemical weapons). Missile development and proliferation destabilises regional security, particularly in areas of tension, with flow-on effects for global security" (DFAT, 2019a).

The development by China and North Korea of long-range missiles in the context of broader geostrategic developments, has caused concern in Australia, leading some commentators to call for Australia to develop a missile defence capability (Benson, 2017). These concerns are discussed in the next section of this Chapter.

Nation states agree to be bound by the international agreements they make to the extent that it suits their interests; interests that may vary over time and in response to changing domestic and international circumstances. The legal regime provides a foundation or context for the creation of behavioural norms by which state and non-state actors abide.

Why nation states seem mostly to abide by the international agreements to which they are party is an active conversation among international lawyers. A comprehensive discussion is in a paper written in the Yale University Law School in 1997 by Harold Koh. Koh argued that the answer lay in the nature of the concept of obedience which contains moral, normative and legal elements (Koh, 1997). This conclusion speaks to the concept of legitimacy and a positive desire to obey rather than the idea of obeying for fear of the consequences of not obeying.

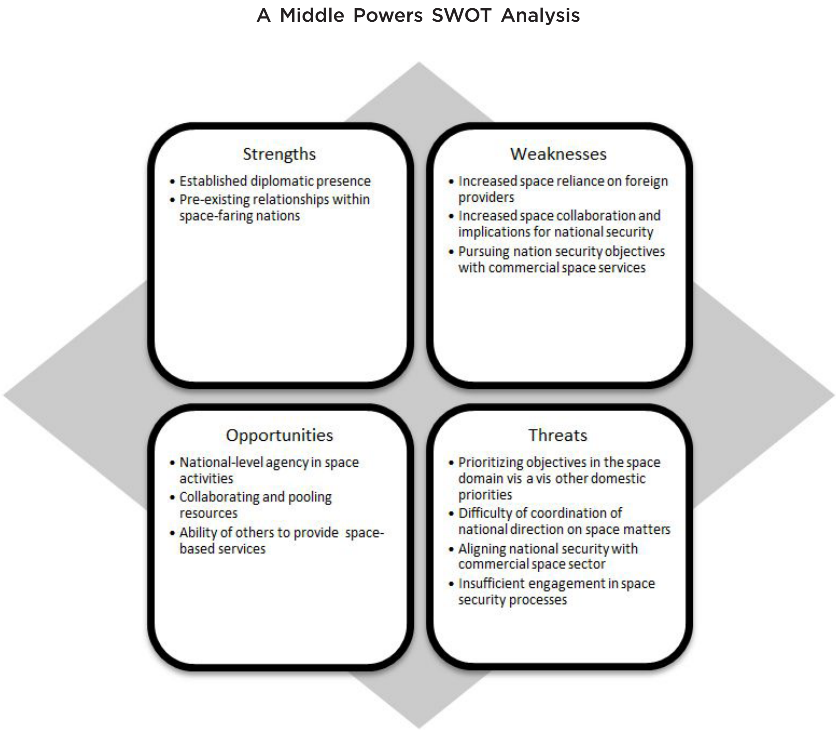
Another paper, written by Downs and Jones (2002), maintains that reputational concerns are the principal mechanism that leads to high levels of compliance with treaties.

Leaving aside the question of motivation and the shortcomings of the treaties the major space powers have broadly adhered to the normative framework and legal regime that was established in the 1960s and 1970s to guide, if not regulate, human activities in outer space (Lele, 2017). This comment applies equally to some of the ‘soft law instruments, such as the Wassenaar Arrangements, which elicit high levels of compliance. Some commentators argue that the elements of some of these instruments have gained such wide acceptance that they have obtained customary law status.

In 2015, the UN Institute for Disarmament Research (UNIDIR) published a study with the title *The Realities of Middle Power Space Reliance* (UNIDIR, 2015). The key part of the study was an analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) that middle powers possess or face in determining their dependence on data and services from space and their approaches to space security. The results of the SWOT analysis in the UNIDIR report are summarised, in general terms, in the figure reproduced on the following page.

The results indicate that there is no single attribute that middle powers bring to space utilisation and space governance; rather they bring a cluster of attributes, not all positive, that need to be balanced and assessed on a nation by nation basis.

Figure 3.4. A Middle Powers SWOT Analysis (from UNIDIR, 2015, p. 8).



The UNIDIR report concluded that:

> "Space Middle Powers can play a critical role in shaping future global direction on space security. Our research highlighted the importance of understanding what level of resilience is needed and how to work towards that through national and international policy mechanisms. For middle power States specifically, with their high degree of space reliance, such an understanding of the true picture of national equities in space and how current international space security processes, and other political developments, may affect them is critical" (UNIDIR, 2015, p.31).

Teresa Hitchins is a globally-respected voice in arms control, space security and space policy. In 2017, she addressed a conference in Canada on global space governance from the perspective of what middle powers might do to promote the cause of space security. Her suggestions followed from the report of the Global Governance Experts (UNOOSA, 2013) and are consistent with the UNIDIR report. They included:

- To establish contacts and focal points in government and industry that would provide reports to the UN General Assembly and to COPUOS;
- To characterise and socialise the application of international law applicable to military uses of space. She cited a collaborative arrangement between McGill

University and the University of Adelaide to develop a manual of international law applicable to military uses of outer space.

- To call a preparatory meeting, ahead of a larger gathering planned for 1-4 October 2017 (Hitchins, 2017).

She concluded that there was a vacuum in leadership on space governance which she asserted could be filled by middle powers, citing Australia, Canada, Germany and the United Kingdom as being in a position to take on such a task (Hitchins, 2017).

The discussion above indicates that medium power status and overall capability may confer standing in international discussions about space security. Just how much remains an open question.

3.4 Australia's Contribution to Space Security as a Middle Power

The third section in this Chapter asks whether any contribution that Australia may make to space security derives from its status as a middle power, or whether such influence as it may have, is conferred by other factors?

Australia played an active role in establishing the international legal order for space. From 1962-1995, the first thirty-three years of its existence, an Australian chaired the Science and Technology Committee of COPUOS – Professor David Martyn from 1962 to 1970 (Home, 2000), was succeeded by Professor John Carver from 1970 to 1995 (Crompton et al., 2011). Australian involvement in COPUOS and other intergovernmental space forums fell away in the 1990s but revived early in the current century. Australia was represented in the ICoC negotiations and is now routinely represented in the major meetings of COPUOS (DFAT, 2018b).

Australia's involvement in space security and space governance occurs within the context of broader foreign and defence policy aims and ambitions. These are designed to address the sum of Australia's relationships with near neighbours, the wider region and the world (DFAT, 2017b; DoD, 2016b).

Of special contemporary concern to Australian policymakers are rapidly changing global power relationships, notably between China, Russia and the United States.

Hugh White is a professor of strategic studies at ANU and a prominent strategic thinker. He was previously a senior Defence official and was the principal author of Australia's 2001 Defence White Paper. In 2010, he wrote an extended essay, called *Power Shift: Australia's Future Between Washington and Beijing* (White, 2010). The essay was controversial because it

questioned the fundamental tenet of Australia's foreign, defence and security policies – Australia's close alliance with the United States. White asked whether Australia's long-term security interests would continue to be best served by the alliance. He argued that American influence in the Asia Pacific region would inevitably wane as Chinese power and influence increased. The questions for White were whether the power shift could be achieved peacefully and what were the consequences of the power shift for Australia.
White argued that five alternatives were open to Australia as the security competition in Asia became more intense. Australia could:

> "…remain allied to America, seek another great and powerful friend, opt for armed neutrality, build a regional alliance with our Southeast Asian neighbours, or do nothing and hope for the best" (White, 2010, p. 60).

White is not the first or only scholar to ask questions about how Australia might best secure its long-term interests in a rapidly changing region and world as China becomes more powerful and assertive. Coral Bell, for example, wrote in 2005 that:

> "Spectacular as China's economic successes have been, they aren't the only reason for a widespread assumption that it's the natural (almost inevitable) hegemon of East Asia. The US may go away sometime; China won't" (Bell, 2005, p. 35).

In the latter part of 2017, White published a second extended essay, *Without America: Australia in the New Asia* (White, 2017). Whereas in 2010 White argued that the United States had choices and options, in his 2017 essay he argued that the game was effectively over, and that the US had relinquished its dominant position in the Pacific and is now in retreat. In White's view the rapidly changing power balance in the Pacific adds to the urgency for Australia to determine a path in the region and the world that acknowledges that the United States is less committed to its Asia Pacific alliances than ever before, leaving Australia with no option but to pursue more independent foreign, defence and security policies.

White made no specific reference to space in either essay. However, as noted in Chapter Two and expanded upon in later chapters, space security sits at the heart of Australia's alliance relationship with the United States.

In contrast to White's position, that of the Australian Government, as indicated in formal documents, including the Defence White Paper of 2016 and the Foreign Policy White Paper of 2017, has been to reiterate the strength and importance of the US Alliance. The Defence White Paper (DWP) states:

> "A strong and deep alliance is at the core of Australia's security and defence planning. The United States will remain the pre-eminent global military power and will continue to be Australia's most important strategic partner" (DoD, 2016b, p. 15).

The 2016 Foreign Policy White Paper was equally unequivocal:

> "Our alliance with the United States is central to Australia's approach to the Indo–Pacific. Without strong US political, economic and security engagement, power is likely to shift more quickly in the region and it will be more difficult for Australia to achieve the levels of security and stability we seek. To support our objectives in the region, the Government will broaden and deepen our alliance cooperation" (DFAT, 2017b, p. 4).

These same documents stress the importance of Australia's trading relationship with China and of Australia's commitment to the international rules-based order. They are clear that Australia welcomes a strong and prosperous China as a member of the community of nations that plays by the established rules and not by the implied or direct use of force as has been seen in recent years in the East and South China Seas.

Australia is heavily invested in ensuring that the United States and China do not fall into war as a consequence of the conflict that arises, axiomatically, between the *status quo* power and a rising power. This concept is encapsulated in the phrase "Thucydide's Trap" which refers to the wars between Athens, the *status quo* power and Sparta the rising power in the 5th Century BCE. How the United States and China work together in space may well determine whether they avoid Thucydides's Trap (Allison, 2017). To quote James Steinberg and Michael O'Hanlon in their 2014 monograph *Strategic Reassurance and Resolve: U.S.-China Relations in the Twenty-First Century*:

> "One of the greatest dangers to long-term stability in U.S.-China relations is the growing threat of conflict involving space. Each side is increasingly dependent on space-based assets, both as part of its national security and for economic activities. Yet [they are] tempting military targets at the outset of a conflict" (Steinberg & O'Hanlon, p. 167).

What opportunities exist for Australia, as a middle power, to strengthen the space security regime in its selfish interest as well as the broader interests of other nations and humanity more generally? The answer is approached by referring to the SWOT analysis discussed in the previous section and shown at Figure 3.4. It is used as a model. The points under each quadrant of the model are discussed regarding Australia's specific circumstances in the Table that follows.

Table 3.3. Middle Powers SWOT Analysis with Respect to Australia.

	From the Model	Australian Experience	References
Strengths	Established diplomatic presence	Acknowledged as a leader of and advocate for middle powers in the formation of the UN	Chapnick, 2005.
		Ranked 6th in diplomatic influence in the region behind China, the USA, Japan, India and Russia	Lowy, 2018a.
	Pre-existing relationships within space-faring nations	Historically close security relationship with the USA of which space is a vital element – host ground stations	Ball, 1980.
		Hosts ground stations for NASA, ESA, assists JAXA (eg. Hyabusa return)	Dougherty, 2017.
Weaknesses		**Being addressed by:**	
	Increased space reliance on foreign providers	Considered an acceptable risk for many years in communications and remote sensing	DITR, 2004.
		(Note: that all nations depend on GNSS provided by the US, Russia, China, Europe, Japan and India)	
	Increased space collaboration and implications for national security	Hosts SSA sensors that contribute to USAF SSN	Beazley, 2016.
		Recent agreements with French, UK and Canadian space agencies	Andrews, 2018a.
		Recent agreements with European companies	Andrews, 2018b.
	Pursuing national security objectives with commercial space services	Shared satellite with Optus, hosted payload on Intelsat 22, purchased satellite #6 to compete USAF WGS Constellation	See Chapter 4.
Opportunities		**Being pursued by:**	
	National-level agency in space activities	Australian Space Agency created on 1 July 2018	Cash, 2018a, b and c.
	Collaborating and pooling resources	Evidence especially between relevant government agencies – GA, BoM and CSIRO and DST Group and universities	See Chapter 8.
	Ability of others to provide space-based services	Nascent space industry sector in Australia has emerged in past decade	GAP, 2017.
Threats		**Being addressed by:**	
	Prioritising objectives in the space domain vis-a-vis other domestic priorities	Opportunity costs have militated against government in a civil program in the past – no evidence of change	See Chapter 4.
			Senate, 2008.

	Difficulty of coordination of national direction on space matters	Problem in the past, the space agency has been established specifically to address this problem	
	Aligning national security with commercial space sector	These two sectors remain bifurcated. The Agency Charter suggests that government is aware of the problem	DIIS, 2018d.
	Insufficient engagement in space security processes	Australia represented on the Group of Government Experts due to report to the UN Secretary General in 2019	DFAT, 2018c.

The UNIDIR report observes that:

> "…the Australian Satellite Utilisation Policy has made two key policy-related decisions which codify the way in which the government will determine external partners and partnerships:
>
> - Maintain a system of export controls that, consistent with Australia's international trade and counter-proliferation obligations, facilitates trade in space-related goods and services while regulating trade that raises national security sensitivities.
> - Maintain foreign investment regulatory frameworks that ensure investment in space-related infrastructure is consistent with Australia's national security interests.
>
> In these two decisions, Australia has tethered the pursuit of external partners to national security and existing policy realities" (UNIDIR, 2015, pp 28-29).

Export controls are designed to limit access to markets. The observation also indicates that Australia's principal interests in space relate to security.

3.5 Chapter Summary

The middle power concept appears nebulous. It appears to have descriptive value, as a simple way of describing a group of states that are neither global powers nor small and of limited global influence. There appear to be no clear-cut definitions about what constitutes a middle power and what does not. Most, if not all, are members of the G-20 group of nations – falling in the bottom half of that group in terms of the sizes of their economies. All middle powers have a stake in the international rules-based order which brings with it an obligation to work to take reasonable steps to uphold that order for purposes of national self-interest. The mechanisms that states use to balance their interests one to the other, such as the UN and its agencies are used by middle powers to achieve influence. The informal association of states known as MIKTA, of which Australia is a member, indicates that the middle power moniker applies to states of diverse histories, cultures and geographies. Canada is a middle power that is often compared to Australia because of the large size and small populations in both countries. The space journeys of these two nations are quite different in terms of their outcomes. Both have been influenced by their security relationship with the United States leading to different outcomes. Canada, next door, and Australia, an ocean away, have contributed to the security of the United States in quite different ways but consistent with their own desire for alliance with the United States.

Australia's contribution to space security as a middle power, as distinct from contributions it may have made as a result of its alliance relationship with the United States, generally accords with the experience and expectations outlined in the model developed in the UNIDIR report published in 2015 and discussed above.

The rise of China represents a fundamental change in Australia's geostrategic circumstances. China is challenging the authority of the international rules-based order in the South China Sea (Swaine, 2013; Lowy, 2018b), and is building close relationships with several nations in the SW Pacific, which is a direct challenge to Australia's long-established primacy in the region (Murray, 2018). Within Australia, there is mounting evidence of the Chinese Government, directly and by proxy, interfering in Australia's internal affairs, including by suborning politicians, stealing intellectual property and other information through cyber means and influencing the media (Hamilton, 2018).

How Australia will negotiate these changes, including in the space domain remains to be seen. Whether the middle power levers of diplomacy and strategic weight will be sufficient to make a difference that fulfils international obligations and promotes peaceful activities in space is open to question. The space policies and activities that middle powers pursue may have more to do with factors other than their middle power status. A series of enduring drivers have shaped Australia's approach to space. These are discussed in the next Chapter.

CHAPTER 4

DRIVERS OR DETERMINANTS OF AUSTRALIA'S APPROACH TO SPACE

Chapter Four addresses the question of enduring factors possessed by Australia that speak to its capability to make a significant contribution to the security of the space environment. The Chapter tests the hypothesis that Australia is obligated to invest in the long-term security of the space environment importantly because of Australia's location and geography. This is the first of five drivers discussed in this Chapter. The remaining four elements speak to questions of political choice.

Obligation has both national and international elements. The chapter provides a critical assessment of those attributes possessed by Australia that form the basis for the nation to play a useful and potentially unique role in the future security and safety of the orbital space environment.

Five drivers in Australia's approach to space characterise its obligation. These are (1) physical factors; (2) a liberal democratic form of government; (3) traditional ties and the US alliance; (4) good international citizen; and (5) opportunity costs.

Since the 1940s space activities have been at the heart of Australia's most important alliance relationships. In the late 1940s, Woomera was established to permit the United Kingdom to develop missiles that could be used in a future war with the USSR. From the 1960s, the United States has been permitted to locate ground stations that remain vital to America's national security interests on Australian soil. Many details of the importance, nature and extent of these space relationships have been and remain shrouded in secrecy. However, they lie close to the heart of Australian foreign, security and defence policies.

4.1 Driver 1: Physical Factors

Australia is a large landmass located between 10^{o} and 43^{o} South latitude and 112^{o} and 153^{o} East longitude. Some relevant figures are:

- Land area: 7.69 million square kilometres (sixth largest nation-state in land area after Russia, Canada, the United States, China and Brazil, and the only nation to inhabit an entire continent with no shared land borders);
- Dimensions: the continental landmass is roughly 3,700 km from north to south and roughly 4,000 km from east to west (similar in dimensions and area to that of the continental United States);

- The continent is low, relatively featureless and geologically stable with a mean elevation of just over 200m, and its highest point being Mount Kosciuszko, at 2,228 metres;
- Population: 25 million, with 89% living in urban areas (ABS, 2018).
- The Australian Government has sovereign responsibility or obligations under international law for approximately 15% of the Earth's surface, including broad security and search and rescue responsibilities for much of the Indian and Southern Oceans.

In summary, the continent is large, flat and, except for the major capital cities, sparsely populated.

There are two sets of physical factors, (1) Australia's remote location relative to other landmasses and (2) relative 'quietness' across the radio part of the electromagnetic spectrum for much of Australia's landmass outside of cities.

4.1.1 Location

The Australian continent hosts ground stations, telescopes and other sensors that are critical to the activities of satellite operators, astronomers and space scientists. The Space Industry Innovation Council (SIIC) that was established in 2009 to advise government about future directions for space activities in Australia, in a planning document, referred to Australia as the "Big Ear".

Australia has three advantages that its location confers on space activities:

Equidistant from North America and Europe Satellite ground stations located in Australia are networked with others located in North America and Europe to provide for continuous communications with space probes as they move away from Earth on their journeys to the moon, planets and beyond. As the Earth rotates about its axis, at least one ground station has sight of the probes, which allows tasking signals to be sent to the probe and data from the probes to reach Earth. Other ground stations support satellites in Earth orbits that provide continuous global coverage for a variety of purposes, including communications, environmental mapping and monitoring, intelligence gathering, treaty monitoring and verification and weather prediction.

Arthur C. Clark, in a seminal paper published in *Wireless News* in October 1945, was the first to outline the principle. He demonstrated that three satellites located an equal distance apart in GEO orbits could broadcast signals across the entire Earth (Figure 4.1).

Figure 4.1. The Principle of Three Satellites Providing Global Radio Coverage. From Clarke (1945).

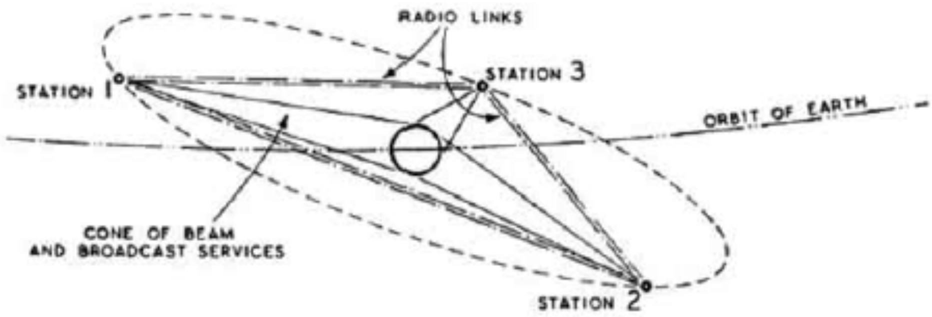


Fig. 3. Three satellite stations would ensure complete coverage of the globe

A corollary is that ground stations distributed more or less equidistantly in longitude on the surface of the Earth, each with the field of view of one of the three satellites described by Clarke, could both control the satellites and receive data from them. Taking advantage of equidistance from North America and Europe, the United States and European nations have made substantial investments in ground infrastructure in Australia to support a wide range of their civil, research and national security activities in space. Examples, several of which have been mentioned in earlier Chapters, include:

- The Canberra Deep Space Communications Complex (CDSCC) located at Tidbinbilla south of Canberra. This station is operated for NASA by CSIRO (CDSCC, 2017).
- The Deep Space Antenna, near the town of New Norcia, 140km north of Perth, in Western Australia. This station is operated by the European Space Agency (ESA, 2018b).
- The Joint Defence Facility Pine Gap (JDFPG), jointly operated by the Governments of the United States and Australia in support of surveillance, treaty monitoring and intelligence gathering activities (Killalea, 2016).
- The Australian Defence Satellite Communications Station (ADSCS), located at Kojarena, east of Geraldton in Western Australia, is a satellite receiving station. It also hosts terminals that are part of the Multi-Use Operational Support (MUOS) system operated by the United States Navy (USN) (Tanter, 2014).

Other important ground stations that serve both domestic and international users include a large ground station near Alice Springs, operated by the Australian Government's geological survey organisation, Geoscience Australia. This ground station receives signals from several foreign-owned and operated satellites including Landsat 7, Landsat 8, NOAA, TERRA, and AQUA (GA, 2016). Data flows from the ground station to international organisations, as well as to Australian users. The Australian Bureau of Meteorology (BoM) operates a range of ground stations that also receive data from satellites owned and operated by other nations. The most important BoM ground station is at Crib Point in Victoria (BoM, 2018b). The data received at this facility are used in Australia for weather prediction and are also processed and fed into global weather and climate models to improve forecasts in many other parts of the world.

Some commercial satellite communications companies also maintain ground stations in various parts of Australia. Optus has a control centre in Sydney from which it operates its own communications satellites, as well as some others under contract, including the two satellites that are part of the national broadband network (Optus, no date). A Swedish company, SSC, operates two ground stations in Western Australia, one at Dongara and the other, at Yatharagga in the Mingenew Shire (SSC, 2018). In 2011, via a commercial contract, SSC supported the launch and provided Telemetry, Tracking and Control (TT&C) services to the Shenzou 8 satellite (Stewart 2011). The Shenzou 8 is China's human-rated space capsule and, in one media report, the stated purpose of Shenzou 8 was to test "rendezvous and docking methods with the Tiangong-1 space module" (Stewart, 2011).

Proximity to Asia There are three aspects to this element of the location driver. The first relates to language and security strategy; the second is a specific Australian response to its security needs; and the third looks to opportunity.

Language: The Indo-Pacific In parallel to China's rise, the language of regional security has changed from references to the Asia Pacific region to references to the Indo-Pacific region. The 2009 Defence White Paper referenced "Asia Pacific" in its title: *Force 2030: Defending Australia in the Asia Pacific Century*. In his forward to the 2013 Defence White Paper the Minister for Defence, the Hon Stephen Smith, wrote of: "the ongoing economic strategic and military shift to the Indo-Pacific" (DoD, 2013, p. ix). This change in language is not confined to Australia but also reflects in statements by the leaders of the United States, Japan and India (Singh, 2017).

The Chinese Foreign Minister, Wang Yi, has expressed displeasure with the term "Indo-Pacific", calling it "an attention-grabbing idea that will dissipate like ocean foam" (Medcalf, 2017).

However, as China has moved to assert *de facto* control of the South China Sea and as it has become more dependent on oil supplies from the Middle East, one response from other affected nations has been to adopt a term that embraces a broader region of security concern. China has a vital interest in ensuring that the sea lines of communication (SLOC), between energy and raw materials providers and China are safe and secure.

Australian Security The Royal Australian Air Force produces a chart called the *Air Staff Planning Chart*. This chart has a series of concentric range rings centred on Darwin and uses an azimuthal equidistant map projection that minimises the distortions caused by more familiar projections, such as the Mercator projection, across the area covered. The chart shows with great clarity that much of the archipelago to Australia's north, as well as the strategic straits (Malacca, Lombok and Sunda) and the South China Sea, are as close or closer to Darwin than is Canberra and the populated south-east of the Australian continent (Fig. 4.2).

Figure 4.2. RAAF Air Staff Planning Chart.

These relationships of distance and place are significant for the defence of Australia. In 1985 Professor Paul Dibb was commissioned by the government of the day to prepare a report, from first principles, on the defence of Australia. He determined, on the basis of geography and history, that any invading force would need to come from, or through, the island chain to Australia's north. On this basis, he recommended a force structure that would be able to defend the sea-air gap to the immediate north and north-west of the continent (Dibb, 1986).

This included continued investment in the Jindalee Over-the-horizon Radar Network (JORN) that had been designed and built by the Australian Defence Science and Technology Organisation (DSTO). JORN is a long-distance surveillance system that works in the high frequency (HF) band of the radio spectrum (DST Group, 2018b). It allows operators to plot aircraft and shipping movements across the region to Australia's north. The technology is built on deep understanding of the structure and dynamic nature of the ionosphere gained in the 1940s and 1950s. This research made a fundamental contribution to developments and investments in radio astronomy in Australia in the 1950s and 1960s, and later to Over-the-Horizon Radar (OTHR) research and development (Fraser, 2016; Wilkinson et al., 2018).

The capability of JORN has increased enormously in the decades since Dibb recommended its continued development and provides an example of the relationship between knowledge of space weather (of which knowledge of the ionosphere is a subset) and the dual use applications to which this research has been applied – radio communications and radio astronomy on the one hand, and surveillance for national security purposes on the other. Indirect evidence in support of this statement is the membership of the National Committee on Space and Radio Science, the members of which include serving and former members of the DST Group, as well as representatives from academia, industry, and key government agencies (NCSRS, 2018).

Opportunity In 2015-16, 60% of Australia's exports travelled through the Indonesian archipelago to markets in China, South Korea and Japan (DFAT, 2016, p. 34). The security of the sea lines of communication, notably through the Malacca, Sunda and Lombok Straits and the South China Sea, are vital to the region and Australia (DFAT, 2017b, p. 30). Looking to the future, the growth markets for advanced technology products, including space products and services, will be in the nations to Australia's north. As these nations become progressively dependent on access to space-based services, a not unreasonable inference is that they are likely to take an increased interest in the safety and security of the orbital space environment - an area in which Australia is developing capability and experience.

Australia's space engagement with the region is mostly confined to bilateral cooperative arrangements between specialist agencies of the Australian Government - notably CSIRO, GA and BoM - and regional space agencies. Space cooperation with Japan is especially strong, diverse and long-standing:

- The Himawari 8 satellite provides vital data to Australia for near real time weather prediction and modelling (BoM, 2018c);

- The Quazi-Zenith Satellite System (QZSS) provides navigation and timing services to Australia (Zaminpardaz et al., 2018);
- Hyabusa 2, landed on the asteroid Ryugu early in 2019 and is due to return to Earth at Woomera in 2020 (New Scientist, 2019; JAXA 2018). This follows the return to Woomera of Hyabusa 1 from the asteroid Itokawa in 2010 (Howell 2018);
- A Japanese research agency, NICT, is a member of the Space Environment Research Centre (SERC), which is a Canberra-based Cooperative Research Centre that is investigating ways to understand and mitigate the risks to satellites in LEO presented by space debris (SERC 2018b); and
- The Japanese Government gifted the launch to Australia of the federation satellite (FedSat) in recognition of the centenary of the founding of the Commonwealth of Australia in 1901 (UniSA, 2007).

There are two space cooperation organisations in the region, APSCO and APRSAF. APSCO, standing for the Asia Pacific Space Cooperation Organisation, is underwritten by China and is not an agency with which Australian governments have become involved (APSCO, 2018). APRSAF, standing for the Asia Pacific Regional Space Agencies Forum, is largely underwritten by Japan (APRSAF, 2018). APRSAF meets in plenary annually and Australia has hosted the forum twice – in Canberra in 2004 and Melbourne in 2010. Australia is involved in several multi-lateral environmental projects that are sponsored through APRSAF. One, which is ongoing, is the Sentinel Asia disaster monitoring project (ESA, 2018c).

Opportunities exist to strength space cooperation with regional neighbours to mutual benefit.

Launch Sites On 29 November 1967, a small Australian-built satellite, known as WRESAT (standing for the Weapons Research Establishment SATellite) was launched from Woomera into a low Earth orbit by an American Redstone rocket (DST Group, no date).
The following points about the WRESAT project are relevant:

- The WRESAT project was opportunistic and not part of a plan by Australia to establish a space program of its own. The booklet prepared by the Department of Supply to acknowledge the launch described the project as a "good example of international space research cooperation" (Department of Supply, 1967). In 1966 the United States brought to Woomera 10 Redstone rockets as its contribution to the tripartite (United States, United Kingdom, Australia) Sparta research program. Sparta aimed to study the re-entry phenomena of vehicles, notably nuclear warheads, that had been in space and were returning to Earth. The Sparta program progressed so well that by the end of 1966, it was evident that there would be at least one spare rocket. The US Government agreed that this could be used to launch an Australian-built satellite, providing the launch occurred before the end of 1967 (Mackellar, no date).

- A hastily assembled team from WRE and the University of Adelaide devised a series of experiments that aimed to increase understanding of the influence of the upper atmosphere on climate and weather. Appropriate sensors were designed, manufactured, tested and integrated into the satellite within the allotted timeframe. WRESAT was launched and useful data were gained. This was a significant achievement.
- WRESAT was launched towards the north. The spent first stage fell to Earth in the Simpson Desert and the second stage fell into the Gulf of Carpentaria. Whether governments today would allow spent rocket stages to fall back to Earth on Australian territory, no matter how remote, is an open question.
- WRESAT was fundamentally an unplanned and unintended civil experiment that was a serendipitous supplement to a military space program.

A second satellite, Prospero, which was designed and built in the UK, was launched from Woomera in 1971 (AMSAT-UK, 2011).

Woomera was a good location from which to launch sub-orbital missiles that could be recovered for later testing and analysis. However, it is not an ideal location from which to launch satellites into orbit, being well south of the Equator and with NE and SE launch corridors presenting safety risks because spent launch vehicles may fall on mines and towns in these corridors. There are better sites elsewhere in Australia and in other parts of the world, as well.

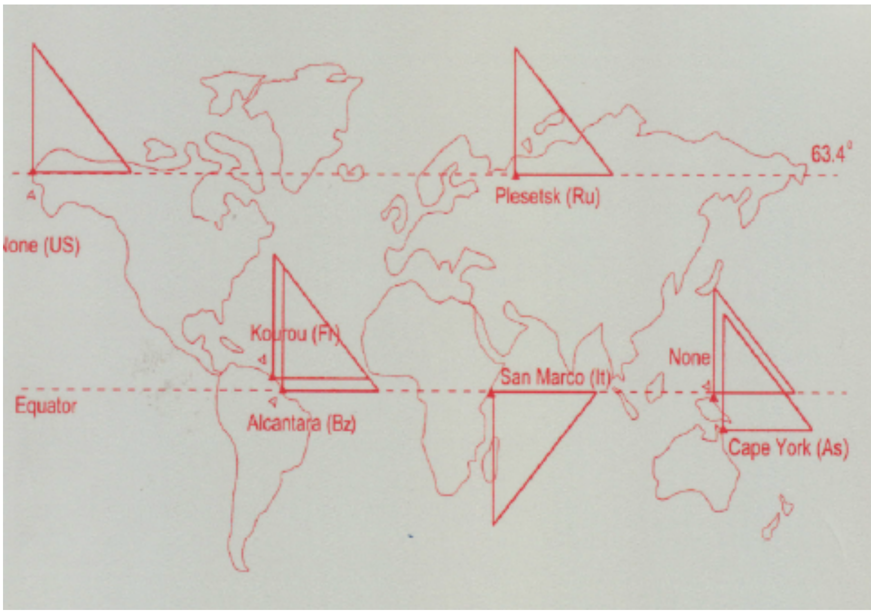
Since 1967, there have been several attempts to develop commercial launch sites in Australia, including at Woomera, on Cape York, near Darwin, near Rockhampton, and on Christmas Island (Dougherty, 2017). All have failed for want of investment based on defensible business cases. Recently, an Australian company, Equatorial Launch Australia (ELA), has announced plans to establish a commercial launch facility near Nhulunbuy in the Northern Territory (ELA, 2018). Whether the venture succeeds remains to be seen. However, this, together with the failed past attempts, does point to the attractiveness, in principle at least, of northern

Australia as a location from which to launch satellites, notably into low inclination orbits to cover the Earth's equatorial regions.

At least three other companies are known to be planning to conduct launch activities from Australia. Gilmour Space Technologies, based in Queensland, is planning to launch sounding rockets to 150 miles in 2019 and to place payloads into Low Earth Orbit in 2020 (Gilmour Space, 2018). Black Sky Aerospace, also based in Queensland, advertises a range of sounding rockets and access to several launch facilities (BSA, 2018). Southern Launch, based in Adelaide, South Australia, plans to launch small satellites from a site near Port Lincoln in South Australia into polar orbits (Southern Launch, no date).

Dolman has devised the chart below and selected what he calls optimum launch points for satellites across the world. He designates just one Australian site, Cape York in far north Queensland. The ELA site near Nhulunbuy in the Northern Territory would seem to mostly satisfy the optimality criteria that lie behind the sites selected by Dolman.

Figure 4.3. Selected Optimum Launch Points: from Dolman (2003).



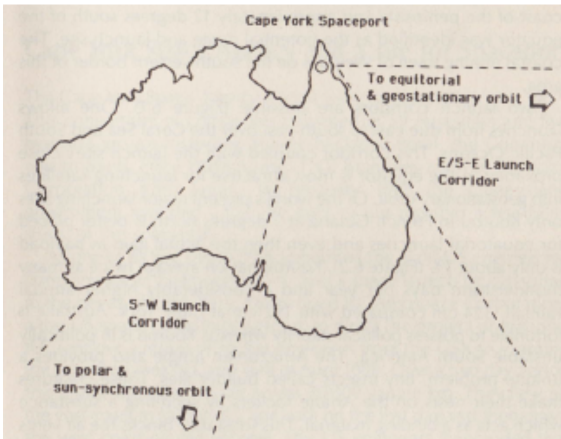
Dolman calls the points on this diagram "optimum launch points" because they allow for:

- Due east launches (the lowest inclination possible from any given launch site, which equals the latitude of the launch site);
- Due north launches (into highly inclined and polar orbits);
- Launches into other orbital inclinations (the range of inclinations is represented by the hypotenuse on the various triangles on the diagram); and

- Spent boosters to fall to Earth safely, away from populated areas. Although Papua New Guinea (PNG) may well have argued against satellite launches into highly inclined orbits from Cape York because of the possibility of injury or property damage (however remote) from first stage boosters or other launch debris falling onto PNG territory. The ELA launch site is located west from Cape York and proposes launch trajectories that avoid overflight of Indonesian and PNG territory.

The launch corridors that were proposed in 1987 for the Cape York spaceport that did not proceed are shown in the diagram below. Note that satellites destined for the most highly inclined, sun-synchronous orbits were to be launched to the south-west with the first and second stages potentially falling on, or close to, remote towns and settlements across central Australia. What may have been permissible in 1987 may not be acceptable in 2019.

Figure 4.4. Proposed launch corridors from spaceport on Cape York.



Source: Gooden B 1990, Spaceport Australia, Kangaroo Press

Astronomy: Access to the Southern Skies Telescopes located in the southern hemisphere afford astronomers views of the centre of the Earth's galaxy, the Milky Way, not available to astronomers in the northern hemisphere. Professor Ray Norris, an astronomer with the Australia Telescope National Facility and an expert on aboriginal astronomy makes this point eloquently:

> "The southern sky is striking compared to that of the Northern hemisphere, often dominated by the magnificent river of the Milky Way weaving across the zenith, crossed by numerous dust lanes" (Norris, 2009).

The absence of high mountains in Australia makes the continent unsuitable to host cutting-edge optical telescopes such as the Giant Magellan Telescope (GMT) proposed for construction in the Chilean Andes within the next few years (GMT, 2018). However, Australia's small population and its distribution in cities and urban centres along the coasts means that much of the continent is remarkably radio-quiet, which suits it well to host radio telescopes and other instruments that are designed to collect exceptionally faint signals.

4.1.2 Electromagnetic Spectrum

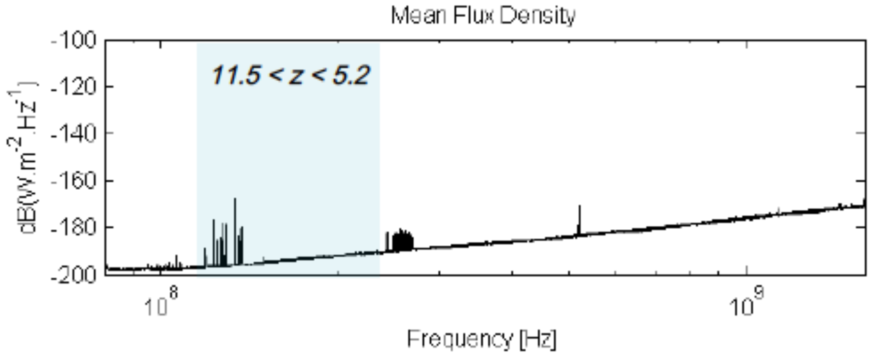
Much of Australia is radio-quiet, making it ideal for radio astronomy. The low frequency element of the Square Kilometre Array (SKA) radio telescope, which is being developed by an international consortium based in Manchester in the United Kingdom, is being constructed, in part, in Western Australia to take advantage of Australia's radio-quietness (SKA Telescope, 2018; SKA Australia, 2018). CSIRO conducted surveys of the radio environment at candidate sites for a radio observatory in Western Australia that would host core elements of the SKA as well as other radio telescopes. These include the Australian SKA Pathfinder (ASKAP) telescope and the Murchison Widefield Array (MWA) (ASKAP, 2018; MWA, 2018).

The deep-space antennas, such as those operated by NASA at Tidbinbilla and ESA at New Norcia, are used to communicate with space exploration missions throughout the solar system (CDSCC, 2017; ESA, no date). They also need a radio-quiet environment to work optimally.

In support of Australia's bid to host at least part of the Square Kilometre Array (SKA) radio telescope, CSIRO undertook a series of extended radio surveys, the summary results of which are published overleaf.

Figure 4.5 is a graphical summary of the results of the radio frequency site survey, at Mileura in Western Australia (Boyle, 2005). The figure indicates a small number of frequencies where radio sources may have presented a problem at the lower end of the frequency range of interest (the area represented in blue). These frequencies, which represent as spikes against the ambient noise floor, indicate that Mileura is exceptionally radio-quiet.

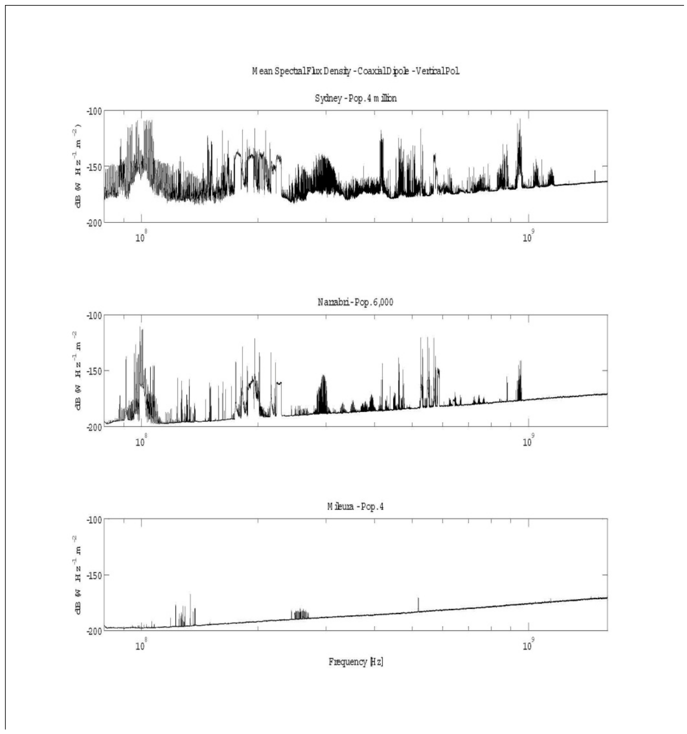
Figure 4.5. Result of Radio Frequency Environment Survey at Mileura, WA, 2005.



From Boyle 2005, p. 38

Figure 4.6 illustrates the profound radio-quietness of Mileura (with a population of four people) relative to Sydney, and to Narrabri in northern New South Wales. Narrabri is the location of another large radio telescope the Australia Telescope Compact Array (ATCA) (ATNF, 2019). This chart indicates that human activity, above all, creates radio noise – the more humans there are, the more the radio noise.

Figure 4.6. Comparative Results of Radio Frequency Surveys conducted in Sydney, Narrabri (NSW) and Mileura (WA), 2005.



From Boyle, 2005, p. 38.

Beyond noise generated on Earth by human activities, satellites present an increasing source of radio frequency interference (RFI) to ground-based radio telescopes (ATNF, 2013; ATNF, no date; Oltrogge, 2012).

4.2 Driver 2: Liberal Democratic Form of Government

Dr Neal Newman was the last representative of NASA to be permanently stationed in Australia. He returned to the US in 2005. Dr Newman would often explain that NASA was very pleased to have major facilities located in Australia because Australia is "There, Bare and Fair". "There" applied to geography, "Bare" applied to radio quietness and "Fair' was a reference to Australia's system of government.

The second identified policy driver concerns Australia's political system and liberal democratic form of government. The rule of law prevails and there is alignment with western values and the international rules-based order that emerged in the aftermath of World War 2.

Dr Newman's point, from the perspective of NASA, was that doing business with Australia is relatively straightforward because of the alignment of core values and interests.

Australia has a federal system of government. Citizens in the six original colonies voted via referenda to create a central government, the Commonwealth of Australia, which came into existence on 1 January 1901. There were two principal drivers for Federation. The first was to permit the common defence of the island continent and the second was to create a common border and a customs union (Quick & Garran, 1901).

The colonies were renamed as States when Federation occurred. The Commonwealth Parliament consists of two chambers. The lower house, the House of Representatives, is the peoples' house. The upper house, the Senate, is nominally the State's House and was conceived by the drafters of the Constitution as a house of review. Ministers, who comprise the executive, are chosen from Members and Senators of the party or coalition of parties that holds the majority of seats in the House of Representatives. The Constitution also provides for a High Court and a judicial system.

At Federation, Australia was a self-governing Dominion within the British Empire, and Whitehall remained influential in defence and foreign policy matters. However, anticipating that Australia would become increasingly responsible for its international, as well as domestic, affairs, those who drafted the Constitution took care to ensure that the national Parliament had the necessary powers to deal with other nation-states on an equal basis. Section 51 of the Constitution enumerates the Commonwealth's powers - those matters about which the Parliament may make laws and allocate monies. The Commonwealth and the States (and

Territories) share some powers and, in the event of inconsistency, the Commonwealth law prevails. All powers not specified, the residual powers, remain with the States. The Commonwealth's powers relevant to space activities include:

- "S51 (i) Trade and commerce with other countries, and among the States;
- S51 (iii) Bounties on the production or export of goods . . . ;
- S51 (v) Postal, telegraphic, telephonic, and other like services;
- S51(vi) The naval and military defence of the Commonwealth and of the several States . . .;
- S51(vii) Lighthouses, lightships, beacons and buoys;
- S51(viii) Astronomical and meteorological observation;
- S51(xx) Foreign corporations, and trading or financial corporations . . .;
- S51(xxvii) Immigration and emigration; and
- S51(xxix) External affairs."

Beyond S51, an entire section of the Constitution is devoted to finance and trade, which contains transitional and enduring provisions. One of the more important enduring provisions is S96, which empowers the Commonwealth Parliament to "grant financial assistance to any State on such terms and conditions as the Parliament thinks fit".

Over the years, legislation that flows from these heads of power has been enacted and Departments of State, statutory authorities, and other organisations, have been established. The machinery of government has become progressively more complex, as have ministerial responsibilities and prerogatives.

When the Constitution was drafted in the 1890s, human activity in space was the stuff of science fiction. Space activities have been added, by analogy, to the portfolio responsibilities of numerous Ministers as has seemed most appropriate at the time. The Minister responsible for posts and telegraphs (S51(v)), by analogy, now has primary responsibility for satellite communications. The Minister responsible for lighthouses, lightships, beacons and buoys (S51(vii)) has responsibility for navigation services, such as those provided by GPS. The Minister for Defence has prime responsibility responsible for representing Australia's security interests in space. The Commonwealth and the States share responsibility for industry development and policy.

Ministers with responsibility for the national security elements of space have not shared classified information with some colleagues, which has reinforced the bifurcation of policy responsibilities between classified and unclassified space initiatives.

The situation becomes more complicated when the residual powers of the States are taken into account. These include responsibility for laws relating to land tenure, land use planning and management, as well as laws relating to the regulation of the professions such as surveying and its associated trades. The States, in summary, are responsible for functions that, today, make routine use of data and services provided by satellites. The workforce that supports these activities is organised by a mix of national, State and Territory laws, regulatory bodies, and professional associations.

The machinery of government at the national level and legacy structures of Australia's colonial heritage continue to exert an important influence on politics and public policy development in Australia, including in space matters. The interests of the States and the self-governing federal territories do not always coincide, and there can be quite fierce competition between them to attract new industries and jobs. This point is developed further in Chapters Seven and Eight.

4.3 Driver 3: Traditional Ties and the US Alliance

Australia's involvement in space activities since the 1940s has been driven fundamentally by national security considerations at the heart of which have been Australia's alliance relationships. In the Australian system, national security decision-making is largely the prerogative of executive government at the pinnacle of which is the National Security Committee (NSC) of Cabinet. The Prime Minister chairs the NSC which is attended by a handful of senior Ministers including the Deputy Prime Minister, the Attorney General, the Treasurer and the Ministers for Foreign Affairs, Defence, Home Affairs and Finance (Australian Government, 2019).

In the past decade, however, legislative oversight of the intelligence community has significantly increased. Major intelligence agencies, including the Australian Security Intelligence Organisation (ASIO) and the Australian Signals Directorate (ASD) are now established under their own Acts. There is an Inspector General for Intelligence and Security (IGIS) who has unfettered access to all parts of the intelligence community and who reports to Parliament and there is a Parliamentary Committee that exercises a degree of oversight of the activities of the intelligence community (IIR, 2017). More recently, a new position, the

Director of National Intelligence has been created. This is a statutory position and the officeholder has oversight, from the official level, of all of Australia's intelligence activities (Blaxland, 2018).

Also, in the past decade, some of the most tightly guarded secrets about US and allied intelligence sharing activities have come into the public domain. Unauthorised disclosures by Wikileaks and by Edward Snowdon have exposed and compromised information about intelligence gathering capabilities and intelligence targets that governments would prefer not to have seen in the public domain (Walsh, 2013). These leaks, coupled with a changed threat environment, changing communications and computing technologies and the strengthened oversight mentioned above have led to far more information being in the public domain about intelligence activities including the space-based intelligence activities that are central to Australia's alliance relationship with the US.

This section views the role of space in Australia's alliance relationships through the lenses of organisational, programmatic, and political impacts.

4.3.1 The Organisational Lens

In World War 2, the United States and the United Kingdom established a deep intelligence sharing relationship, especially in Signals Intelligence (Sigint), which involves the interception and decryption of foreign communications. Australia, Canada and New Zealand were admitted as second parties to the partnership (Richelson, 1989). This cooperation endures and is referred to as the Five Eyes partnership. Tasking across the Five Eyes partnership is shared, as is the intelligence gained (Privacy International, 2013).

Since the invention of the internet, the world of intelligence has moved from one of information scarcity to information glut, leading to fundamental changes in the ways that intelligence is collected, processed, disseminated and protected. The nexus between intelligence and operations is also becoming much closer and more immediate. In the aftermath of the terrorist attacks in New York and Washington on 11 September 2001, the 'need to know' principle that has been the conceptual well-spring of protective security practices for many years was challenged by a different paradigm, the 'need to share' (Best, 2011). The unauthorised disclosures, mentioned above, of Wikileaks and Edward Snowden have led to intelligence agencies winding back the need to share principle.

Some intelligence agencies, the very existence of which was classified until the 1970s and 1980s, now have websites and public personas. The Australian Signals Directorate (ASD), for example, is Australia's national Sigint organisation. Until the 1970s, the media was restrained from making any public reference to the organisation, then known as the Defence Signals Directorate (DSD). DSD was protected by a D-Notice that was issued to newspaper proprietors, editors and other media organisations. The D-Notice sought the cooperation of the media not to publish material about DSD, because to do so might have compromised the national interest (Hall, 1978). Today, ASD's website is undiplomatically direct in stating the organisation's mission: "Reveal Their Secrets – Protect Our Own" (ASD, 2018). However, the capabilities, strengths and weaknesses, targets, successes and failures of ASD, and its sister organisations, remain carefully guarded secrets.

Ada Bozeman (1992) has pointed out that all nations acknowledge that intelligence activities are a necessary and expected element of statecraft. Michael Herman summarises the situation thus:

> "Organised intelligence . . . has been a twentieth-century growth industry, and most governments now have it as a permanent institution. It is a significant part of the modern state and a factor in government's success and failure" (Herman, 1996, p. 2).

Nations also take measures to protect their secrets by establishing security processes and procedures and by investing in counter-intelligence organisations (ibid).

In the defence and national security realm, the relationships between the United States, the United Kingdom, Australia, Canada and New Zealand extend well beyond intelligence sharing. They embrace regular Ministerial level meetings, exchanges of military personnel, joint exercises, shared research and efforts to ensure interoperability between forces when on combined operations (Canada, 2018; UK, 2018).

Australia's alliance with the United States is the cornerstone of Australia's national security (DoD, 2016b). Central to the alliance is the intelligence relationship at the heart of which, since the 1960s, have been the joint facilities (Ball, 1980; Fraser, 2014). The satellites controlled and supported by the joint facilities were essential to the nuclear deterrence posture of the United States (Ball, 1988). The strategic level return to Australia of these arrangements, certainly during the Cold War, was the implied nuclear guarantee provided by the United States (Gyngell, 2017).

4.3.2 The Programmatic Lens

Space-related activities that Australia has permitted its allies to undertake on Australian soil include:

- The missile development programs at Woomera from the late 1940s until the 1970s that were conducted mainly with the United Kingdom;
- The joint facility at Pine Gap that supports American Sigint satellites;
- The joint facility at Nurrungar, near Woomera, that supported ballistic missile early warning satellites until the facility was closed in 1999 and replaced by a relay ground station located within the security perimeter at Pine Gap; and
- The recently installed space radar and space telescope at North West Cape.

Woomera and its Enduring Legacy Paul Hasluck, in the *Official War History*, makes brief mention of the Anglo-Australian Joint Project which lies at the heart of the Woomera story (Hasluck, 1970, pp. 690-692). The definitive history, however, is Peter Morton's monograph, *Fire Across the Desert* (Morton 1989). Morton tells the story of the politics, the people and the technologies that were developed from the project's beginnings in 1946 to its closure in 1980. In these years Australia and the United Kingdom developed and tested missiles for strategic and tactical use at Woomera. The Woomera Prohibited Area (WPA) was declared in 1947 for the purpose of "testing of war materiel" (DoD, 2015). This clause, which is not defined, endures in the current legislation that regulates the use of, and access to, the range (Australian Government, 2014). It allows for much latitude in terms of the uses to which the range has been put, including the development of missiles capable of delivering nuclear weapons.

Elaborate security precautions were taken to protect the projects under development at Woomera (Morton, 1989). Even visitors needed a permit to be allowed into the town (ibid, p. 247). Woomera's heyday was in the 1960s and 1970s when up to 7,000 scientists, engineers, technicians, support personnel and their families made the Woomera Township their home. The town was not opened to unrestricted public access until 1982 (OCA, 2014). Ken McCracken is one of Australia's early space scientists. In his memoirs, he recounts an exchange that occurred between himself and the director of the Weapons Research Establishment (WRE) in 1965. For context, WRE was the Australian Government's operational, engineering and scientific interface into the Joint Project. Dr McCracken had worked on NASA satellite missions and had just been interviewed for a professorship at the University of Adelaide.

> "I arranged to visit the director of WRE. On being ushered into his room, he said, 'Oh, McCracken, I've heard of you. Let me make it clear from the outset that there is no way that you can get access to the rocket range or our facilities' " (McCracken 2008, p. 207.)

Three points emerge from this vignette. The first was the uncompromising concern for security by Australian authorities. The second was the gap between the classified and unclassified space research communities in Australia. The third was the whip hand held by the defence and security communities over Australian space activities. McCracken found a way to circumvent WRE's intransigence by persuading British colleagues to develop instruments that could be flown from Woomera under the Joint Project arrangements. Somewhat ironically, a year or so later, a team from the University of Adelaide, led by Professor John Carver, was invited by WRE to join the WRESAT project as the 'only outsiders' to contribute to the project (McCracken, 2008, p. 216).

The Joint Facilities and "Full Knowledge and Concurrence" In the 1960s the Australian Government agreed to requests by the United States to locate three important facilities on Australian soil. These were a naval communications station at North West Cape on the extreme western edge of the Australian continent, a ground station to receive data from Sigint satellites at Pine Gap near Alice Springs, and a ground station, near Woomera in South Australia, to receive data from satellites that warned of ballistic missile launches (Ball, 1980). All of these bases have been politically contentious, perhaps more so in the past than in the present, but critics remain. In the 1960s, 1970s and 1980s, the principal opponents were mostly from the political Left, and as explained below, elements within the Labor Party were strong opponents. The bases were targets for those seeking to express anti-war and anti-American sentiments (D'Alpuget, 2010) and there were several violent protests at the facilities. In later years, although the protests waned, other critics emerged, one of the most important being Malcolm Fraser, the former Liberal Prime Minister. Not long before his death in 2015, Fraser wrote:

> "…I have grave concerns over [Pine Gap's] continued operation. It can now be used to target drone killings, whether to take out a single person or to destroy some other target. . . Such involvement in offensive operations is not necessarily in Australia's interests. . . The real question is whether we want to be involved if there ever were a major war between China and the United States" (Fraser, 2014)

A condition of the facilities being hosted on Australian soil was that the Australian Government should have detailed understanding of the facilities' operations and activities and should also be in a position to concur with the specific uses to which the facilities were being put by the United States. This was the principle of 'full knowledge and concurrence'. In 2013, the Minister for Defence, the Hon Stephen Smith delivered a Ministerial Statement to the House of

Representatives in which he defined 'full knowledge and concurrence' in the terms that follow. The Minister said in part:

> "'Full knowledge' equates to Australia having a full and detailed understanding of any capability or activity with a presence on Australian territory or making use of Australian assets. 'Concurrence' means Australia approves the presence of a capability or function in Australia in support of its mutually agreed goals. Concurrence does not mean that Australia approves every activity or tasking undertaken. Some of the ways by which we develop and maintain full and detailed understanding are by having Australian involvement in operations; having access to products; and through provision of briefs or reviews of activities when they occur, or on a regular basis" (CPD, 2013, p. 7071).

In January 2019, The Minister for Defence, The Hon Christopher Pyne made a Ministerial Statement to the House of Representatives about full knowledge and concurrence. He used language similar to that used by Minister Smith in 2013 and added:

> "At a practical level, full knowledge and concurrence means:
>
> First, that Australia is to be consulted about any new purpose proposed for any activity, or a significant change to an existing purpose, and we will be advised of any significant change to expected outcomes.
>
> Second, it means that Australia will be briefed and advised on outcomes achieved.
>
> And finally, proposals for new equipment or significant upgrades to existing equipment, including communications links, will be advised in sufficient time to confirm that the changes align with mutually-agreed purposes, or to seek further clarification, if required" (CPD, H of R, 2019, p 14052).

A critique of the policy, especially as it applied to Pine Gap, was published in the *Alice Springs News On Line*, shortly after Minister Pyne's statement to the House (Finnane, 2019). The point is the policy unanimity in the approaches of the major parties to the joint facilities. As discussed in a section to come, this has not always been the case.

An Australian is the Deputy Chief of Facility (DCOF) at Pine Gap and Australians are directly involved in the facility's operations (Dorling, 2013).

In their early years of operations, especially, the bases were shrouded in secrecy. Over time, such public disclosures as have occurred, have been made with caution and reluctance by responsible American and Australian authorities (Richelson, 1999). More recently, in the latter part of 2018, the Australian Broadcasting Commission (ABC), screened a seven-part drama called *Pine Gap*. Although not in any respect a documentary, the series provided insights into intelligence sources and methods that would not have been revealed to public gaze in the past (ABC, 2018c).

North West Cape In 1962, the Australian Government agreed to a request from the Government of the United States to establish a very low frequency communications station at North West Cape on the western extremity of the continent (Ball, 1980). The purpose of the facility was to permit assured communications between US command authorities and American submarines, potentially to order nuclear weapons strikes against targets in the Soviet Union and China. Secure and reliable satellite communications were in their infancy and could be readily intercepted and exploited by organisations that were not the intended recipient. Very low frequency radio signals, passing encrypted messages, were a reliable alternative. The Australian Government's agreement to host the facility was, at the time, contentious. Opponents were concerned that Australia, by hosting the facility, could be complicit in starting a nuclear war with no voice in the decision. Further, by hosting the facility, Australia may itself become a nuclear target (ibid). In 1992, operational responsibility for North West Cape was transferred from the USN to the RAN to communicate with its ships and submarines (Shire of Exmouth, no date).

The Communications Station at North West Cape is not related to space capabilities. It was, however, the first of the joint facilities and the principles that govern the hosting arrangements for joint facilities in general were first developed in the context of this establishment.

Pine Gap In 1966, the Australian Government gave permission for the United States to establish a second facility in Australia, at Pine Gap, near Alice Springs (Ball, 1988). Initially called the Joint Defence Space Research Facility (JDSRF), it opened in 1970 and has continued to expand since then (Rosenberg, 2011; CPD H of R, 2013, p. 7071-7077). In the 1960s, the public cover story for the facility, reflected in its title, was that it conducted space research. Its importance to the United States was obvious from the outset because of the security measures that covered all aspects of the Facility's operation.

The base serves as the ground reception station for Sigint satellites, the first of which, the Rhyolite series, did not have encrypted communications (Bamford, 2002). The location of the base, near Alice Springs, in the centre of the Australian continent, was vitally important at the time. The United States was concerned to ensure that intelligence collection ships operated by the Soviet Union could get nowhere near the base to learn which Soviet signals were being collected by the Americans (ibid).

Pine Gap is now an established part of the national security landscape that, as noted above, has bipartisan support.

Also, as noted above and perhaps controversially, Pine Gap, has, to quote former Prime Minister Malcolm Fraser, become "integral to the conduct of modern warfare", a development about which Fraser expressed "grave concerns" (Fraser, 2014, p. 251). This points to an important change in the importance of Pine Gap to Australia's own military capabilities. Kim Beazley, a former Defence Minister and later Australian Ambassador to the United States, said:

> "The facilities are no longer simply a price paid for broader Western interest and the broader alliance. Activity at the bases is an integral part of the Australian military and intelligence communities' order of battle. Their removal would not simply diminish US direct capabilities, they would diminish Australia's, leaving a gap Australia could not replicate technologically, let alone afford to replace" (Beazley in Dean et al., 2016, p. 217).

Advances in intersatellite communications link technologies, could eventually remove the need for the United States to retain a ground station at Alice Springs. Future satellites, instead of reporting and being controlled through Pine Gap, could communicate directly to the United States. Australia's influence within the alliance could well be reduced because the nexus between Australia's 'real estate' and satellites vital to the national security of the United States will have been broken. From the perspective of future Australian governments seeking to make a strategic level contribution to the Alliance, locating ground-based Space Situational Awareness (SSA) sensors in Western Australia (see below), would seem, therefore, to be a welcome development.

Nurrungar Three years after approving the joint facility at Pine Gap, in 1969, the Australian Government formally approved the establishment of a Defence Space Communications Facility (DSCF) near Woomera in South Australia (Richelson, 1999). The facility was contentious, and Professor Des Ball called it a "Base for Debate" in a book of that name (Ball, 1987). The Agreement between the governments of Australia and the United States, under which the facility was established, refer to it as the Joint Defence Space Communications Station (JDSCS). More commonly known as 'Nurrungar', the facility served as a ground station for satellites launched and operated by the United States in the Defence Support Program (DSP). The satellites supported by Nurrungar were in GEO slots typically above the Indian Ocean from whence they would detect the heat plumes of ballistic missiles being launched against the cold background of the upper atmosphere and space. Their principal purpose was to provide advanced warning of nuclear missiles having been launched against the United States and its Allies (Ball, 1987).

The DSCF was established in 1969. Its name was later changed to the Joint Defence Facility Nurrungar (JDFN) and in 1999 it closed (DoD, 2016c). Royal Australian Air Force (RAAF) personnel were integrated into the facility's operations and the Deputy Commander of the Facility was a RAAF Wing Commander (05 equivalent rank in US terminology).

DSP satellites were progressively improved during the program's life, with the last satellite being launched in 2007 (USAF, 2015). The replacement for the DSP is the Space-Based Infra-Red System (SBIRS) (CSIS, 2016).

Although JDFN has long closed, Australia still supports the DSP/SBIRS mission. A Relay Ground Station (RGS) is located at the Joint Defence Facility Pine Gap (JDFPG). Data are transmitted from the SBIRS satellites via the RGS and then directly to the SBIRS operational control centre at Buckley Air Force Base, near Denver, Colorado, in the United States. A contingent of Australian personnel is integrated into the operational control centre. Their presence and direct involvement in SBIRS operations provides substance to the principle of 'full knowledge and concurrence' that successive Australian governments have applied to the operations of the joint facilities (Biddington, 1998).

Space Situational Awareness As discussed in Chapter Two, new joint facilities, a space radar and a space telescope, are being established at North West Cape. These sensors will be a part of the USAF's Space Surveillance Network (SSN), which tracks and catalogues the movements of satellites, space debris, and other space objects. This is a growth area. The United States is building a second-generation ground-based SSA sensor called Space Fence on Kwajalein Atoll in the Marshall Islands. This sensor is due to become operational in mid-2019 (Fonder et al., 2017). There is a possibility that a second radar will be constructed in Australia, possibly at North West Cape (ibid). Commercial companies are developing capabilities and providing data and services to governments and commercial customers as well (AGI, 2019).

4.3.3 The Political Lens

There is a party-political dimension, to Australia's alliance with the United States, echoes of which persist today some 70 years since the precipitating events in the 1940s.

In the 1940s, the United States was preparing to share information about guided weapons with the United Kingdom that would be relevant to projects at Woomera. However, the

Americans had two broad concerns. The first was the extent of communist influence in the Chifley Labor government, including the loyalty of senior ministers, notably Dr Evatt, the Minister for External Affairs. The second was a perception that Australia's general approach to security was lax (Horner, 2014).

In 1947 the United States obtained direct evidence of a serious and high-level breach of security in Canberra. The United States cease providing classified information to Australia of any sort, including information relevant to guided weapons in 1948 (Morton, 1989; Horner, 2014). The discovery was made through an exceptionally closely held Sigint program called Venona, through which Soviet diplomatic communications were being intercepted and decrypted (Haynes & Klehr, 1999). ASIO's official history records that more than 200 cables from Canberra to Moscow were decrypted in the period 1943-1948 (Horner, 2014). From 1947, the United States reduced and eventually suspended the flow of all classified information to Australia until the Australian Government could demonstrate "that the security of the Australian Government is comparable to that of the United Kingdom" (Horner, 2014 p. 64). The leaks emanated from a small group of officials in the Department of External Affairs (Ball & Horner, 1998).

A very small number of Australian Ministers and officials were briefed about Venona, in order that they might comprehend the seriousness of the situation and why the United States had suspended the flow of classified materials to Canberra (Ball & Horner, 1998). In 1948, a high-level delegation from MI5, the counter intelligence organisation of the United Kingdom, came to Australia and recommended major changes to the Australian Government's security arrangements. Most importantly, the review recommended that a security intelligence organisation be formed (Horner, 2014). This was the genesis of the Australian Security Intelligence Organisation (ASIO) that came into being in March 1949.

With these arrangements in place, classified material again began to flow to Australia from the United States. According to Moreton, the practical effect of the suspension on the Woomera programs was not significant. A group of Australians who had been selected for classified training were placed in limbo for some time, but the suspension was lifted before serious adverse impact occurred (Moreton, 1989 p. 106). Full American-British collaboration on ballistic missile research resumed in 1951, clearing the way for rapid developments at Woomera that involved British, American and Australian researchers and officials (Moreton, 1989 p. 108).

The late 1940s were years of political and social ferment in Australia. Within the Labor Government, led by Prime Minister Ben Chifley and the trade union movement, were groups and individuals openly sympathetic to communist ideology and communism. Some were members of the Australian Communist Party. Labor attempted unsuccessfully to nationalise the banks and in the months before the 1949 election dealt firmly with a coal strike and re-introduced petrol rationing at the very time that voters were seeking to put the privations of war behind them (Day, 2001). At the federal election held on 10 December 1949, Labor lost office in a landslide to a conservative coalition of parties led by Robert Menzies (Hughes & Graham, 1968).

Australia's alliance with the United States was formalised in 1951 with the signing of the ANZUS Treaty (Australian Government, 1997). The Treaty committed Australia, New Zealand and the United States, to 'consult' in the event of one of the three coming under attack from an aggressor. New Zealand effectively withdrew from the Treaty in 1984 when it banned visits to New Zealand ports by US Navy ships that may have been carrying nuclear weapons (Hager, 1996). Australia and the United States continue to observe the Treaty and it provides the basis for the annual AUSMIN talks discussed in Chapter Two and again in Chapter Six.

In 1949, the Soviet Union detonated its first atomic bomb (Richelson, 2006). In 1950, the Menzies government committed Australian forces to the Korean war and introduced a Bill into Parliament to ban the Communist Party (Millar, 1978; Menzies, 1970). In 1951, plans by the United Kingdom to explode an atomic device on the Montebello Islands off the coast of Western Australia were under development. To protect this activity, the Australian Parliament passed the Defence (Special Undertakings) Act in 1952 (Horner, 2014; Australian Government, 1952). Pine Gap was later brought under the ambit of the Act which underscores the seriousness attached to security at the facility.

In April 1954 Vladimir Petrov, the Third Secretary in the Soviet Embassy in Canberra, and his wife Evdokia, defected (Horner, 2014). Petrov was the most senior Russian to have defected to the West since the start of the Cold War. His defection was a coup for ASIO and occurred just weeks before the federal election that Menzies had called for May. The Coalition, which had been expected to lose the election, ran on an anti-communist platform and was returned to office (Jaensch, 1997).

Meanwhile, tensions in the Labor Party between communist and anti-communist elements at the extremes, became unsustainable and the party split in 1955 (Maddox, 1996). Conservative, anti-communist elements formed a new party, the Democratic Labor Party. The electoral impact of the “Split,” as the event became known, kept the Labor Party out of office for many years (ibid). Tensions within the Party between Left and Right factions had a direct impact on the health of the Alliance, notably during the period of the Whitlam government (1972-1975) and discussed below.

Internationally, the threat to the West posed by communism was considered to be immediate and real (Lanyi & McWilliams (eds), 1966, pp. 517-525). Mao Tse Tung’s communist army defeated the forces of Chiang Kai Shek in 1948 and forced the latter to retreat to the island province of Taiwan (Millar, 1978). The colonial arrangements that had served British, indeed European, interests so well until World War Two became unsustainable and many colonies demanded and were granted their independence in the following 10-15 years (ibid). India won its independence from the United Kingdom in 1948 and quickly forged close links with Moscow without being drawn fully into the Soviet orbit. Indonesia, which had won its independence from the Dutch also formed relationships with Moscow and Beijing that deeply concerned Canberra (Watt, 1968). Australia supported regional organisations including the South East Asian Treaty Organisation (SEATO) that was established as an anti-communist bulwark and Australian forces were deployed to Malaya to support the British to defeat a communist inspired insurgency in that country (Millar, 1978; AWM, no date).

This was the milieu in which the United Kingdom, supported by the United States, developed its missile and atomic programs in Australia (Hasluck, 1970). Australia provided real estate to support programs that were designed to protect the West against the Soviet Union and communism.

Coalition governments from 1949 to 1972 in effect appropriated Australia’s alliance relationship with the United States as an anti-communist plank that differentiated the Coalition from the Labor Party and helped to keep Labor from office for a long time. The most obvious disagreement was over Australia’s commitment to the war in Vietnam that was opposed by the Labor Party (Edwards, 1997). Space activities, notably the hosting of the Joint Facilities, was a divisive issue in the Labor Party and reflected in the community as a doubt or an uncertainty about the Party’s commitment to the US alliance (ibid).

Broader social changes, the unpopularity of the war in Vietnam, a weak Coalition Prime Minister (William McMahon) and an inspirational Labor leader brought 23 years of Coalition rule to an end on 2 December 1972 (Edwards, 1997; Hocking, 2008). The Labor Party, led by Gough Whitlam, assumed office and thus began an era of tumultuous change in Australia’s domestic politics and international relations.

The joint facilities aroused particular opposition from the left wing of the Australian Labor Party and in the years immediately before the Whitlam Labor government was elected and during its term of office (2 December 1972 to 11 November 1975), serious concerns were harboured in the United States that the base might be closed down by the Whitlam government (Richelson, 1999). These concerns never materialised.

However, on 11 November 1975 the Whitlam government was dismissed by the Governor-General in controversial circumstances following the refusal of the Senate to pass money bills that were crucial to the continuity of the government's activities (Kelly, 1995). There have been suggestions, made at the time and repeated since, that the United States may have been directly involved in the manoeuvrings that led to the downfall of the Whitlam government to ensure that the joint facilities, Pine Gap in particular, were not put at risk (Richelson, 1999). Certainly, the United States' Ambassador, Marshal Green, urged Ministers and senior officials to resolve the crisis but there is no evidence of a conspiracy whereby the crisis in the Parliament was confected to create the grounds for the government's dismissal to protect the bases (Edwards, 2006).

Those who argued for the bases to be closed did so on four main grounds:

- Anti-American and anti-war sentiment in the context of the Vietnam war;
- Concern that the bases could become targets for nuclear attack – a point subsequently acknowledged as a possibility by the Australian Government;
- Concern that Australia could be complicit in the initiation of nuclear war because critical information, and even orders, might pass through Australian sovereign territory without the government having any means to intercede and only the ability to 'concur'; and
- Secrecy, that some claimed was excessive, meaning that even Australian Ministers and senior officials may not have been fully aware of the capabilities of which the bases were a part (Richelson, 1999).

On 6 June 1984, in a ministerial statement about arms control and disarmament, Prime Minister Hawke advised the Parliament that the facilities were not 'military bases'. And further:

> "Among the functions performed are the provision of early warning by receiving from space satellites information about missile launches, and the provision of information about the occurrence of nuclear explosions, which assists in nuclear test ban

> monitoring and supports nuclear non-proliferation measures" (CPD, H of R, 1984. p. 2983).

The Hawke government effectively ended the fractured approach within the Australian Labor Party (ALP) to the importance and enduring nature of Australia's alliance with the US. Whilst pockets of opposition to the joint facilities still existed in the community and with the Left faction of the ALP, political heat went from the debate.

4.3.4 Modern Times

In 2012, the Gillard government produced a Foreign Policy White Paper that made only passing reference to space activities. It acknowledged the investment in space technologies being made by regional nations, noted the importance of protecting "this space-based and space-related infrastructure" and concluded:

> "Australia's regional connections, geographical location and long-term engagement on space issues position us well. However, we need to continue our investment in space-related ground infrastructure to capitalise on our location and ensure that our capabilities remain relevant" (DFAT, 2012b, p. 239).

This may have been a veiled reference to the SSA sensors that the Australian and United States Governments had agreed to relocate from the Americas to North West Cape.

Five years later the 2017 Foreign Policy White Paper was more explicit. To emphasise the importance of the topic, a section is devoted to space security. This reads in part:

> "…the expansion of space-based technologies creates risks. States are continuing to develop capabilities to disrupt satellites and degrade space-dependent military systems, threatening our defence networks and those of our alliance partner the United States. Potential state adversaries may also exploit space to obtain sensitive information about our security. In response, the Australian Defence Force is strengthening its space surveillance and situational awareness capabilities.
>
> Australia is committed to strengthening international rules and laws that apply to space, including military uses of space" (DFAT 2017b, p. 97).

As noted at the beginning of this chapter, the single most important explanation for Australia's approach to space, as reflected in policy, investment and organisational arrangements has been the allied dimension viewed largely through the lens of national security. Policy references to space matters were muted until the end of the first decade of the 21st Century when a public Australian voice about the importance of space began to emerge.

4.4 Driver 4: Good international citizen

The fourth policy driver that explains Australia's approach to space is an extension of the discussion, in Chapter Two about Australia's support for the international treaty regime and, in Chapter Three, about Australia's status as a middle power.

The discussion in Chapter Two noted that Australia is one of only 18 nations to have ratified all five of the space treaties. The discussion in Chapter Three was from the perspective of the structure of the international system and the role and influence of middle powers within that structure. The emphasis in this chapter is on Australia's identity and influence internationally – irrespective of whether being a middle power confers particular responsibility, privilege, or authority in relation to world affairs generally, and to space in particular.

4.4.1 The Limits to Influence in World Affairs: Harbingers

Before the German invasion of Poland in 1939, the United States had started to give attention to the possibility of having to fight wars simultaneously against the Axis powers (Germany, Italy and Japan). The fourth of five options in the so-called RAINBOW war plan was:

> "a "Germany-first" strategy, in conjunction with European allies, with a strategic defensive against Japan in the Pacific" (Stoler, 2016).

This strategy was formally adopted by Roosevelt and Churchill in 1941. Australia had no direct part in this decision making.

In 1943, The United Kingdom and the United States began to plan for a post war world in which the Allies were the victors. Australia was one of several of the smaller allies that were not consulted or whose suggestions were flatly rejected by the great powers; evidence of limited influence.

Key decisions about the post war shape of Europe and the global order were made by the leaders of the Soviet Union, the United Kingdom and the United States at a series of face-to-face meetings held in Tehran (1943), Yalta (February 1945), and Potsdam (July/August 1945). The smaller allies, including Australia, were not involved and complained about not being consulted. The fundamental reason for this was their lack of great power status (Hasluck, 1970, p. 593).

4.4.2 Creating the United Nations

As mentioned earlier, Australia played an active role in the San Francisco conference from which emerged the United Nations Organisation. There are differences of opinion about the value and impact of the contributions of the smaller allies. Assessing Australia's contribution, Hasluck, in the *Official History*, made two salient points:

- Australia proposed 38 amendments to the draft UN Charter of which “26 were either adopted without material change, adopted in principle or made unnecessary by other alterations . . . a significant contribution” (Hasluck, 1970, p. 507).
- As an elected member of the Executive Committee of 14, and hence the Coordination Committee, Australia was involved in the day-to-day management of the conference and went on to become a member of the Executive Committee of the Preparatory Commission that was established to bring the United Nations into being. (ibid, pp. 507-8).

Hasluck concluded:

> “Australia was a good ally, but it was one with an independent mind and a practice not merely of speaking its mind but of shouting to make sure it was heard” (ibid, p. 629).

From 1942 Australia was unremitting in bringing others to a “truer understanding” of the situation in the Pacific.

> “It expressed not regionalism, but a view, established when Australia first fought in Europe that, in the modern world, war, peace and security are global” (ibid, p. 629).

The not insignificant role played by Australia in the formation of the United Nations cemented its voice as a nation committed to what is now referred to as the international rules-based order. In space matters, in the 1950s and 1960, this translated to support for the United Kingdom at Woomera and later the United States (Moreton, 1989). Also, experimentation into the structure and characteristics of the upper atmosphere and ionosphere continued and possibly boosted by Australia’s involvement in the International Geophysical Year in 1957 (Dougherty, 2006).

Australia participated in the early discussions sponsored by the United Nations about regulating space. In June 2018, the Australian representative at the UNISPACE+50 High-level Segment, 61st Committee on the Peaceful Uses of Outer Space (COPUOS), reminded delegates that:

> “Australia was one of the 18 nations to join the inaugural COPUOS in 1958. When the UN General Assembly established COPUOS as a permanent body in 1959, Australia was one of its 24 founding members. Over the years we have also had involvement in the subcommittees; notably, Australia continuously chaired the Scientific and Technical Subcommittee for over 30 years” (DFAT, 2018b).

A succession of governments signed all five of the space treaties. Australia was a model international citizen in terms of upholding the ideal of space being a commons from which all of humankind could derive benefit. Also, by hosting launch programs and joint facilities, it was assisting its allies and the West, more broadly, to embed the rules-based order that emerged from World War 2 (DFAT, 2018c).

The emergence of China as a near competitor to the United States, political uncertainty in the United States under the Administration of President Trump and the emergence of populist parties across the Western world are combining with technological change to challenge the rules-based order that emerged from World War 2.

Australia is attempting to determine how to respond to these power shifts of global consequence. The 2017 Foreign Policy White Paper was unequivocal that Australia would work to strengthen its alliance relationship with the United States:

> 'Our alliance with the United States is central to Australia's approach to the Indo–Pacific. Without strong US political, economic and security engagement, power is likely to shift more quickly in the region and it will be more difficult for Australia to achieve the levels of security and stability we seek. To support our objectives in the region, the Government will broaden and deepen our alliance cooperation, including through the United States Force Posture Initiatives" (DFAT, 2017b, p. 4).

The extent to which Australia might be prepared to go, not only to advocate for but to defend, the rules-based order, both in general terms and with particular respect to space, is unclear. In a speech in October 2018, the Secretary of the Department of Foreign Affairs, Frances Adamson, emphasised the importance to Australia of the international rules-based order including in the space domain (DFAT, 2018c). She noted that government and other Australia actors are increasingly aware of the dependence of the national, regional and global economies on the services and data provided by satellites, and informed her audience that Australia was participating:

> "…in a Group of Governmental Experts on Further Practical Measures for the Prevention of an Arms Race in Outer Space. The Group has been mandated to consider and make recommendations on substantial elements of an arms race in outer space, including inter alia, on the prevention of the placement of weapons in outer space. Assuming that consensus is reached, the Group will deliver its report to the Secretary-General in 2019" (DFAT, 2018c).

Involvement in the Group of Government Experts (GGE) suggests that government is determined to ensure that Australia's voice is heard in these discussions. This is an example of Australia becoming involved as a middle power in discussions of importance to humanity.

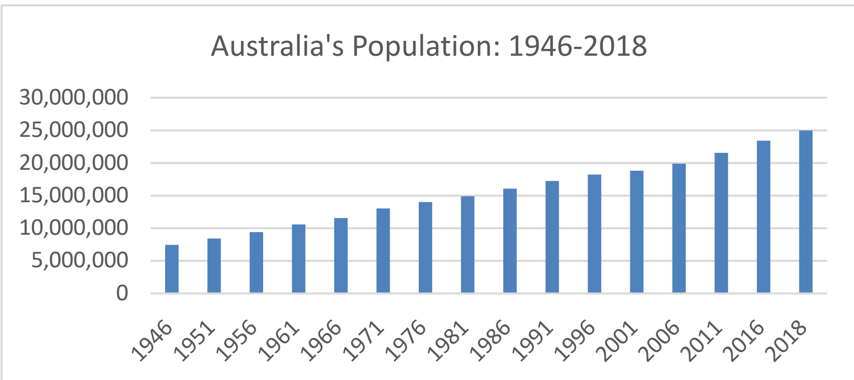
4.5 Driver 5: Opportunity costs

A former State Treasurer once remarked in a private aside that, from the perspective of politicians, "Space is expensive and run by geeks". In the Treasurer's experience, at least, the individuals who came to his office seeking money for space projects were mostly scientists and engineers who were seeking funding to research and develop technologies of interest to them. Business cases and the social and commercial potential of their plans were often not well-developed (Biddington, 2013a).

Australia's economic and social development, as noted in the first section of this Chapter is defined by a small population that occupies a very large area of land and with responsibilities that extend well beyond the continent to the surrounding oceans and the Australian Antarctic Territory. A small population leads to a correspondingly small tax base, which has presented many challenges to the Commonwealth and the States in providing basic infrastructure.

Figure 4.7 is a graph of Australia's population growth from 1946 to 2018. It shows that in the first 35 years of Australia's involvement in space activities (from 1946-1981), Australia's population doubled from around 7.5 million to 15 million people and that a further 10 million people have been added to the population since 1981.

Figure 4.7. Australia's population: 1946 to 2018.



Source: Australian Bureau of Statistics

Two examples illustrate the challenge faced by a small population attempting to develop and sustain infrastructure across a large continent and contiguous ocean areas. The Eyre Highway is the road that crosses the Nullarbor Plain connecting the eastern States to Perth in Western Australia. It was not fully sealed until 1976. A point of comparison is that the Canadian Government completed the Trans-Canada Highway in 1962 (Trans-Canada, undated).

The north-south railway connecting Adelaide to Darwin was not completed until 2004 (Railway Technology, 2019).

Calls for a government funded national space program are in direct competition for funds to meet basic demands. Further, as will be discussed in later chapters, the business cases advanced in favour of a national space program have been less than compelling and have lacked essential political support. A case can be made that the Commonwealth showed considerable foresight in the space investments it did make in the early years, notably in:

- Astronomy and ionospheric and atmospheric physics, leading on the one hand to international scientific recognition and, on the other, to over-the-horizon radar technology which continues to make an important contribution to Australia's security; and
- The acquisition and processing of data from remote sensing satellites for geological and land use purposes and for weather forecasting and climate monitoring.

These investments satisfied the same basic demands for community services, as did investment in road and rail infrastructure.

Companies that have sought government backing for particular space projects have often framed their cases around the technology at their disposal and that they are trying to sell rather than on an analysis of the market needs that have the manifest support of users.

Requests for government investment, often as an 'anchor tenant' to provide start-up capital, have come from a 'technology push' and not from a 'user pull' perspective; solutions looking for problems. The failed AusBIRD project is an exemplar of this approach.

In 2006-7, a project called AusBIRD was launched in the State of Victoria. A Victorian company, Euro Pacific Strategies, led by a former State Treasurer, Mr Tony Sheehan, teamed up with the German space agency (DLR) to construct a constellation of eventually eight satellites, that would be launched to detect bushfires in Australia and elsewhere in the world. AusBIRD asserted that the information from the satellites would substantially improve detection, response to and control of fires (DLR, 2008). Proven infra-red sensors developed by

DLR, and flown on the BIRD satellites, were at the core of the proposal and there was no question about the quality of the sensing technology (Hanowski & Kuch, 2002).

Firefighting, and emergency response more generally in Australia is a State and Territory responsibility. Money is disaggregated and there is no easy mechanism for bringing it into a common pool. The proponents of AusBIRD failed to appreciate that they would need to deal with numerous governments if they were to have any chance of raising the funds they sought to start the project. Also, the fire authorities made clear to the proponents that their sole interest was to obtain data from satellites that were timely, accurate and relevant. The fire authorities had no interest in becoming satellite operators (Biddington, 2008a). The German engineers were puzzled that fire authorities did not quickly embrace AusBIRD. In the engineers' view, the benefit in terms of data quality was obvious. The proponents of AusBIRD failed to address how data from the proposed satellites would be integrated into the overall firefighting system and whether the data represented an incremental or transformational opportunity to Australian firefighters. The Government of South Australia signed a letter of intent with AusBIRD but the project did not proceed (Government of South Australia, 2008).

In summary, the proponents of AusBIRD failed to understand and address the whole system.

AusBIRD's chances of success may have improved had fire authorities, insurance companies, and other potential beneficiaries or end users of the technology been convinced of the value of the system. Building this level of support takes time. The process is political, demands patience, and costs money. AusBIRD is not an isolated case.

A company called AstroVision, attempted a not dissimilar approach to AusBIRD and also foundered. Little evidence remains of AstroVision's brief existence. However, there is an interview with the company's CEO, Shubber Ali, that sets out the company's plans and ambitions (The Space Show, 2005). Astrovision tried to persuade the Commonwealth and State and Territory governments to become anchor investors to underwrite the cost of building and launching a series of weather satellites. Data from the satellites would be streamed to mobile devices at a small per unit cost and would inform users about current weather (Biddington, 2004). The Bureau of Meteorology (BoM) already provides a service similar to that proposed by Astrovision. The BoM system, based mainly on data from ground-based rain radars has a limited predictive capability, is provided at no cost and is readily available via the BoM website (BoM, 2019). Astrovision could not convince investors how or why the satellite-based sensors that it proposed would deliver a better service to the service already in place.

In 2009-10, an Italian company, e-Geos, entered into a small contract with the Land Property and Management Authority (LPMA) of NSW to bring a mobile ground station to Australia. The aim was to demonstrate the capability of the Cosmo-Skymed infra-red satellite system initially in the context of emergency response to natural disasters – fires in the south and floods in the north over the Australian summer (Cosmo-Skymed, 2018). The trial was conducted in August 2010 when there was neither fire nor flood against which to demonstrate the capabilities of the system. A further initiative to conduct a trial over the following summer did not proceed because e-Geos was not willing to accept just in-kind support to run a trial in Canberra. e-Geos sought a substantial amount of cash as well which none of the potential trial participants were prepared to pay because of the unplanned and opportunistic nature of the activity. The mobile ground station spent the summer packed-up on its trailer in the LPMA yard in Bathurst in regional NSW; a lost opportunity for all concerned (Biddington, 2010b).

The AusBIRD, Astrovision and e-Geos/LPMA proposals were 'technology push' initiatives. They sought to capitalise on existing satellite technologies the data from which would be sold into new markets in Australia. None of these initiatives, however, were able to articulate a compelling business case that demonstrated value for money and addressed the question of opportunity costs for potential investors.

As these initiatives fell away, a new generation of space entrepreneurs and space researchers began to emerge in Australia. These people and the companies they have formed are intent on developing an upstream space sector in Australia based initially on cubesats and small launch systems. Others are seeking to develop downstream applications some of which have the potential to transform current business practices in niche areas. Costs are relatively low, and the aims and objectives are more closely aligned to research and development activities and budgets than to larger commercial investments at least in the first instance. These activities are the Australian instantiation of Space 2.0 discussed in Chapter Two.

4.6 Chapter Summary

This chapter concludes that Australia's geography, extant capabilities, and commitment to the international rules-based order are necessary conditions for investment in the long-term safety and security of the orbital space environment.

The drivers discussed stand, in their own right, as independent variables. They are the keys that explain or provide the rationale for Australia's involvement with space activities since the 1940s. National security interests and alliance obligations have been the major policy determinants and the secrecy that has surrounded these activities has militated against the development of a broader national conversation about Australia's interests in space.

A fundamental principle of sovereignty is that national governments are obliged to do what is necessary to defend the nation's borders, the populace and their livelihoods (Crick, 1968). Australia's critical infrastructure and economy and society more generally are so dependent on secure and assured access to data from satellites that governments now have an unavoidable obligation to pay attention to space security as an essential element in the achievement of broader economic and national security interests (TISN, 2015). The Australian Government is making modest investments in Space 2.0 technologies to promote national security interests, including in space security, especially Space Situational Awareness (SSA).

Modest investments to create an environment that encourages private companies to develop a domestic space industry have also been made. Whether this encouragement will lead to something beyond the creation of a niche industry sector remains to be seen.

CHAPTER 5

AUSTRALIAN SPACE POLICY DEVELOPMENT: 1970s-2007.

This chapter addresses the second research question about public policy and spending priorities. Between the 1970s to 2007, behaviours and themes were established that inform the question about policy continuity or discontinuity in Australian space policy. The evidence indicates these behaviours may serve as pointers to future Australian space activities, including, those concerned with the security of the orbital space environment.

5.1 Political and Economic Context

In November 1975, in controversial circumstances, the Australian Labor government led by Gough Whitlam was sacked by the Governor General (Hocking, 2012). A Coalition government (Liberals and the Nationals)., led by Malcolm Fraser came into office (Strangio et al., 2017). Fraser led the Coalition parties to electoral victories in 1975, 1977 and 1980. He lost the 1983 election to the Labor Party led by Robert (Bob) Hawke (Jaensch, 1997).

During Fraser's Prime Ministership the economy languished, there was a high level of industrial disputation and unemployment was high. The Australian economy was protected by high tariffs and was becoming increasingly uncompetitive on global markets. Fraser's policy interests lay more in international affairs and in promoting multiculturalism than in economic reform (Carney, 2015).

In presenting the Hawke government's first Budget in 1983, the Treasurer, Paul Keating, presented some stark numbers:

> "This Government inherited an economy undergoing its worst recession in fifty years.
>
> Activity, both in the farm and non-farm sectors, began to weaken almost two years ago and was still falling when the Government came to office.
>
> Gross Domestic Product has declined by 4.5 per cent from its pre-recession peak.
>
> The labour market deteriorated even more sharply than this figure suggests.
>
> Nearly three-quarters of a million Australians were already out of work when the Government took office.
>
> Unemployment had risen by 263,000 during the previous twelve months.
>
> Inflation, at 11.5 per cent, was running at more than double the OECD average and was accompanied by high interest rates" (CPD, H of R, 1983, p. 44).

In the weeks between the election and the opening of Parliament, Hawke convened an economic summit that included business leaders, union leaders, Federal and State politicians, in Canberra (Hughes, 1998). An accord was struck between business and the unions, setting the scene for a decade of macro and later micro economic reform. Under Hawke, and his successor, Paul Keating, several large government-owned business enterprises were fully or partially privatised, including the Commonwealth Bank, QANTAS, TAA (a domestic airline now absorbed into QANTAS), and ANL (the Australian National (shipping) Line). Telecom, the government-owned telecommunications monopoly was also partly, and later fully, privatised (Hughes, 1998).

In 1996, the Labor Party, led by Paul Keating, lost the election and a Coalition government led by John Howard came to office and remained in place for 11 years. The first Budget of the Howard government was harsh. The size of the Public Service was reduced and funds were removed from functions traditionally performed by public sector organisations, including in health and education (Strangio et al., 2017). The government, which had firmly embraced neo-conservative economic theory, believed that these functions were better performed by the private sector where competition would lead to improvements and efficiencies (ibid, 2017).

National security and border protection issues played to the government's advantage, its industrial relations policies did not. By 2007, there was mood for change in the electorate and in November of that year the Labor Party, led by Kevin Rudd, was returned to the Treasury benches. John Howard even lost his seat (Megalogenis, 2008).

The following sections show how space policy and investments were influenced by these broader political and economic forces from the decision by the Fraser government to establish a wholly government owned satellite communications company, called Aussat, in the late 1970s until the election of the Rudd Labor government in 2007.

5.1.1 Aussat

In 1979, the Liberal Coalition government led by Malcolm Fraser announced the creation of a government-owned business enterprise, Aussat (Dougherty, 2017). The decision to establish Aussat was framed in terms of a discussion about telecommunications policy (Paltridge, 1989). Until 1975 postal and telecommunications services were delivered by a government owned and operated monopoly, the Postmaster General's Department (PMG). The Whitlam government split the PMG into two in 1975, creating Australia Post to deliver the mail and Telecom Australia to deliver domestic telecommunications services. The Overseas Telecommunications Commission (OTC), responsible, as the name implies, for connecting

Australia to the world, was retained as a separate entity (Hughes, 1998). Media interests, notably Publishing and Broadcasting Ltd (PBL) the board chair of whom was Mr Kerry Packer, sought to end Telecom's monopoly and to expose the Australian telecommunications market to price competition (CPD H of R, 1979, p. 279). PBL provided a report to the government prepared by a US satellite communications expert, Mr Donald Bond, which proposed a relatively modest satellite communications system that would link Australia's capital cities. It would allow content, notably for television, to be moved around Australia at much reduced cost to the monopoly service provided by Telecom Australia (Paltridge, 1989).

The government's response was to establish a Task Force in September 1977 to "inquire into all aspects related to a national communication satellite system for Australia" (NCSS, 1978, p. iii). The Task Force, chaired by Mr Harold White, the General Manager of OTC, delivered its report to government in July 1978 and recommended:

> "The introduction of an Australian national communications satellite system and that arrangements for its provision be commenced as early as practicable" (NCSS, 1978, p. xiii).

The representative of the Department of Finance on the Task Force dissented from this recommendation arguing that the potential improvements that the national communication satellite system promised to deliver to Australia's already sophisticated telecommunications system could not be justified on grounds of cost (NCSS, 1978).

The Fraser government accepted the recommendations of the Task Force, against the advice of the Department of Finance. Aussat Pty Ltd was established in November 1981 as a wholly-owned Government Business Enterprise (GBE) (Paltridge 1989). In May 1982, Ian Sinclair, the Minister for Communications, made a lengthy statement to the House about Aussat. He described the project as:

> "…an inspirational undertaking for our nation, comparable to the Snowy Mountains scheme, the Indian Pacific standard gauge trans-Australia railway link and the ANZCAN-Australia-New Zealand-Canada-communications cable project" (CPD H of R, 1982, p. 2406).

He spoke about maximising Australian involvement in the project and noted that the contractor (the Hughes Corporation) had offered to include AU$5.1m of Australian content in the project, which he described as:

> "…significant having in mind the high technology involved in the manufacture of the space components of satellite systems and the lack of existing Australian capability in the satellite field" (ibid).

The Minister concluded his statement as follows:

> "The Government earnestly hopes that as we get closer and closer to the launch date in 1985 more and more Australians will show an entrepreneurial zeal in helping to establish our satellite system as a truly important national project of benefit to all the people of this country" (ibid).

Eventually, Aussat would operate a constellation of three capable communications satellites built by the Hughes Corporation in North America (Wade, 2017). Aussat began to earn revenue in 1985. However, the company lost money in all but one year of its operations. At the time of its sale in December 1991, Aussat had accumulated AU$799 million of debt, which the Commonwealth agreed to pay to dispose of the business to a new company called Optus (JCPA, 1994). Optus was granted Australia's second telecommunication licence and one element of the agreement was that Optus would take a debt-free Aussat off the Commonwealth's hands. The issue of the second licence was a major change to the Australian telecommunications sector because the monopolies enjoyed by Telecom and OTC came to an end (Dougherty, 2017).

Aussat resulted from developments in telecommunications technology coupled with the development of telecommunications policy. Satellites provided a means to achieving a set of broader telecommunications policy ends (Fraser, 1983). There is no evidence that the Fraser or Hawke governments regarded Aussat as providing a gateway into the development of an Australian space industry.

5.2 The Madigan Report and its Consequences

In March 1984, The Department of Science and Technology and a commercial entity, Auspace, jointly sponsored a symposium to explore whether Australia should develop its own space capabilities (AATS, 1985). This was the genesis of the Madigan Report. In July 1984, the Hon Barry Jones the Minister for Science and Technology, invited the Australian Academy of Technological Sciences (AATS) to conduct a review into Australia's space activities. The AATS formed a Working Party, chaired by Sir Russel Madigan, a respected mining company executive. The Working Party's report was published in June 1985 with the title *A Space Policy for Australia* (AATS, 1985). This report is known commonly as the Madigan Report, named after the Chair of the Working Party.

A figure quoted at the time was that Australia would spend more than AU$400m on operational space systems by the end of 1985 (AATS, 1985). The report found that Australia had the technical and industrial capacity to support a national space program. However, there was a ‘Catch 22’ situation to be resolved, which Madigan described thus:

> “We cannot enter the market without first demonstrating the ability to produce space-qualified equipment and we cannot gain this experience without first entering the market” (ibid, p. 4).

Madigan warned that the private sector lacked the resources to “carry the rest of Australia on its back in the space age” and further:

> “The commitment to a space programme must be a government decision, not a commercial one. It is a decision to ‘be in it’, or be left behind – to maintain an optimum degree of self-determination or become dependent on others” (ibid, p. 2).

Madigan recommended that an investment of AU$100 million over five years by the Commonwealth would resolve the ‘Catch 22’ and see Australia on its way to becoming a spacefaring nation (ibid, p. 55). The government provided AU$2.5m to initiate what became known as the National Space Program (NSP) in the FY1985/86 Budget (CPD H of R. 1985).[4] Mr Chynoweth, the government member who spoke to the Appropriation Bill hailed the expenditure as:

> “…the dawn of Australia’s move into the infinite opportunities that space offers Australia” (CPD, H of R, 1985, p. 2372).

The Madigan Report made 16 recommendations that aimed to achieve industry, technology and scientific goals, initially funded by government. Numerous recommendations were made about strengthening Australia’s remote sensing capabilities, initially with investment in ground stations and data processing systems and later with investment in Australian designed and manufactured space-based sensors and satellites. The report also recommended that a central agency be established as a statutory authority with its own board of management to coordinate the space program that the agency was expected to generate. The report acknowledged the military origins of human activity in space and stated directly that “. . . most ‘space companies’ are involved in both military and civilian space activities” (AATS, 1985, p. 64).

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[4] The Australian financial year begins on 1 July and ends on 30 June of the following year.

The dual use of space implications of this statement for Australia's circumstances, however, were not explored. Madigan certainly consulted Defence – those parts of the department responsible for Defence science and technology and for Woomera (ibid, p. 184). There is no evidence in the report of engagement with the policy or strategy areas of the department; a point also made by Ball (Ball & Wilson (eds), 1992, p 326).

The Madigan report was prepared for a junior Minister, the Hon Barry Jones. As Minister for Science, Jones was in no position to draft terms of reference that addressed defence and national security aspects of space. He had to be content with what he could achieve within the confines of his portfolio. Jones did have some success and in 1986 the government established the Australian Space Board (ASB) as a non-statutory body within the industry portfolio (then the Department of Industry, Technology and Commerce – DITAC). In 1987, the Australian Space Office (ASO) was created to provide a secretariat to the ASB and to manage the anticipated national space program.

In 1990, the ASO through DITAC, published an *Australian Space Industry Development Strategy*. It contained a lengthy foreword attributed to the Minister of the day, Senator the Hon John Button, which explained why, except perhaps in niche areas, developing a viable space industry in Australia would be difficult to achieve (DITAC, 1990). The Strategy outlined what might or could occur but lacked explicit financial commitment.

In April, May and June 1992, three reports of consequence to Australia's space development were published. They were:

- A report prepared by the Senate Standing Committee on Transport, Communications and Infrastructure with the title *Developing Satellite Launching Facilities in Australia and the Role of Government*, based on submissions and hearings conducted from July 1991 (Senate, 1992).
- A review of the Australian Space Office (ASO) conducted by the Bureau of Industry Economics (BIE) with the title *An Economic Evaluation of the National Space Program* (BIE, 1992).
- A review by an Expert Panel, established by the ASO, with the title *An Integrated National Space Program*, to review the performance of the ASO in its first five years of operation and to suggest future directions, as well (DITAC, 1992).

The Senate Committee focused on the proposals then in front of government to establish launch facilities and to offer a broader range of launch services, one at Woomera and another on Cape York. The Committee recommended that legislation and regulations be developed to support such launch activities as might occur in Australia in the future. It also recommended the establishment of a national space policy council. The Committee approached the question of Commonwealth investment and industry support cautiously. If the principal commercial backers proceeded with the launch proposals, there might be a case for carefully defined Commonwealth support.

> "The final decisions on whether to proceed with the developments will be on the commercial judgements made by the respective proponents. However, based on the evidence received and the fact that no launching service in the world operates without substantial government subsidy, the Committee recognises that for such developments to be commercially viable, the positive support of governments would be needed in the form of support with legislation, regulation and international negotiations and at the very least infrastructure assistance" (Senate, 1992, pp. 107-8).

However, the Committee also recommended that:

> "…if current industry assistance schemes are found to discourage or inhibit space industry development proposals, they should be reviewed. Furthermore, such reviews should not be confined to the space industry but should be conducted to encourage development proposals from other industries" (ibid, pp. 108).

On the one hand, the Committee seemed to say that for a launch industry, to succeed, it would need direct government financial support. On the other hand, the Committee seemed to say that space should not be singled out for special treatment and that any specific initiatives that might be set in place to support the space industry should apply to other industries as well.

The team from the Bureau of Industry Economics and the members of the Expert Panel gathered considerable material in tandem by holding joint meetings with numerous interested parties (DITAC, 1992). Notwithstanding these shared experiences and shared data, the two reviews came to fundamentally different conclusions as indicated below.

The BIE report concluded that the ASO was not delivering value for money and that the ASB and the ASO should be wound up with their functions re-distributed to other departments and agencies. The last two sentences of the BIE Report are plain:

> "While Australia has geographic advantages in relation to launch sites, this [is] not complemented by parallel advantages in launch technology or manufacture. Australia's economic interests would thus seem to be best served by focussing on

> those areas of high technology – primarily outside the space sector – where it has competitive strengths and readier access to more open markets" (BIE, 1992, p. 123).

In contrast, the Expert Panel report concluded that overall the ASB/ASO "have given good account of themselves and have, with minor exceptions, provided value for money" (DITAC 1992 p.xi). The Expert Panel report notes that its members had an additional benefit of being able to read and comment on the BIE report. The Expert Panel report devotes a chapter (Chapter 6) to discussing and then rejecting the recommendations of the BIE report before proposing instead an Integrated National Space Program (INSP) to guide Australia's future space development (DITAC, 1992, pp. xv-xxi)

Both the BIE and the Expert Panel reports emphasised that Australian space development efforts should focus on building remote sensing capabilities. This was at variance with the actual priorities of the ASO which was investing time and effort to establish the viability of a launch facility on Cape York in far north Queensland. The Expert Panel commented:

> "If the Cape York Spaceport proposal does not eventuate, the criticism that the Executive Director spent too much time and resources on Cape York would be vindicated" (ibid, p. 27).

More broadly, the Expert Panel noted that the ASB/ASO had operated in difficult circumstances. It lacked staff, clear direction and, perhaps most importantly, suffered from "apparent isolation and inability to win political support" (p. 27). Lack of high-level support translated to a lack of money and human capacity to deliver on its more ambitious goals. The AU$100 million recommended by Madigan did not materialise. The evidence suggests that three of the more important reasons were:

- *Poor ministerial advocacy:* According to one member of the Expenditure Review Committee (ERC) that was responsible for crafting the Budget, the Minister responsible, Barry Jones, was not effective in arguing his case for money to implement the recommendations of the Madigan Report. "It was a pity, but Barry was just too emotional about his portfolio to be able to argue for it, and as a result it lost out" (Ralph Willis quoted in D'Alpuget, 2010, p. 148).
- *Flaws with the Madigan Report:* Although the government "accepted the thrust of the Madigan Report's Recommendations", some of its proposals were considered to be, "too ambitious" (Ball & Wilson (eds), 1992, p. 358).

- *Bureaucratic resistance:* Key departments and agencies were not supportive of the ASO/ASB. Dr John Boyd, the former Deputy Director of the ASO, in evidence to the 2008 Senate inquiry (discussed in Chapter Six) said:

  "…we were always facing a lack of concerted support at the higher levels in departments and among ministers . . . there certainly was a lack of enthusiasm for it [the ASO], apart from being undermined in some quarters" (Senate, 2008, p.49).

  Taking this point a step further, Boyd said that the main agencies with space interests, Defence being the "big one", were supportive at the level of rhetoric but made clear that they would not "pay for any of it" and would not be told what to do (ibid, pp. 49-50).

The table below, reproduced from the BIE Report, shows the annual appropriations received by the ASO in the first seven years of its existence.

*Table 5.1. Annual expenditure under the National Space Program: 1985-86 to 1991-92.**

Financial Year	*Approvals ($'000)*	*Expenditure ($'000)*
1985-86	3,121	3,069
1986-87	14,202	5,250
1987-88	60	3,150
1988-89	2,245	5,388
1989-90	1,096	2,444
1990-91	6,063	5,469
1991-92	7,463	3,172
	34,250	27,942

* The Australian financial year begins on1 July and ends on 30 June of the following year.

Notwithstanding its budget constraints, the ASO provided funding for two major scientific instruments, the Australian Endeavour Space Telescope and the Advanced Along Track Scanning Radiometer (AATSR) and it also funded three research centres (James, 1998, Dougherty, 2017). Much of the ASO's effort, however, over the course of its existence, was to facilitate the development of an Australian space launch capability.

Throughout the years of the ASO's existence several launch proposals were placed before the Commonwealth, the most promising of which was an initiative to launch large satellites into GEO from a site on Cape York. In May 1994, the newly formed Australian Space Council (ASC) informed the Minister of progress with the Cape York project in the following terms:

> "Five consortiums have attempted to raise the necessary capital of around AU$900 million for development of the site and the operations proposed for the Spaceport. The Sydney-based Euro-Pacific Capital Group Pty Ltd is the sole remaining company that is attempting to raise capital for the first stage of the project.
>
> If the project were to attract funding, the Commonwealth Government remains committed to providing appropriate support and encouragement for the development of a Cape York launch facility" (ASC, 1994, p. 3).

Although obtaining finance for any launch initiative from Cape York was proving difficult, the ASC remained optimistic and in a further section of the same report proposed a "project of national significance," whereby the government would commit to:

> "…fund the launch of two rockets from Australia with development agreements with private interests with confirmed capital" (ibid, p. 20).

In 1995 the ASC confirmed to the Minister that establishing a commercial spaceport in northern Australia remained a priority (ASC, 1995, p. 5). The Minister was also advised that two commercial operators remained active with projects.

In 1996, Space Transportation Services Ltd (STS), one of the companies that had encountered financial difficulties at Cape York, moved its attention to the Northern Territory with a plan to launch Proton rockets from a site that was eventually selected. In February 1998, STS announced that the project would not proceed because international partners had withdrawn their support citing cost considerations. (James, 1998; Dougherty, 2017).

There was one further serious attempt to develop a heavy-lift launch facility on Australian territory in the period covered by this Chapter (the late 1970s – November 2007). This was the attempt to develop a spaceport on Christmas Island in the Indian Ocean through a company known as the Asia Pacific Space Centre (APSC). The project was granted Major Project Facilitation status by the Australian Government under which the government funded upgrades to the airstrip and other infrastructure on Christmas Island (Dougherty, 2017). APSC planned to launch its first satellite in 2002 and to be launching 10-12 satellites annually by 2005 (APSC, 2000). APSC failed to meet is development milestones and the project has not progressed (SMH, 2006).

During the period that these launch initiatives were being contemplated, the launch market, especially for large satellites being placed into GEO was tightly constrained. The Senate report published a table, provided by the ASO, which indicated that in the years 1995 to 2005 only

133 commercial satellites were projected for launch and some of these would be launched on the same vehicle. As few as four commercial satellites were projected for launch in 1998 and 1999 (Senate, 1992, p. 60).

Paltridge noted that in 1989 and 1990, there were fewer than 15 commercial launches in each of those years and that this included US military payloads launched on commercial vehicles from the United States (Paltridge, 1992, p. 105). He concluded that:

> "An Australian spaceport would have to contend with the fact that many foreign governments would use their own facilities, regardless of commercial considerations" (ibid, p. 113).

5.2.1 International Comparisons

As outlined in Chapters Two and Three, space activities are global with the weight of activity focussed in a very few countries, all located in the northern hemisphere. International dimensions of human space activities were outlined in a lengthy Appendix in the Madigan Report. The Senate report and the BIE and Expert Panel reports, all devoted whole chapters to commentary about the global space industry as well. Much of the commentary stated the capabilities of other nations without drawing comparisons to Australia. However, the importance to Australia of international collaboration in space matters was acknowledged. The Madigan report noted:

> "The experience of ESA has shown . . . that relatively small economies can obtain equity in a range of space programmes, and develop space industry capability, through international participation" (AATS, 1985, p. 42).

Based on this argument, the sixth recommendation of the Madigan report was:

> Australia should actively pursue the possibility of international collaboration in space and, in particular, of joint initiatives with countries in the East Asian region" (ibid, p. 42).

The BIE report dismissed the suggestion that "participation in space activities is necessary for future competitive advantage should space related activities become a major part of overall economic activity" (BIE, 1992, p. 122). The report also acknowledged that the cases of Canada and Sweden were useful and relevant from the perspective of comparison. Both, however, had advantages not open to Australia, because of their proximity to the United States and European markets respectively (ibid, p. 122). This led the BIE report to conclude, as already stated but worth repeating, that:

> "Australia's economic interests would thus seem to be best served by focussing on those areas of high technology – primarily outside the space sector – where it has competitive strengths and easier access to more open markets" (ibid, p. 123).

The Expert Panel report discussed international trends in civil and defence space developments and included a section on international perceptions of Australian space activities. The quality of Australia's science and scientists, Australia's competence in Earth observation and professionalism and ingenuity with respect to ground systems was noted around the world. There was "universal criticism [about] the lack of clarity in organisation, confusion as to who does what and, above all, who is able to fund what" (DITAC, 1992, p. 22). Australia's geographic and geopolitical advantages were noted but they would only come into effect "when other conditions for cooperation are right" (DITAC, 1992, p. 23). The Expert Panel concluded:

> "…the common theme is the need to clarify Australian space policy and organisational responsibilities. Without this, increased cooperation abroad will be difficult in the extreme – even participation at international symposia presently fails to make its full impact" (ibid, p. 23).

5.2.2 Defence

The Senate, BIE and Expert Panel reports all acknowledged that Defence had an important stake in Australia's future space activities, but none explored the implications of these investments from an industry development and sustainment perspective. Concerning launch services, the Senate inquiry report quoted advice from Defence that was unequivocal. For example, Defence:

> "…does not accord a significant strategic or force structure priority to Australia possessing its own launch facilities and has no interest in providing resources or financial assistance towards their development" (Senate 1992, p. 68).

Nevertheless, if a launch facility were to be developed, especially at Cape York, Defence noted it may make use of the facility – if it met the needs of Defence and if it were cost effective (ibid, p. 68).

The BIE Report, in less than one page, outlined the principal interests and involvement of Defence in space activities. The Report described Defence as a "customer, not a developer, of space technology" and noted that it was participating in two space-related Cooperative Research Centres and that the Defence Science and Technology Organisation (DSTO) undertook some space-related research (BIE, 1992).

The Expert Panel noted that the end of the Cold War did not seem to have dampened military investment in space and that future spending would likely focus on "surveillance, arms verification and safe communications, and the special requirement for launches at short notice" (DITAC, 1992). The Panel foreshadowed that defence programs could be expected, where possible, to make the most of civil programs and concluded:

> "…it is more than ever essential for civil space programs, even the most modest, to develop the closest possible cooperation with the defence space community and to coordinate priorities. . . the alternative to maximum cooperation is the expensive development of two parallel programs, and the duplication of costly – and under-used – facilities" (DITAC, 1992 p. 21).

With respect to the situation in Australia, the Expert Panel recorded that it had received comments about the "unsatisfactory integration of civil and defence aspects of space activities in Australia" and concluded that "the lack of interaction between Defence and the ASB/ASO is an important weakness in the efforts to develop a real NSP" (BIE, 1992, p. 88).

This was also the view of Desmond Ball. In a 1992 paper, he commented that the "lack of interaction between Defence and the ASO must rank as one of the most important weaknesses in the efforts to develop a national space policy" (Ball & Wilson (eds), 1992, p.330). In this paper Ball pointed out that Defence had no representation in the ASO or the ASB and, similarly, was not represented on a series of expert working groups that the ASO set up to better inform its work.

5.2.3 The Australian Space Council

As noted above, the Australian Space Council (ASC) was formed in 1994. This occurred with the passage of the Space Council Act (Australian Government, 1994). Madigan had recommended in 1985 that civil space matters should be overseen by a statutory body, somewhat independent of the government of the day. Nine years later this recommendation was given effect. The Bill was waved through the Senate as one of several unopposed Bills on the last sitting day of 1993 (CPD, Senate, 1993, p. 4761). Similarly, following a short debate on 9 February 1994 in the House of Representatives the Bill was passed unopposed (CPD, H of R, 1994, p 650). The Bill became law on 25 February 1994 when Assent was given.

A fourteen-member Council was appointed by the Minister. Seven members were drawn from government departments and agencies and seven, including the Chair, were drawn from industry and academe. The Act required the Council to develop and present a five- year plan to government for the development of an integrated space industry. The Act also obliged the

Council to inform the Minister of progress and to revise the plan on an annual basis. The ASC presented its first plan to the Minister in May 1994 (ASC, 1994).

A second version of the plan was issued in April 1995 (ASC, 1995). This was a report on progress made in implementing the 1994 plan. The 1995 plan was approved for public release ahead of formal consideration by government. The reason given was to inform a government ordered "reassessment of the National Space Program [NSP] by the Standing Interdepartmental Committee (IDC) on International Space in consultation with the Australian Space Council" (ASC, 1995, Forward (sic)). The IDC broadly endorsed the NSP but the outcome was pyrrhic (Dougherty, 2017). A new government, with different views about development of the Australian space sector was about to be elected.

5.3 The Howard Government

On 2 March 1996, John Howard led the Coalition parties to a decisive electoral victory over the Labor Party led by Paul Keating. The Howard government chose to implement the recommendations of the 1992 BIE report and disbanded the Australian Space Council and the Australian Space Office in 1997 (James, 1998) as part of a more sweeping set of changes that were driven, in part by ideology and, in part, by practicality.

> "There was also an insistence on deficit reduction to be achieved by further privatisation (sale of public assets) and public sector efficiencies (reducing government expenditure). Public sector modernisation would be accompanied by a transfer of service provision to the private sector (given appropriate market incentives, private enterprise would perform more effectively). Indeed, Howard claimed that particular entrenched 'elites' (bureaucrats and non-government activists in advantaged positions . . .) dominated most programs and much service provision. They must be challenged by opening them up to market competition" (Strangio et al., 2017, pp. 205-6).

The Howard government's first Budget, slashed public sector spending, including the number of public servants employed across all areas of government. Government spending across a range of programs including programs that promoted industry development was also cut (Jones, 2006).

In the mid 1990s, there were at least four proposals before government to establish launch facilities and to offer launch services in Australia. These included:

- The Kissler organisation planned to launch and recover payloads at Woomera.

- The International Resource Corporation (IRC), launching either from Cape York or from Christmas Island.
- The Space Transportation System (STS), launching either from Melville Island or Gunn Point in the Northern Territory, later Cape York was considered.
- The United Launch Systems (ULS) launching from an island located off Gladstone in Queensland (James 1998).

As noted already, none of the launch projects proceeded due to limited demand for launch services, and difficulties in securing financing. A consequence was that civil and commercial space industry development 'wilted', to quote the word used by Matthew James, in a paper he prepared, as a member of the Parliamentary Library research staff, for parliamentarians (James, 1998).

One positive to emerge from these failures was legislation to regulate the space launch industry. The Space Activities Act (Australian Government, 1998), described by Dougherty as a 'world first', became law in 1998 (Dougherty 2017). The Act stood as model domestic space legislation. It has been referred to and adapted by numerous nations seeking to devise domestic legislation that promotes and facilitates space industry development. The Act and subordinate regulations were written with large launch vehicles and satellites in mind.

The Act sought to balance the interests of industry seeking to mitigate risk by providing investment certainty with the obligations that the Liability Convention, in particular, imposes on governments. Basically, the launching State is liable to pay for any damage caused on the ground or in space by a launch vehicle or satellite that has been granted a license by that State. Damage might be a consequence, for example, of a launch failure or collision between satellites. The Australian Government has sought to lay off the financial risks by insisting that companies and others seeking to provide launch services and to launch satellites carry very high levels of costly insurance. More recently, and discussed in Chapter Six, the Act has been reviewed and updated in an effort to facilitate the launch of small Australian satellites, some potentially from Australian launch sites.

5.3.1 Administrative Arrangements

In the Debate in the House of Representatives that led to the passing of the Australian Space Council Bill, one of the speakers was Dr David Kemp. Kemp had pursued an academic career in political science before entering politics as the member for Goldstein, at the time a safe Liberal seat in Melbourne. He later became a Minister in the Howard government. In his speech from

Opposition in February 1994, Dr Kemp gave some insight into the thinking of the Coalition on the arrangements that should govern civil space activities in Australia. He said that

> "Prior to the last election the coalition was of the view that there were advantages in passing the primary responsibilities for the national space program to the CSIRO's Office of Space Science and Applications, sometimes referred to as COSSA. This was to have been overseen by an active Space Council, as currently constituted. Since the last election there have been changes to the management and structure of COSSA and the management and nature of the Space Office. The Space Office is under new management and this new management is, I understand, working well with both the CSIRO and the Space Council" (CPD H of R, 1994, p. 650).

Dr Kemp then spoke about the need to ensure that COSSA and the ASO did not duplicate their efforts and he suggested that the Space Council could employ COSSA on a consultancy basis to develop policy and plans. In the last sentence of his speech, he said:

> "We will be assessing the extent to which the five-year plan facilitates the development of private sector value-added activity from our space involvement and the kind of commitment which the departments and agencies which are members of the council are prepared to make to achieve a balanced and integrated space program (CPD, H of R, 1994, p. 650).

The changes foreshadowed by Dr Kemp were introduced into the 1996-97 Budget (APH, 1996) although not all survived due to broader cuts to CSIRO's budget. The result was that the Howard government closed down the ASO and the ASC. COSSA was also disbanded and a new Cooperative Research Centre for Space Systems (CRCSS) was established. Policy responsibility for civil space matters remained with the Department of Industry, Tourism and Resources (DITR).

The CRC program is designed to facilitate collaborative research between industry, universities and other research organisations. Industry involvement in the CRCSS was limited to four small companies that are identified by blue text in the table below.

Table 5.2. Participants in the CRCSS at 30 June 2002.

CRCSS Participants at 30 June 2002	
Core	**Supporting**
CSIRO	Codan Ltd
University of South Australia	Curtin University of Technology
Queensland University of Technology	Defence Science and Technology Organisation
University of Technology, Sydney	DSpace Pty Ltd
Vipac Engineers and Scientists Ltd	LaTrobe University
University of Newcastle	
Auspace Limited	

Source: CRCSS Annual Report 2001-2002.

The CRCSS was fundamentally an activity funded by government through agencies, notably CSIRO, and six universities. The companies involved, notably Vipac and Auspace, were both investors in and beneficiaries of the CRCSS, providing services to CRCSS for which they were paid.

The core activity of the CRCSS was the Federation Satellite (FedSat) program. FedSat was a signature science and technology project that was established to celebrate the centenary of Federation on 1 January 2001. The satellite hosted five sensors that sought to collect data about the space environment or promote technological development notably in satellite communications.

The initial contract to build the satellite was let to a British company that ceased to trade before the satellite had been completed. Such hardware and software as had been produced was transferred to Auspace, a small Australian company with premises in Mitchell, a suburb of Canberra. This is where Fedsat was completed. The satellite was launched from Japan on 14 December 2002; the launch being a gift from Japan to Australia to acknowledge the centenary of Federation (CRCSS, 2002). FedSat functioned until April 2007 when its battery failed and communications were lost (UniSA, 2007).

The launch of FedSat was greeted with optimism as the dawning of a new industry in Australia that would emerge from the research enabled by the satellite. The Minister for Science of the day, The Hon Peter McGauran, was quoted as saying:

> “I don’t think there has been any other single event in recent memory that has so raised the profile and awareness of science and technology as has the launch of FedSat” (Kingsley, 2003).

The Minister did not talk specifically about space *per se*, but about science and technology more generally. Another article, published by the US-based Earth Observation Portal (EO Portal, 2002) was more explicit:

> The specific mission of CRCSS is to promote Australian space research and to create a favourable and sustainable environment for Australian industry, government agencies and universities, involved in services, applications, and research" (ibid).

In the same article, referring to one of the five experimental payloads on the satellite, the Vice Chancellor of the University of Technology in Sydney, Professor Ross Milbourne said:

> "From these beginnings, we envisage a major expansion in related research activities including communication systems, satellite communication systems and digital signal processing" (ibid).

To complete the FedSat story, a small number of researchers and operations staff gained direct benefit and experience. The University of South Australia's historical highlights page notes that data collected by FedSat:

> "…contributed to the awarding of 37 PhDs and 10 Masters qualifications in space research, successful development and maintenance of satellite ground facilities during operations, and the publication of approximately 750 articles relating to FedSat activities" (UniSA, 2007).

A bid for funding for a follow-on CRC was submitted in 2006 to enable a further tranche of space-related research. The bid was disallowed because the government removed the national interest criterion as one of the metrics on which future CRC applications could be justified and assessed. This policy change effectively scuttled the re-bid which was based heavily on the national interest criterion, in part because of limited interest from potential private sector investors (Biddington, 2006a).

In parallel with development of the CRCSS, the government also entered into a treaty level agreement with the Russian Federation to facilitate civil space cooperation between the two countries, essentially in providing launch services from Australia that made use of Russian launch vehicles. The agreement necessitated amendments to the Space Activities Act. The Explanatory Memorandum that accompanied the Bill listing the amendments, noted that:

> "…The industry is expected to contribute up to $2.5 billion to the balance of payments through till 2010 and to generate several thousand new jobs over the coming decade if it achieves 20 per cent of the international launch market. The National Benefit Cost

> Ratio is estimated at $7.44 per dollar of investment. An estimated 779 new jobs would be created in the first year of operation, peaking at 4,278 in year three and averaging at 2,232 jobs over subsequent years" (Australian Government, Explanatory Memorandum, 2001)

The launch projects that the amendments set out to encourage did not eventuate. However, the numbers indicate the optimism that existed at least in some quarters of industry and government.

The Howard government's civil space policy was eventually outlined in a document with the title *Australia's Space Engagement* (DITR, 2003). This document was first issued in 2003, with revised editions being released in 2004, 2005 and 2006 (Dougherty, 2017). The policy stated support for the development of an Australian space industry sector, providing the private companies took the lead. Government would facilitate as necessary but would not become an anchor investor or underwriter of the sector.

> "The Australian Government's space engagement is user- and market-driven rather than supply-driven or "technology push", with a key objective being to obtain secure and economic access to the benefits of using space" (DITR, 2003, p. 2).

As noted already, the policy stated further:

> "The market failures for the space sector are the same as for most other high-technology industries. These are addressed by generic Government industry programs and do not require a dedicated space program. The Australian Government does not support a centrally funded "space office" or space program . . ." (DITR, 2003, p. 3).

Such intra-governmental policy coordination, as was needed, was achieved through an inter-departmental committee, the Australian Government Space Forum.

Later chapters discuss the changes that led to the establishment of the Australian Space Agency in 2018. On the face, the Agency's establishment represents a major change in policy. Closer examination, however, indicates a high level of policy continuity and the continuance of a bifurcated narrative between space as a national security priority and space as an industry development priority.

In April 2001, a new committee, called the International Space Advisory Group (ISAG) was formed at the instigation of the Prime Minister and in response to a letter he had received from Dr Andrew Thomas, the Adelaide born and educated astronaut. The ISAG's purpose was quite specific, to determine how Australia might contribute to and participate in international space programs, such as the International Space Station (ISS) program (DISR, 2001). A further aim was to develop Australia space industry capability by explicitly leveraging international partnerships from the outset. The ISAG was chaired by Dr Paul Scully-Power, the first person born in Australia to fly in space (internal ISAG correspondence).

The space science and space enthusiast communities invested some effort in the ISAG. The National Space Society of Australia (NSSA) arranged a three-day workshop in Sydney in July 2001, which was attended by more than 30 researchers from various Australian universities and other research organisations. A summary record was prepared and provided to the ISAG (NSSA, 2001). The then Chief Scientist, Dr Robert Batterham, was briefed and a progress report was prepared for the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) (internal ISAG correspondence, undated). A final report was provided to government in 2002 and, to quote Dougherty "was met with indifference by government and no action was taken" (Dougherty, 2017, p. 174).

5.4 Space and Self Reliance

In 2003 and 2004, two PhD theses were written about the prospects for an Australian space industry. The first, submitted in 2003 by Noel Siemon, discussed the strategic factors associated with global technology dependence as they applied to a national space-related innovation system. Siemon argued that Australia needed to move from an uncoordinated, science-oriented approach to space to an approach that balanced science drivers with technology drivers to build a national "network innovation system". Once in place, this system would lead to a reduction of Australia's technological dependence on other nations (Siemon, 2003).

The Second thesis was submitted by James Moody in 2004. Moody argued that if Australia were to adopt a Complex Product System methodology, it could move forward to develop new industries, including a space industry. Moody used the FedSat project as a case study. He concluded:

> "…based on the current space policy and innovation mechanisms in Australia, it is currently impossible for Australia to develop a space industry made up of high value, complex products" (Moody, 2004, p. 343).

Both Siemon and Moody sought to identify the policy settings that would need to change to allow Australia to contribute more fully to increasingly globalised high technology industries, including in the space sector. Both writers, Moody especially, as the quote above from his thesis indicates, were pessimistic.

Globalisation, as explained by writers such as George Friedman (2009) and Thomas Friedman (2005) challenges the meaning of such concepts as self-reliance, technological independence and national capability. Can a country claim to be self-reliant if critical elements of its defence capabilities are manufactured, maintained, repaired and modified, offshore? The 1987 Defence White paper was clear:

> "The capacity to maintain, repair, modify and adapt defence equipment to the Australian environment, independently of overseas sources, is of fundamental importance for our combat effectiveness in all levels of conflict" (DoD, 1987, p. 76).

In 2004, Defence released *The Defence Electronic Systems Sector Strategic Plan* (DoD, 2004). The principal purpose of this document was to state what needed to be done by Defence and by industry to achieve self-reliance. The Plan demonstrated the challenges and difficulties that had to be overcome in translating the high-level objective of self-reliance into industry capability and capacity - actual jobs and skills, factories, test facilities and other necessary infrastructure (ibid).

Space systems barely rate a mention in Defence White Papers and related documents before 2010; a point that is discussed in Chapter Six. The Electronic Systems Sector Plan quoted above, identified five areas of defence electronics where industry capability was considered "…critical for Australia's defence self-reliance". The five areas were military systems integration, electronic warfare systems, mobile military communication, niche capabilities in radar and underwater acoustic technologies (ibid, p. 9). Later in the document, a comment is made about capabilities which "…transcend all three operating environments (land, sea, and air)…" (ibid, p. 86). In understanding what the Sector Plan did not say, a reasonable observation is that, in 2004, space was not an area of concern for Defence from the perspective of industry support. Evidence is presented in Chapter Six that shows a change in this position.

5.5 Developments Beyond Government

Three further events occurred between late in 2004 and 2006 that were precursors to later activities. As will be shown below, they exposed frustrations at the same time as they raised awareness and influenced developments following the election of the Rudd Labor government in November 2007.

5.5.1 The Australian Space Forum

On 2 November 2004, Melbourne Cup Day, 70 or so members of the Australian space community gathered for a one-day Forum in Canberra to consider ways to persuade government to invest in a national space program. Among those present was Mr Jeff Kingwell, who describes himself as an Australian with a "multi-decadal career in managing space projects" (Kingwell, 2014). In 2005, Kingwell published a short paper about the meeting in the journal *Space Policy*. The paper's unpromising title was *Punching below its weight: Still the future of space in Australia*. Its opening paragraph states:

> "Students of space policy have long been puzzled by Australia's apparent aversion to a national space program despite an occasionally manifested space capability. Although such a commitment was recommended by a succession of government sponsored investigations, Commonwealth governments, both Labor and Coalition (Liberal/National), have for at least the past 35 years consciously avoided the type of programme that has been almost universally embraced by developed countries and by an increasing number of developing countries" (Kingwell, 2005).

Kingwell did not elaborate on what he meant by a 'national space program'. Later in the paper, Kingwell described the 70 or so participants in the November 2004 workshop as "space enthusiasts, scientists, engineers, policy makers and representatives of various space-related industries" (ibid). Beyond Kingwell's paper, nothing came of the 2004 meeting.

5.5.2 The Chapman Report and the Space Policy Advisory Group (SPAG)

In March 2005, Senator Grant Chapman (Liberal, SA) brought together an informal group, which he called the Space Policy Advisory Group (SPAG), to help him prepare a personal report for the Prime Minister about Australia's performance in space. Chapman believed that Australia was not doing sufficient to protect its national interests and, at the same time, that industry development opportunities were being missed.

The Group met twice, in May and August 2005. Mr Roy Sach, a former RAAF officer and Defence official with considerable experience in US alliance policy, acted as the Secretary for the group. He drew the key themes together into a report called *Space: A Priority for Australia*, which concluded with an eight-point action agenda and three recommendations. The recommendations were that the government:

- "…acknowledge that space is of strategic national relevance to Australia.
- formulate a national space policy; and

- assign to an agency accustomed to managing broader national issues, such as Department of Prime Minister and Cabinet, responsibility for coordinating the Australian strategic space policy framework" (Chapman, 2005).

Senator Chapman forwarded the report to the Prime Minister, the Hon John Howard, in November 2005. The Prime Minister promptly passed the report to the Minister for Industry, Tourism and Resources, the Hon Ian Macfarlane, and asked him to respond on the government's behalf. The response came in the form of a letter from Minister MacFarlane to Senator Chapman dated 20 April 2007, well over a year later. The letter affirmed that the government's decentralised approach to managing space matters would remain and that there was no requirement for central coordination. On the question of strategic relevance, the letter said:

> "It is the Government's assessment that Australia has adequate access to space capabilities through commercial and inter-governmental arrangements. Reliance on foreign-owned facilities is not unique to space technologies" (MacFarlane, 2007).

Senator Chapman considered the response to the SPAG Report to be something of a personal rebuke. However, during the summer of 2007/8, he worked with other Senators from South Australia to establish a Senate inquiry into Australia's performance in space.

On 24 November 2007, the Labor Party, led by Kevin Rudd, won office. John Howard not only lost the election but lost his seat as well. This change in political fortunes set the scene for the 2008 Senate Inquiry that Senator Chapman helped to initiate. Before discussing the Senate inquiry in the next Chapter, there is one further event that was material to the inquiry being established. This was the South Australian Space Initiative.

5.5.3 The South Australian Space Initiative (SASI)

On 28 August 2006, a meeting was held under the auspices of the South Australian Government's Defence Industry Advisory Board (DIAB) to discuss ways in which a space industry could be developed in South Australia. The DIAB, since re-branded as DefenceSA, was tasked with encouraging the growth of Defence industries in the State. The SASI was the result of an unsolicited offer to the DIAB from a company called Metafilm which, in due course, was contracted to organise a conference that was called the South Australian Space Summit. Metafilm also produced for the DIAB a summary report of the event including recommendations about how to proceed (DIAB, 2006 unpublished; Biddington 2006b). The recommendations were not progressed by the DIAB.

Among those who attended the meeting were:

Dr Andrew Thomas, the Adelaide born and educated astronaut,

Senator Grant Chapman,

Mr Chris Schacht, a former Labor Party Senator and Minister with civil space responsibilities in the early 1990s, and

Senior officials from the Defence Science and Technology Organisation.

Senator Chapman informed those present that he was determined to bring space to the attention of the national parliament. (Biddington, 2006a). In this regard, the SASI served as a further catalyst for the 2008 Senate inquiry.

5.6 Chapter Summary

The Madigan Report set lines of argument that are as familiar today, as they were in the mid 1980s. The role of the Australian Space Agency, created in 2018, is not materially different to the task given to the Australian Space Office in the 1980s. As later Chapters will show, there is remarkable policy consistency and continuity the wellspring of which was the Madigan report and the successor documents discussed above. The evidence presented in this Chapter indicates that successive governments were not persuaded that a compelling business case for substantial public investment in a civil and commercial space sector in the decades from the 1980s through to the election of the Rudd government in 2007 had been made. Defence stood apart from the civil sector and was not well integrated into the discussions about a civil sector, the dual use aspects of space capabilities notwithstanding.

The next Chapter, Chapter Six, presents evidence of change; change that may represent a "Tipping Point" in Australia's space journey, from which there can be no return to the attitudes and outlooks revealed in this Chapter, Chapter Five.

CHAPTER 6

AUSTRALIAN SPACE POLICY DEVELOPMENT: 2008-2017

Chapter Five provided insight into precedents that are relevant to this chapter. Chapter Six addresses the question of public policy spending priorities in the context of a series of developments that took place between the election of the Rudd Labor government in November 2007 and the announcement in September 2017 that an Australian Space Agency would be established in 2018.

In this period policy makers were awakened to the importance and potentials of space both within and beyond the defence and national security realm. Ideology gave way to pragmatism and an element of opportunism as well. The decade opened with a Senate inquiry and ended with a space agency. An underlying theme throughout the decade was space security and an increasingly well-informed discussion about the role that Australia might, should, and possibly must play to guarantee, to the extent possible, that access to the data and services of satellites was secure and assured for all potential users.

In 1959, Charles Lindblom, who was a noted American Economist, wrote an influential paper called *The Science of "Muddling Through"* (Lindblom, 1959). In this paper, he contrasted two decision-making processes. He termed the first the rational comprehensive, or "root" method of decision-making and the second, the disjointed incremental or "branch" method of decision-making. The former is logical, evidence-based and dispassionate. "Muddling through", in contrast, admits to the influence of political processes in decision-making and takes account of different interests, and power and authority structures. It is a messy process based on what Lindblom called a process of "successive limited comparisons".

During the eleven-year period covered in this Chapter, significant developments occurred in terms of Australia's approach to space. A series of events and activities occurred some of which were connected and flowed sequentially, others were disconnected and proceeded in parallel. The evidence to be presented indicates that there was no single leader and no overall plan or strategy that gave direction to the progress that was achieved.

In terms of the research questions outlined in the Introduction, this Chapter is focused on the third question. Does the evidence presented indicate an increased level of policy attention to space activities? Is there evidence of policy continuity or discontinuity? At the end of 2017, had the conditions been established upon which a self-sustaining space sector had a reasonable chance of emerging in Australia? Is space security a priority? Further questions relate to process. Does it matter if the processes leading to improvement over the past decade were disjointedly incremental? Might lessons to be drawn from developments between 2007 and 2017 that inform future developments to meet the needs of government, industry, the research community, international partners and other stakeholders?

This Chapter presents and tests the evidence.

The Chapter is organised into seventeen principal sections:

1. Domestic Politics
2. The 2008 Senate Inquiry
3. National Security Statement
4. 2009: The Global Financial Crisis A ‘Tipping Point’ for Australian Space?
5. Space Industry Innovation Council
6. Australian Space Research Program
7. Earth Observation and Global Navigation Satellite System Capability Development
8. The 2013 Satellite Utilisation Policy
9. Defence and National Security
10. Review of the Space Activities Act
11. The ‘Tiger’ Team
12. The Expert Reference Group
13. The States and Territories
14. The International Astronautical Congress of 2017
15. Innovation, Research and Space
16. The Need for a Champion
17. Chapter Summary.

The Chapter examines the evidence of enduring themes that reflect the interests of some important and influential actors and, also, to the importance of leadership and of leaders who succeeded in building coalitions of interests that were noticed and accorded legitimacy by Ministers, officials and the broader community.

The events discussed occurred against an international environment that is undergoing profound shifts in global power and a technology landscape that is rapidly transforming many established businesses and business models, including in the space sector. The decade began with a Labor government in office and a Senate inquiry not of the government’s choosing. The decade ended with a Coalition government announcing in 2017 that a space agency would be established in 2018.

6.1 Domestic Politics

The decade was marked by considerable political instability in Australia. From November 2007 to December 2018, there were five Prime Ministers (one twice – Kevin Rudd, Labor). This meant that Ministers and portfolio responsibilities also changed frequently. Throughout the decade, the Minister for Industry was responsible for civil space matters. Between November 2007 and December 2018 there were eight Ministers for industry. These responsibilities were often linked to one or more other responsibilities, including innovation, science, research, climate change, higher education and jobs, as indicated in the following table.

Table 6.1. Ministers for Industry and other matters Nov 2007- Dec 2018.

Portfolio Name	From /To	Minister
24 November 2007, Election of Rudd Labor Government		
Innovation, Industry Science and Research	Nov 2007 – Jun 2010	Carr
Change in Leadership Julia Gillard PM		
Innovation, Industry Science and Research	Jun 2010 – Aug 2010	Carr
21 August 2010, Election of Gillard minority Labor Government		
Innovation, Industry Science and Research	Aug 2010 – Sep 2011	Carr
Innovation, Industry Science and Research	Sep 2011 – Feb 2013	Carr
Cabinet Reshuffle Due to Resignations		
Industry and Innovation	Feb 2013 – Mar 2013	Combet
Unsuccessful Challenge to Gillard's Leadership		
Climate Change, Industry and Innovation	Mar 2013 – Jul 2013	Combet
Change in Leadership Kevin Rudd PM		
Innovation, Industry, Science, Research and Higher Education	Jul 2013 – Sep 2013	Carr
7 September 2013, Election of Abbott Coalition Government		
Industry	Sep 2013 – Mar 2014	MacFarlane
Industry and Science	Mar 2014 –Sep 2015	MacFarlane
Change in Leadership Malcolm Turnbull PM		
Industry, Innovation and Science	Sep 2015 – Feb 2016	Pyne
Industry, Innovation and Science	Feb 2016 – Jul 2016	Pyne
2 July 2016, Election of Turnbull Coalition Government		
Industry, Innovation and Science	Jul 2016 – Jan 2017	Hunt
Industry, Innovation and Science	Jan 2017 – Dec 2017	Sinodinos
Jobs and Innovation	Dec 2017 – Aug 2018	Cash
Change in Leadership Scott Morrison PM		
Industry, Science and Technology	Aug 2018 – Mar 2019	Andrews

Source: Australian Government Ministry lists published at http://australianpolitics.com.

One of the issues that caused the political instability demonstrated in Table 6.1 was climate change. No Australian government managed to develop a coherent policy that balanced competing policy objectives in ways that satisfied powerful climate change sceptics (including Prime Minister Abbott) as well as those who accepted the strengthening scientific consensus that the world is warming at a dangerous rate because of human activities (Strangio et al., 2017, pp.290-293). Another issue concerned the future employment prospects of many Australians as the nature of work changed. In place of the manufacturing jobs of the 20th Century, Australians were encouraged to innovate and to seek global markets for their inventions. In taking office, Prime Minister Turnbull insisted that there was, "No better time to be an Australian". A few months later he launched an "ideas boom" (DPMC, 2015). Such rhetoric did not resonate with many electors. Catherine Armitage, an experienced economics reporter, wrote:

> "When the Prime Minister spoke innovation and jobs during the election campaign, voters saw robots and job losses. And no wonder: the Committee for Economic Development of Australia has warned of the "high probability that 40 per cent of Australia's workforce, more than 5 million people, could be replaced by automation within the next 10 years" (Armitage, 2017).

The Turnbull government scraped back into office at the 2016 election with a one seat majority.

Echoes of these divisive and destructive debates are evident in Table 5.1 above. The seemingly minor changes in Ministers' titles, for example whether "Industry" precedes or succeeds "Innovation", indicates a shift in policy emphasis. In the case of the Abbott Ministries the word "Innovation" was dropped altogether.

Ahead of the 2016 election, the Liberal Party had no explicit space policy (Liberal Party, 2016). The Labor Party devoted one paragraph in its National Platform to the topic. This stated:

> "Australia increasingly relies on space infrastructure. Our nation's security and social and economic wellbeing depend on access to space-based research. Labor will deliver a National Space Policy to provide a clear statement of intent for Australia's space-related activity and harness the strengths of our space research and industry sectors" (ALP, 2015, p.37).

At a level below contentious politics and ministerial portfolios, the years 2007-2018 were characterised by a series of reviews, reports and other initiatives that were relevant to the development of the Australian space sector. The more important, are shown in the table below.

Table 6.2. Chronological list of reports and reviews, and other events of policy significance in the evolution of Australia's approach to space: November 2007- December 2018.

Month/Year	**Report/Review/Event**	**Other Events**	**Sponsor/Owner**
24 Nov 2007		ALP wins office, Kevin Rudd, PM.	
19 Mar 2008		Senate inquiry into Australia's space science and industry sector announced	Senate Standing Committee on Economics
2008	*The Value of Spatial Information: The impact of modern spatial information technologies on the Australian economy*		CRC for Spatial Information
Jun 2008	Interim Report of Senate Inquiry,		
Aug 2008	*Strategic Roadmap for Australian Research Infrastructure*		Department of Industry, Innovation, Science and Research
Nov 2008	*Lost in Space? Setting a new direction for Australia's space science and industry sector*	Final report of Senate Inquiry	
May 2009		Space Policy Unit funded Australian Space Research Program (ASRP) announced	Department of Industry, Innovation, Science and Research
2009	*An Australian Strategic Plan for Earth Observations from Space*		Australian Academy of Science and the Australian Academy of Technological Sciences and Engineering
2009	*Defending Australia in the Asia Pacific Century: force 2030* Defence White Paper 2009		Minister for Defence (the Hon Joel Fitzgibbon)
4 Dec 2009	First formal Statement on National Security to Parliament		National Committee for Space Science Australian Academy of Science
24 June 2010		Julia Gillard replaces Kevin Rudd as PM	
2010	*Decadal Plan for Space Science: Building a National Presence in Space 2010-2019*		
21 August 2010		Federal Election. Julia Gillard forms a minority government with cross bench support	
Sep 2010	*The Economic Value of Earth Observation from Space*		ACIL Tasman for the CRCSI and Geoscience Australia
8 Nov 2010		AUSMIN Melbourne	DFAT and Defence
2011	*Principles for a National Space Policy*		Department of Industry, Innovation, Science and Research
Jun 2011	*A Review of Current Australian Space Activities, Executive Summary*	Asia Pacific Aerospace Consultants	Department of Industry, Innovation, Science and Research
Sep 2011	*2011 Strategic Roadmap for Australian Research Infrastructure*		Department of Industry, Innovation, Science and Research

2012	*Continuity of Earth Observation Data for Australia: research and Development Dependencies to 2020*		CSIRO
Jan 2012	*Continuity of Earth Observation Data for Australia: Research and Development Dependencies to 2020*		CSIRO
2012	*Australian Innovation System Report - 2012*		Department of Industry, Innovation, Science and Research and Tertiary Education
July 2012	*Australian Strategic Plan for GNSS*		Australian Spatial Consortium
2012	*2012 National Research Investment Plan*	Note: Foreword by Prime Minister Gillard.	Department of Industry, Innovation, Science and Research
Oct 2012	*Australia in the Asian Century*		The Prime Minister (the Hon Julia Gillard)
14 Nov 2012		AUSMIN Perth	DFAT and Defence
Dec 2012	*Space Industry Innovation Council: Report 2012 (Final Report)*		Department of Industry, Innovation, Science, Research and Tertiary Education
2013	*Defence White Paper 2013*		Minister for Defence (the Hon Stephen Smith)
2013	*Australia's Satellite Utilisation Policy*		Minister of Industry, Innovation, Science, Research and Tertiary Education (Sen the Hon Kim Carr)
2013	*Strong and Secure: A Strategy for National Security*		The Prime Minister (the Hon Julia Gillard)
27 June 2013		Kevin Rudd replaces Julia Gillard as PM	
30 Jun 2013		Australian Space Research Program formally ends	
7 Sep 2013		Coalition wins office, Tony Abbott, PM.	
Oct 2014		Awarded right to host IAC2017 in Adelaide in September 2017	Space Industry Association of Australia
Dec 2014	*Australian Innovation System Report*		Office of the Chief Economist, Department of Industry
24 Oct 2015	Review of the Space Activities Act announced		
15 Sep 2015		Malcolm Turnbull replaces Tony Abbott at PM	
2015	*National Innovation and Science Agenda: Welcome to the Ideas Boom*		Department of the Prime Minister and Cabinet
2 July 2016		Double Dissolution Election. Turnbull government returned with a one seat majority	
2016	Defence White Paper		Minister for Defence (Sen the Hon Marise Payne)

2016	*Australian Earth Observation Community Plan 2026*		Australian Earth Observation Community Coordinating Group (inc CSIRO and BoM)
March 2017	Legislative proposal paper and other documents released for public comment		
July 2017	Expert Reference Group (ERG) announced, to report by end of March 2018	Dr Megan Clark, former CEO of CSIRO, Chair of the ERG	Minister of Industry, Innovation and Science (Sen the Hon Arthur Sinodinos)
Sep 2017	Drafting commenced on revisions to Space Activities Act		
25-29 Sep 2017	68th International Astronautical Congress	4,500 delegates	Space Industry Association of Australia
25 Sep 2017	Announcement that Australia will have a space agency	Made at the Opening ceremony of the IAC by the Minister for Education and Science (Sen the Hon Simon Birmingham)	Federal Cabinet
25 Sep 2017	Announcement that the Labor Party supports the creation of a national space agency	Made by Senator Kim Carr, Shadow Minister for Industry (including civil space matters).	Shadow Cabinet
Sep 2017	*A Vision for Space Science and Technology in Australia: Securing and Advancing Australia's Interests Through Space Research*		National Committee for Space and Radio Science (NCSRS), Australian Academy of Science
Oct 2017	*Australian Space Industry Capability: A Review*		Department of Industry, Innovation and Science
Nov 2017	*Australia 2030 Prosperity through Innovation: A Plan for Australia to thrive in the global innovation race*		Innovation and Science Australia
Nov 2017	Foreign Policy White Paper		Minister for Foreign Affairs and Trade (The Hon Julie Bishop)
8 May 2018	Commonwealth Budget brought down, funding for space agency announced		Minister of Industry, Innovation and Science (Sen the Hon Michaelia Cash)
1 July 2018	Australian Space Agency formally established		Dr Megan Clark AC, Inaugural Head
24 August 2018		Scott Morrison replaces Malcolm Turnbull as PM	
December 2018	*Australia's Tech Future: Delivering a strong, safe and inclusive digital economy*		Minister for Industry, Science and Technology (The Hon Karen Andrews)

Table 6.2 indicates that from late in 2007 to the end of 2018 considerable thought was given by many people to Australia's place in space, beginning with the Senate inquiry in 2008 and ending with the Expert Reference Group (ERG) in 2017.

The reports fall into four broad categories:

- Documents that relate to the value of Earth observation and downstream services more generally;
- Defence White Papers and other documents that relate to national security and to Australia's place in the world;
- Documents that relate to the development of Australian civil space policy; and
- Documents that relate to Australia's commitment to research and innovation.

These reviews and reports are discussed in sections that follow.

6.2 The 2008 Senate Inquiry and Actors Involved

Three Senators, all from South Australia, the terms of two of whom were due to end on 30 June 2008, joined forces to cause the inquiry to be held. The idea for the inquiry originated in the office of Senator Natasha Stott-Despoja in late 2007. Senator Stott-Despoja was a member of the Australian Democrats Party, one of the minor parties in the Senate. Senator Chapman (Liberal) and Senator Annette Hurley (Labor) agreed to join her cause (Biddington, 2008b). At the time, Senator Hurley was also the Chair of the Senate Standing Committee on Economics. She agreed to conduct the inquiry under the auspices of her committee rather than to form a Select Committee for the specific purpose of inquiring into Australia's performance in space.

6.2.1 The Inquiry

The Senate announced the inquiry and referred the Terms of Reference to its Standing Committee on Economics on 19 March 2008. The Review was to deliver an interim report by 23 June 2008 and a final report not later than the end of October. The inquiry was specifically directed to give consideration to national strategic coordination requirements and to take account of findings and policy options of the National Innovation System Review (Senate Inquiry, 2008 p. vii).

6.2.2 Submissions

The Inquiry received 88 written submissions of which 84 are accessible to the public. In addition, evidence was taken from 67 witnesses (some of whom had also provided written submissions) at six hearings in Canberra, Adelaide and Sydney. The Committee produced an interim report in June 2008 and a final report in November 2008 (Senate Inquiry, 2008).

6.2.3 Respondents

The inquiry attracted submissions from across the Australian space community as indicated in Table 6.3 that follows.

Table 6.3. Responses to 2008 Senate Inquiry by Type of Respondent.

SUBMISSION BREAKDOWN BY TYPE OF ORIGINATOR (ADJUSTED)

	Total	%
Commonwealth Depts/Agencies	6	7.1
State Govts	3	3.6
Universities	9	10.7
Secondary Education (STEM)	2	2.4
Private Submissions	37	44.0
Large For-Profit Companies	4	4.8
SMEs	4	4.8
Prof Bodies, Industry Associations, Outreach	19	22.6
	84	100

Plus 4 Not in the public domain

Government departments and agencies, notably Geoscience Australia (GA), the Bureau of Meteorology (BoM), Defence and CSIRO made submissions that indicated their high levels of dependence on satellite-based services (Senate Submissions, 2008, Nos 21, 65, 70 and 77 respectively). The BoM argued for the design and construction of sensors, optimised to meet Australian collection requirements, that could be launched as hosted payloads on satellites operated by other nations. Defence stated that it was preparing a White Paper in which its requirements for space capability would be outlined. None proposed any radical changes to current legislative and organisational arrangements and none of the civil agencies expressed any desire to become satellite owners and operators.

In its submission, CSIRO stated that:

> "As Australia's premier space research agency CSIRO is able to broker partnerships with other research players, sustain dialogues across government and industry to identify future priorities and work with government and industry to develop space-related capabilities to support their programmatic measurement requirements" (Senate Submissions, 2008, No 77).

Submissions were received from nine of Australia's 39 universities, almost one in four. Most were statements of capability and most argued for increased government investment in the space sciences including in upstream (in space) capabilities. La Trobe University concluded its submission thus:

> "Australia needs to invest in space science and technology: in the development of assets in space and supported by ground facilities. . . The public interest is space needs to be leveraged into educational programs that attract young people into the basic

sciences, mathematics and engineering . . . These are matters of urgency . . ." (Senate Submissions, 2008, No 24).

Twelve for-profit companies made submissions. Four were large corporates (two were satellite communications companies and two were major systems integrators (MSIs). Four were small and medium enterprises and the remaining four are more correctly described as private submissions made in the name of single owner/single employee companies. They have been counted as Private Submissions in the Table above. The submissions from all twelve private entities focussed on the need for Australia to become more actively involved in upstream activities - the design, construction and operation of satellites and satellite payloads. Only one of the twelve companies that made submissions emphasised the downstream processing and manipulation of data to support a range of applications. The remainder focussed on the need for Australia to develop upstream capabilities.

Four of the 19 advocacy organisations that made submissions represented the downstream remote sensing and precision timing and navigation communities. Almost all the remainder argued for better government coordination and for public investment in upstream activities, including increased funding for the space sciences, in several cases to permit Australian scientists to participate as members of international teams analysing data from a variety of satellites and other sensors to pursue their diverse interests, including in ionospheric physics and the geosciences (Senate Submissions, 2008, Nos 53 and 73).

The submissions from individuals reflected disparate interests, ambitions and agendas. Many asserted that space science and space industry development was important for Australia but compelling evidence, metrics, and other data that might have given substance to the assertions was not provided. One example, from a well-informed space enthusiast follows:

> "We need a Government space body. We need a space industry. And, one day, we'll need a space port. Will an Australian Prime Minister promise that, by 2020, Australia will again be a serious player in the space game, and have the honesty and ability to actually carry it out?" (Senate Submissions, 2008, No 29).

Some discussed the importance of education in the space context as a vector for encouraging more secondary school students to pursue tertiary studies in Science, Technology, Engineering and Mathematics (STEM).

Questions of policy and strategy were not well covered. Three private submissions (those from Biddington, Gilbert and Sach) specifically addressed these matters and a small number of government and university submissions referred to questions of policy as well. The inquiry chose not to make specific comment or recommendations about space policy in the context of national strategy. Frances Brown, then the editor of *Space Policy*, which is one of a few refereed journals focussed on space policy in the world, made a submission in which she wrote that she had been:

> "…consistently surprised during [the 20 years of her editorship] by the low level of space activity (and consequent dearth of Australian perspectives in terms of article submission) in Australia compared with that of other 'industrialized' countries" (Senate Submissions, 2008, No 69).

She argued for the need for "people with expert knowledge . . . to elucidate the multifarious benefits of space to the right people" (ibid).

Her submission pointed to a capability gap in Australia's space capability: the absence of a narrative and narrators.

6.2.4 The Senate Committee Report

The Senate Committee released an interim report in June 2008, which raised a series of questions that formed the basis for several supplementary submissions. The questions also provided the basis for a lengthy resolution that was adopted on the voices at the Australian Space Development Conference (ASDC) held in Adelaide in July 2008. This resolution was forwarded to the Senate inquiry as a consensus position from a representative gathering of the Australian space community and was reproduced as an Appendix to the Senate Committee's final report.

The final report was called *Lost in Space? Setting a new direction for Australia's space science and industry sector*. It made six recommendations, that are summarised below:

1. To establish a government website dedicated to space matters;
2. In the context of innovation to better coordinate space activities and to reduce Australia's "over reliance on other countries in areas of space technology";
3. To form a government unit to coordinate Australian space activities, including those in the private sector;
4. To establish a Space Industry Advisory Council;
5. To have the Council conduct a systematic data gathering exercise about the size and shape of the Australian space industry as precursor activity to the possible establishment of a space agency; and

6. That any Australian Space Agency reassess the case for Australia becoming more closely linked to an international space agency, (Senate Inquiry, 2008, pp. 66-67).

All but the sixth recommendation of the Senate Committee were accepted by government and implemented during 2009. The sixth was not rejected out of hand. Some history relates to this last item. As a consequence of the European Launcher Development Organisation (ELDO) program at Woomera, in 1974 Australia was invited to become a member of the then recently formed European Space Agency (ESA). Australia formally declined this invitation in 1983 (Dougherty, 2017). ESA has made similar approaches since 1983, each of which has been declined (ibid). Official resistance to Australia seeking to become an associate member of ESA has two bases. The first is cost. ESA imposes an annual membership fee to cover administrative overheads. In Australia's case this would amount to AU$20 million. The second objection relates to the ESA policy of *juste retour* under which money invested in specific programs by member states is returned to those states as contracts in value equivalent to the original investment made. Australian officials have struggled to identify companies and other organisations in Australia with the capability and capacity to take advantage of the *just retour* principle (Biddington, 2009b). Several witnesses told the Senate inquiry that Australia should join ESA. This question continues to surface periodically and is now being addressed by the Australian Space Agency.

6.2.5 Impact of the Senate Inquiry

The Senate inquiry was a product of persistence and frustration. Persistence by Senator Stott-Despoja who was determined that governments pay more attention to space, and frustration by Senator Chapman for the way in which his efforts to raise a subject that he considered of national importance had been, in effect, dismissed by Ministers of his own Party.

There is no evidence that the inquiry was driven by public sentiment or demand. The Senators were not responding to broader community concerns. Their motives, as noted in the previous paragraph, were personal. Space industry representatives were consulted informally about the terms of reference after the Senators had agreed amongst themselves to conduct the inquiry (Biddington, 2008b).

Governments are not obliged to act on the recommendations of Parliamentary inquiries and the impact of such inquiries can, therefore, be limited. A conclusion that could be drawn is that had the government not responded so swiftly to the global financial crisis (see below), the funds that led to five of the six recommendations of the Senate's space inquiry in 2008 being implemented may never have been made available through the normal course of the budget cycle. The money was allocated as one element of a spending package called *Powering Ideas: An Innovation Agenda for the 21st Century* which allocated almost AU$ 8.6 billion in the 2009-10 Budget. This represented an unprecedented increase of 25% over the previous year's allocation to research and innovation in Australia (Carr, 2009). The huge spending increase, which included money for the space sector, was part of the government's response to the Global Financial Crisis (GFC) and was not made in response to the merits of the arguments in the Senate inquiry *per se*. The Senate inquiry achieved impact because of fortuitous and serendipitous timing. Its recommendations could be quickly accepted and then acted upon within a much larger policy construct.

6.3 The National Security Statement of 2008

On 4 December 2008, the Prime Minister, the Hon Kevin Rudd MP, made a national security statement to the Australian Parliament (CPD, H of R, 2004). This was the first time an explicitly crafted national security statement had been delivered to the Parliament. The statement canvassed the gamut of threats facing Australia including in the military and cyber domains. Its principal purpose was to announce the establishment of a new National Security Adviser position in the Department of Prime Minister and Cabinet (DPMC). The role of the Security Adviser was to strengthen coordination between all Commonwealth departments and agencies and between the Commonwealth and the States and Territories on all matters where there were shared interests and responsibilities in national security, which was defined in much broader terms than simply military and the role of the Australian Defence Force.

The statement was silent about space. Nothing was said that would inform the Parliament and wider publics about the importance of and threats to the safety and security of the space domain. However, in parallel with preparation of the National Security Statement, in the latter part of 2008, an inter-departmental committee was convened by DPMC to inform the Prime Minister about Australian space activities. The Committee held several meetings, one of which, on 1 April 2009, was augmented by a group of invited representatives from industry and the research sector (Biddington, 2009a). The recommendations from this committee provided additional context to the framing of the May 2009 Commonwealth Budget.

6.4 2009: The GFC, A 'Tipping Point' for Australian Space?

Australia managed to avoid the worst of the Global Financial Crisis (GFC) of 2007-2009, partly because the government and the Reserve Bank of Australia (RBA) moved swiftly to pump billions of dollars into the economy to keep people in employment. The RBA lowered interest rates and the Government quickly embraced an “expansionary fiscal policy” to quote the Reserve Bank’s “Explainer” document about the GFC (RBA, no date).

The May 2009 Budget made provision for GFC related spending across the economy. The largest schemes were applied nationally but with local impact. Two of the more important were a home insulation scheme and another to build halls for schools (Strangio et al., 2017). Included in the raft of measures funded under the *Powering Idea*s agenda, was an initiative called “Super Science - Space and Astronomy”. AU$160.5 million was allocated over four years to these activities. AU$111.9 million was allocated to astronomy projects and the remainder to space activities, further divided into two components:

- AU$40.0 million to establish an Australian Space Research Program (ASRP); and
- AU$8.6 million to establish a Space Policy Unit (SPU) within the Department of Innovation, Industry, Science and Research (DIISR, 2009a).

The SPU administered the ASRP and supported a Space Industry Innovation Council (SIIC) that was established to advise the SPU. All monies allocated in response to the GFC had to be spent by 30 June 2013.

Malcolm Gladwell popularised the concept of the ‘tipping point’ in his book, first published in 2001, with the title *The Tipping Point: How Little Things Can Make a Big Difference*. He identified three characteristics of ‘tipping points’:

> “…one, contagiousness; two, the fact that little causes can have big effects; and three, that change happens not gradually but at one dramatic moment…” (Gladwell, 2001, p. 9).

Gladwell considered the third trait to be the most important because it allows sense to be made of the other two and “permits the greatest insight into why modern change happens in the way it does” (ibid, p. 9).

In late 2008, early 2009, a range of “little things”, to use Gladwell’s phrase, coalesced. They included:

- The Senate inquiry recommendations;
- The creation of the Inter-Departmental Committee by DPMC (Biddington, 2009a);

- The Chair of the Australian Space Industry Chamber of Commerce wrote to the Prime Minister, proposing a modest investment in civil space activities, emphasising satellite ground stations (Biddington, 2009c); and
- A senior official with responsibility for civil space matters in the Department of. Innovation, Industry, Science and Research (DIISR) saw an opportunity to promote his section as part of a coordinated effort across the Department to obtain its share of the funds to be released in response to the GFC (Biddington, 2009b).

The “dramatic moment” was the May 2009 Budget when the money was allocated.

6.5 The Space Industry Innovation Council

In establishing the Space Industry Innovation Council (SIIC) the government fulfilled the fourth recommendation of the Senate inquiry. The Council met 13 times between its formation in November 2009 and its dissolution on 31 December 2012. It provided formal advice to government in 2010 and 2011, made several submissions to other inquiries and delivered a final report early in 2013. It also conducted three space sector stakeholder forums in 2010 and provided comment on the draft Australian Space Policy that was released eventually as Australia’s Satellite Utilisation Policy (SIIC, 2012).

The SIIC was chaired by Dr Rosalind Dubs, a highly credentialed businesswoman with considerable international experience. One Council member was a GNSS expert, others were drawn from large companies whose main business in Australia is to serve as prime contractors for Defence. The satellite communications industry was represented as were government departments and agencies, astronomy and the wider research community. One industry association was represented (Biddington 2009d). A former Chief Defence Scientist was a member of the Council, but Defence was not represented directly. There was no representation from SMEs, or the remote sensing community (SIIC, 2012).

The Council proceeded cautiously and provided, in the words of its Final Report, “realistic, pragmatic and strategic advice to the Australian Government on space sector priorities” (SIIC, 2012). Most of the opportunities identified for growth were in the downstream sector of the space economy. Human space flight and space exploration were not mentioned as areas for targeted investment or development in Australia. Two of the Council’s recommendations in its Final Report concerned space security.

"*Implementation Recommendation 1.4*: There needs to be strong Australian involvement is space situational awareness (SSA) research and development as announced jointly by the USA and Australia in November 2011, noting that SSA is already a dual use field making significant use of international networking".

"*Implementation Recommendation 2.4*: While the Australian space industry will remain a niche domain, the implications of denial of access to space services have profound implications for our entire economy, so the training and nurturing of a cadre of experts who can advise on protective national action is critical. Council recommends that DIISRTE follow up the space industry skills audit currently being undertaken with a space sector focused skills development and networking program for researchers and industry" (SIIC, 2012 p. 4).

The Council produced a Strategic Roadmap embracing the decade 2010 to 2020. Public funds and other resources were not provided to realise the Roadmap. Eight years into the decade and many of the proposed targets and outcomes remain aspirational or only partly accomplished. The Roadmap, read in conjunction with the 2013 Satellite Utilisation Policy (discussed below), provides a clear exposition of Australia's principal and enduring interests in space.

6.6 The Australian Space Research Program

As noted above, the Australian Space Research Program (ASRP) was formally announced in May 2009. There were two types of grant. Awards of up to AU$5m were available for industry development programs and awards of up to AU$1m were available for educational programs (DIISR, 2009b). The ASRP funds were released in four competitive rounds with the later rounds having to deal with compressed timeframes in which to complete their projects. The space community embraced the program and an independent review of the impact of the program concluded that it had met its objectives and provided value for money to the Commonwealth (DISS, 2015).

Across the life of the program, from a total of 96 applications, numerous of which were rebids, 14 were funded. One Stream A education grant was funded in each of the four rounds and 10 Stream B grants were funded across the life of the Program as well.

No funds were allocated in the May 2013 Budget to support follow-on activities.

Table 6.4, on the following page, is a summary of the projects that were funded and Table 6.5 indicates where the money was spent on a State and Territory basis.

Table 6.4. Australian Space Research Program: Summary Table.

ASRP: SUCCESSFUL APPLICANTS (AU$m rounded to 2 decimal places)

Project Name	Round	Stream	Industry	Grant Awarded to	UNSW	UQ	RMIT	UniSA	ANU	Flinders	TOTAL
Pathways to Space (Powerhouse Museum)	1	A		UNSW	0.99						
Hypersonics	1	B		Uni of Queensland		5.00					
Platforms for Climate change	1	B		RMIT			2.85				
Antarctic Broadband	1	B	2.11	Aerospace Concepts (ACT)							
ISU Southern Hemi – Summer Space Program	2	A		UniSA				0.48			
Space Debris tracking	2	B	4.04	EOS (ACT)							
GRACE Follow-on	2	B		ANU					4.67		
SAR Formation flying	2	B		UNSW	4.64						
Place and Space	3	A		Flinders University						0.95	
Satellite Communications	3	B		UniSA (ITR)				5.00			
LANDSAT Data Clean Up	3	B	3.47	LMC (VIC)							
Satellite System Engineering	4	A		UNSW	0.68						
Plasma Thruster (Vacuum chamber at Stromlo)	4	B		ANU					3.12		
Greenhouse Gas Monitor	4	B	2.35	VIPAC (SA)							
TOTAL			**11.97**		**6.31**	**5.00**	**2.85**	**5.48**	**7.79**	**0.95**	**40.35**
Percentage			30		16	12	7	14	19	2	100

Key: Blue: Stream A Educational Grants
Black: Stream B University led Industry Grants
Crimson: Stream B company led Industry Grants

Source: ASRP Fact Sheets issued by DIISR.how d

Table 6.5. Distribution of Successful ASRP Applicants and Money by State/Territory.

Where	No	**$m**	**%**
SA	4	8.78	22
ACT	4	13.94	35
NSW	3	6.31	16
Vic	2	6.32	16
QLD	1	5.00	12
TOTAL	14	**40.35**	**100**

Organisations based in South Australia and the Australian Capital Territory were, in aggregate, more successful than were their counterparts from the other States. There were several bids from entities based in Western Australia, however, none succeeded. No bids were received from Tasmania or the Northern Territory.

6.6.1 The ASRP Legacy for SSA.

The ASRP was opportunistic in that it was part of the larger response to the GFC. There was no follow-on, deliberate and long-term plan by which Australia could strengthen its space credentials, including its industry capacity. The modest funds notwithstanding, important infrastructure was acquired and installed in the Advanced Instrumentation and Technology Centre (AITC) at Mt Stromlo and several of the funded programs either explicitly or implicitly addressed technology questions relevant to space security. The Space Debris Tracking project that was funded by the ASRP helped to build civil capacity and capability relevant to space situational awareness. It was further developed into a bid for a Cooperative Research Centre that was funded in 2014 as the Space Environment Research Centre (SERC, 2018b).

6.7 Earth Observation and GNSS: Capability Development

Beyond Defence, three Commonwealth Government agencies, BoM, GA and CSIRO are heavily reliant on data from satellites all of which are operated by other nations or foreign commercial providers. On Earth Observation from Space (EOS) matters they collaborate closely, and with other organisations too, notably FrontierSI (formerly the Cooperative Research Centre for Spatial Information (CRCSI)) and the academic EOS community through the Australian Earth Observation Community Coordinating Group (AEOCCG, 2016).

6.7.1 The Value of Earth Observation from Space

In 2015, an economic consulting firm, ACIL Allen, prepared a report for the CRCSI on behalf of the broader EOS community with the title, *The Value of Earth Observations from Space to Australia* (ACIL Allen, 2015). This report was a successor to earlier reports prepared in 2008 and 2010. The 2015 report adopted a case study approach and concluded that:

> "The total direct economic benefits identified from the use and application of EOS data from the case studies were found to be:
> — AU$496 million in 2015
> — AU$1,694 million expected by 2025.
> The total social and environmental benefits identified from the use and application of EOS data were found to be:
> — AU$861 million in 2015
> — AU$1,329 million by 2025" (ibid, p. i)

The report estimated, in the sectors surveyed through the case studies, that almost 9,300 jobs were dependent on secure and assured access to EOS data. This number was estimated to grow to almost 16,000 jobs in 2025 (ibid, p. ii) in the sectors surveyed. An important caveat was added to the effect that the 2015 study did not account for "the number of jobs that may potentially be created because of new businesses taking advantage of the lowered technical and financial barriers to EOS" (ibid, p. 1).

These numbers become important in Chapter Seven, in the context of the goals and ambitions that government has set for the Australian Space Agency.

The ACIL Allen report discussed the potential impact on the Australian economy if access to EOS data were partially or completely denied. A complete denial of service was considered unlikely, however, if it were to occur, it would cause "serious disruption" to many important sectors of the economy. The report assessed that a partial denial of service:

> "…would create serious problems for many government services including weather forecasting, ocean monitoring and landscape monitoring. It would limit the effectiveness of these services with increasing consequences for many sectors in the Australian economy" (ibid, p. 102).

The report noted that Australia's dependence on other nations for access to EOS data is obtained through a range of "mechanisms and intergovernmental agreements", and cautioned:

> "It would be important to ensure that these mechanisms are sufficiently robust to protect the EOS supply chain on which Australian governments and industry rely" (ibid, p. 102).

This caution points to the importance of Australia maintaining strong international links with the owners and operators of the satellites, the data from which are so important to many parts of the Australian economy.

6.7.2 The Bureau of Meteorology.

The Bureau of Meteorology (BoM) received its first satellite images, from the United States via airmail, in 1960. These were of no use from a forecasting perspective but did permit the Bureau, from the beginning of satellite-based weather monitoring, to become confident in the use of this data (Day, 2007, p. 340). BoM has been using satellite data for forecasting since 1977 (ibid, p. 388). Today, BoM operates a satellite ground station at Crib Point south east of Melbourne which receives data from Japanese, Chinese and American weather satellites (BoM, 2018b). BoM's 2016-17 Annual Report, states that the Bureau received data from 19 satellites (BoM, 2017, p. vi). To handle the data volumes from satellites and other sensors, since the 1960s, BoM has been at the forefront of high-performance computing (HPC) in Australia (Day, 2007, pp. 459-460). BoM operates one of the largest supercomputers in operation in Australia (Barbaschow, 2016). The Bureau also works closely with other HPC centres, including the National Computational Infrastructure (NCI) located at ANU (NCI, 2018).

6.7.3 Geoscience Australia

A predecessor organisation to GA, the Australian Surveying and Land Information Group (AUSLIG), began to receive satellite imagery from the US Landsat satellite in 1979 (GA, no date). Data from the Landsat series of satellites have been received ever since. GA operates a ground station near Alice Springs (GA, 2016). The organisation also takes advantage of the NCI supercomputer located at ANU (Lewis et al., 2017). The data cube project described by Lewis was a development project that now, is becoming an open source national capability called Digital Earth Australia (DEA). DEA will allow users to access Analysis Ready Data (ARD) at no cost to develop "new applications that increase efficiency, improve productivity and allow them to compete in global markets" (GA, 2018a).

> "DEA is working with FrontierSI (the former CRC for Spatial Information) to develop an industry strategy that ensures DEA will generate value for the Australian spatial industry and the international digital economy" (ibid).

This quote points to a high level of consensus between the various elements of the Australian EOS community about the potential benefits that DEA offers as a downstream capability within the Australian space sector.

6.7.4 CSIRO

CSIRO, Australia's civil science and industry research organisation, has made an important contribution to Australia's place in space over many years. The organisation has developed a timeline that outlines the major steps along this path (CSIRO, 2018b). There are four principal and overlapping elements:

- Radio astronomy, atmospheric and ionospheric physics;
- Spacecraft tracking, notably through management and operation under contract to NASA, of the Canberra Deep Space Communication Complex (CDSCC) at Tidbinbilla;
- The use of data from Earth observation satellites to inform much of CSIRO's environmentally-focussed research; and, more recently,
- Support to industry, notably the space start-up community.

In June 2018, CSIRO established the CSIRO Centre for Earth Observation (CCEO). This is a small team tasked to coordinate CSIRO's internal requirements and external commitments and relationships that relate to Earth observation (CSIRO, 2018c). One of the responsibilities of the CCEO is to coordinate CSIRO's requirements for the tasking, downlink and data distribution from NovaSAR-1 satellite (CSIRO, 2018a).

6.7.5 Spatial Information Reviews

Between 2008 and 2016, Australia's Earth observation community conducted a series of reviews into Australia's remote sensing requirements and capabilities. In broad terms, three government agencies, GA, BoM and CSIRO, joined forces with the learned academies and the wider research community to define Australia's space-based imagery requirements to 2020 and beyond. A similar group formed to produce a roadmap for GNSS. The principal public reports and reviews and their sponsors are provided in the table below.

Table 6.6. Earth Observation: Major Reviews 2008- 2016

Review Title	Sponsor/Author	Year
The Value of Spatial Information: The impact of modern spatial information technologies on the Australian economy.	Sponsor: CRCSI Author: ACIL Tasman	2008
An Australian Strategic Plan for Earth Observations from Space.	Sponsors: AAS and ATSE	2009.
The economic value of earth observation from space, prepared for the Cooperative Research Centre for Spatial Information (CRC-SI) and Geoscience Australia.	Sponsors: CRCSI and GA	2010
Continuity of Earth Observation Data for Australia: Operational Requirements to 2015 for Lands, Coasts and Oceans (CEODA).	Sponsor: GA	2011
Continuity of Earth Observation Data for Australia: research and Development Dependencies to 2020.	Sponsor: CSIRO	2012
Australian Strategic Plan for GNSS.	Sponsor: ASC	2012
The Value of Earth Observations from Space	Sponsor: CRCSI Author: ACIL Allen	2015
Australian Earth Observation Community Plan 2026: Delivering essential information and services for Australia's future	Sponsor: AEOCCG	2016
2026 Spatial Industry Transformation and Growth Agenda: Action Plan:	Joint sponsors: SIBA | GITA and CRCSI	2017
Space: A Roadmap for unlocking future growth opportunities for Australia	Sponsor: CSIRO	2018

The most comprehensive of these reports was the CEODA Report of 2011 prepared by Geoscience Australia. At the front of the report were listed eleven key points that painted a concerning picture. The third, fourth and fifth points of the eleven points are reproduced below. They raised the alarm.

> "3. Of the 22 EOS sensors currently being used for operational programs in Australia, 19 (86%) are expected to cease functioning by 2015.
>
> 4. Australia has not secured access to any future space-based sensors that are relevant to observing the Australian land mass and its coastal regions.
>
> 5. Alternate, non satellite-based sources of data do not exist for most types of space-based EOS data, especially those used for environmental monitoring programs" (GA, 2011, p ix).

CSIRO prepared a complimentary report to the CEODA. Called *Continuity of Earth Observation Data for Australia: research and Development Dependencies to 2020*, it was published after the main report (CSIRO, 2012).

These two reports, together with the others listed in Table 6.6, prepared the ground for new investments including those made by CSIRO and outlined above.

6.7.6 The Cooperative Research Centre for Spatial Information (CRCSI)

The CRCSI was another important actor in the spatial information domain during the period 2007 – 2018. It served as a rallying point for researchers and companies working in the geo-spatial domain and provided a mechanism to engage relevant government agencies as well. One of its singular achievements was to create an umbrella structure, known as 43pl, that allowed many small and medium enterprises to participate in and benefit from being associated with the CRC (CRCSI, 2016). Government funding for CRCSI ceased on 30 June 2018. However, the organisation has been restructured and now operates as FrontierSI (CRCSI, 2018).

6.7.7 Industry Associations

Two national industry associations, both undergoing major changes, directly support the EOS and GNSS communities. They are SIBA | GITA and the Surveying and Spatial Sciences Institute (SSSI).

SIBA / GITA SIBA | GITA is the merger of two associations in 2017, the Spatial Industries Business Association (SIBA) and the Geospatial Information Technology Association Australia and New Zealand (GITA ANZ). SIBA | GITA focuses on developing the spatial industry as a whole, and states on its website that it is the "peak body" that represents and advocates for the Spatial Industry. From the website:

> "Our vision is to see spatial information underpin Digital Transformation in Australasia. At the very heart of who we are is our mission to grow the opportunities and capabilities of our members, so that our industry can contribute to the prosperity and sustainability of our region" (SIBA | GITA, 2019).

The SIBA | GITA website does not publish a list of members. It states, however, that its members include "…businesses who supply surveying and spatial services, as well as educational institutions and government agencies who provide critical services and support, and organisations who use spatial information in the public and private sector".

The Surveying and Spatial Sciences Institute (SSSI) The SSSI, on its website, describes itself as:

> "…the national peak body catering for the professional people who make up the spatial information industry. SSSI gives a voice to the members of the spatial science community in both the national and international arena" (SSSI, 2019).

The Institute sits above State and Territory organisations. The State organisations were established before Federation as professional associations for surveyors in the colonies. They grew up independently of each other and have their own histories and traditions.

Technological change, notably the advent of GNSS and land-based augmentation systems, is placing stress on the SSSI. In the 2016 Annual Report of the SSSI, the President, Mr Bernard O'Sullivan, wrote:

> "…I [was] extremely disappointed to see the splintering and division that has occurred in our industry over the last 12 months. In an environment where there is a dramatic decline in new entrants to our professions and in the number of young professionals, in all professions, joining member-based organisations like SSSI, the formation and re-emergence of splinter groups can only be detrimental to the industry as a whole" (SSSI, 2016, p. 7).

Mr Gabriel van Wyk, the regional chair for NSW echoed these sentiments in his report about the activities of the NSW Branch of the SSSI. Speaking about the NSW Excellence in Surveying and Spatial Information (EISSI) Awards, he wrote under the heading "Challenges":

> **"**We started this year in high hopes that we would finally, after many years of sustained discourse and collaboration, reach an agreement with the EISSI brand owners ISNSW [5] and ACS [6] in terms of the Spatial Awards for NSW. This was not to be and I am personally rather disappointed. We will continue in our willingness to collaborate, however difficult this sometimes seems to be. Our resolve remains - we want to see a united industry and we will always be prepared to enter into discussions to further this goal." (SSSI, 2016, p. 21)

If agreement about an annual event where awards are presented could not reached, the question arises whether these associations are likely to be able to agree on more substantive issues that confront the surveying profession.

These difficulties point, in part, to challenges faced by national organisations when dealing with their State-based forebears that have long-standing traditions some of which pre-date Federation.

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[5] ISNSW = Institution of Surveyors, NSW, founded in 1891 See: http://www.surveyors.org.au/

[6] ACS = Association of Consulting Surveyors.

In April 2016, the ACT Government sponsored a meeting in Melbourne that attempted to bring SIBA (before its merger with GITA), SSSI and the Space Industry Association of Australia (SIAA) into a closer alignment, initially through an informal collaboration mechanism. Whilst there was nodding agreement that the entire sector would benefit from regular common approaches to governments and the media, the initiative did not progress (Biddington, 2017e).

SIBA | GITA and the SSSI represent established companies and interests in the downstream sector of the space industry. These organisations, or their predecessors, provided written submissions to the 2008 Senate inquiry. However, there is no evidence that they contributed to or were consulted in the context of later reviews that sought to quantify Australia's space industry capabilities.

6.7.8 Section Summary

Three key points from this section are:

- Government agencies, notably GA, BoM and CSIRO are heavily invested in processing and disseminating EOS data and there is evidence of cooperation and collaboration.
- The spatial information industry is undergoing rapid transformation because of new technologies in both the GNSS and EOS domains. There is uncertainty as to what this means for professions and associations of long standing.
- Spatial information companies do not generally regard themselves as space companies. Whilst they may acknowledge their dependence on data from satellites, their focus is in the processing of EOS data, and geospatial data from other sources as well, to serve diverse downstream markets.

Companies in the spatial sector draw a distinction between themselves as data users and manipulators and the satellite companies that provide the data.

6.8 The 2013 Satellite Utilisation Policy

In 2013, the Industry portfolio had overall responsibility for civil space policy coordination. Numerous other departments had, and continue to have, specific regulatory responsibilities and they contribute to overall policy development and to representing Australia's interests internationally. In 2009, in the context of the government's response to the GFC, the Minister for Innovation, Industry, Science and Research, Senator the Hon Kim Carr, was invited by the Prime Minister, Kevin Rudd, to develop for Cabinet consideration a national space policy.

A two-step process was adopted to bring the policy to fruition. The first step was a principles document that was used by the Space Policy Unit as an educative tool, principally inside government (Biddington, 2010c; Biddington, 2010d). This document was called *Principles for a National Space Industry Policy* (DIISR, 2011a). It was eventually expanded into a draft national space policy, with that title, that was submitted to Cabinet for consideration early in 2013. The title of the document was changed in Cabinet to the more mundane, *Australia's Satellite Utilisation Policy* (DIISRTE, 2013). This change was made deliberately to raise no expectation in government or the wider community that Australia was about to embark on an ambitious publicly funded national space program (Biddington, 2016b).

The policy was launched in April 2013 by Senator the Hon Kate Lundy in her capacity as Minister Assisting the Minister for Innovation, Industry, Science, Research and Tertiary Education (DIISTRE).

The policy was practical and pragmatic. It proposed seven principles as the basis for decision-making and investment. These are summarised below:

- Focus on space applications of national significance – specifically Earth observation, satellite communications and position, timing and navigation (PNT);
- Assure access to space capability – this was a statement about building resilience into the systems and processes by which Australia gains access to satellite-based services;
- Strengthen and increase international cooperation – especially on foreign owned and operated satellite systems on which Australia depends;
- Contribute to a stable space environment – support of the application of the rules based international order to the space domain;
- Improve domestic coordination – to develop shared understanding and strategic direction of Australia's uses and approach to space;
- Support innovation, science and skills development, to include strengthened space research cooperation with international partners; and
- Protect and enhance national security and economic well-being, to include prioritisation of a space situational awareness capability (DIISRTE, 2013).

No funds were allocated to bring the policy to fruition in the May 2013 Budget that was framed against a background of disunity in government and a looming general election. The

Labor government was performing badly in the opinion polls and Prime Minister Gillard was deposed and replaced by Kevin Rudd in June, just months before the election that was held on 7 September 2013.

At the election, the Coalition parties, led by Mr Tony Abbott, had a decisive victory. The new government quickly set about dismantling numerous Labor policy initiatives including in the areas of climate change, energy policy, industrial relations and welfare (Strangio et al., 2017, pp. 278 – 282). In the context of these changes, space policy development was not a priority. The *Australia's Satellite Utilisation Policy* document, remained in place, neither endorsed nor dis-endorsed, by the Abbott government and that of Mr Abbot's successor Malcolm Turnbull. It was overtaken in 2018 when the Australian Space Agency came into being.

Questions about space, however, did not go away. They moved back into the realm of defence and national security. The Abbot government initiated two important defence reviews. The first, called the *First Principles Review*, was established in August 2014. The second was a new *Defence White Paper*. Before discussing these documents and their impacts on defence space policy, there is need to return to 2008-9.

6.9 Defence and National Security

The Department of Defence is the Australian Government department most heavily invested in space activities at the strategic, operational and tactical levels. Australia's alliance with the United States sits at the heart of these activities.

6.9.1 The Australia/US Alliance: AUSMIN Talks

The annual Australian/US Ministerial (AUSMIN) Talks have been discussed in Chapters One and Three. The Talks provide an opportunity for the Australian Ministers for Foreign Affairs and Trade, and Defence meet annually with their US counterparts, the Secretaries of State and Defence. The talks discuss the health of the Australia/US alliance, review the regional and global security environment and set priorities for the future (Bower, 2011; USSC, 2018a).

6.9.2 2010 and 2012 AUSMIN Talks and SSA

At the 2010 AUSMIN talks held in Melbourne, considerable attention was devoted to the emerging importance of the need for Australia and the United States to have assured and secure access to outer space (DFAT, 2010a). These sentiments were repeated in the communique issued after the 2012 talks (DFAT, 2012a). Specific initiatives were announced, notably the placement of space surveillance radar and a space telescope at North West Cape. These ground-based sensors would be operated by the RAAF and the data would flow into the

USAF's space surveillance network (discussed in Chapter Two). Data from both systems would also contribute to the situational awareness of the ADF.

The radar has been re-located from Antigua in the Caribbean to North West Cape. It has been refurbished and is now operational. The telescope which has been relocated from New Mexico is due to become fully operational in 2021 (May, 2017).

The Defence White Papers of 2009 and 2013 and the Communiqués from the annual Australia United States Ministerial (AUSMIN) talks, especially in 2010 and 2012, demonstrate the extent of official concern about the security of the space environment, especially in the Low Earth Orbits and foreshadow investments by Australia in sensors that are designed to improve knowledge of the location of objects in orbit around Earth, especially space debris, in absolute and relative terms.

6.9.3 Dependence on Space

Peter Jennings, a former senior Defence official, now the Executive Director of the Australian Strategic Policy Institute (ASPI), a Canberra-based 'think tank', summed up the broader challenges that have confronted Defence regarding space. In June 2018, Jennings wrote:

> "When I was the deputy secretary for strategy in the Defence Department, one of the things on my to-do list which never quite got done was to produce a public defence policy for space. Even back in Palaeolithic 2009 it was slightly embarrassing that such a policy statement, classified and unclassified, didn't exist. So many ADF capabilities relied on communications, IT, sensors and emitters that drew on systems operating in or through space. Indeed, wherever Defence links into Australia's national infrastructure for logistic support, or engages with government decision-makers, or works with friends and allies, our complete reliance on the enabling effects of space systems is matched only by our utter vulnerability to those systems being damaged" (Jennings, 2018).

Jennings identified four factors that prevented him from delivering such a policy statement:

- "…the sheer number of players across the Defence tribes who felt they had a dog in the space fight."
- "…no one section of Defence had enough control of space policy to champion change and spur faster policy development."
- "Third, notwithstanding the 'critical enabler' label that was attached to space, Defence's senior leaders weren't really galvanised by the issue. Not in the way they could be galvanised about the big issues like platform acquisition or

occupying floor space in the Russell headquarters. Space was 'niche'—just like cyber used to be. And that was just inside Defence. Beyond the department was, well let's call it Dimension X: an uncharted world of departments and agencies whose staff didn't have security clearances (gasp!), bureaucratic decision-makers who were focused on economics (shock!) and politicians who didn't think space was important (beam me up!)"

- "Finally, there are one or two green shoots of hope that our major political parties are seeing the promise of more investment in space. There's bipartisan support for the new space agency and for sustaining a meaningful defence industry base which will clearly be a central player in space technologies and systems" (Jennings, 2018).

Toward the end of the article, and looking to a fifth-generation Defence Force, Jennings makes the point that there remains an undue focus on platforms (ships, tanks and planes) in Defence and not enough emphasis on end-to-end systems.

Table 6.7, below, illustrates, if somewhat crudely, the growing realisation in Defence and in government of the importance of space to Australian military strategy and operations. The table simply shows the number of times the words 'space' (in the context of outer space) and 'satellite' appear in the texts of the seven Defence White Papers that have been produced by various governments between 1976 and 2016. The Dibb Report is included as a reference point.

Table 6.7. References to 'space' and 'satellite' in Defence White Papers since 1976.

Document	Number of times 'space' occurs	Number of times 'satellite' occurs
Defence White Paper 1976	Nil	Nil
Dibb Report	Nil	4
Defence White Paper 1987	Nil	4
Defence White Paper 1994	3	8
Defence White Paper 2000	Nil	2
Defence White Paper 2009	31	15
Defence White Paper 2013	37	11
Defence White Paper 2016	51	7

The table shows that a step function change occurred towards the end of the first decade of the 21st Century. There appears to be no single reason for this. Rather there was a coalescence of events and activities. These included:

- The creation of the Defence Imagery and Geospatial Organisation (now called the Australian Geospatial Organisation – AGO) in 2000 (AGO, 2018).
- Entry into service of satellites and payloads on satellites in which Defence had a direct stake – notably the shared commercial/defence communications payload on the Optus C1 satellite in 2003 and the hosted communications payload on a commercial satellite – Intelsat-22 (Pathfinder, 2009; Aerospace Technology, 2018). Defence has a long-running, multi-phase communications satellite project, called JP2008 that, not without problems including in the provision of ground terminals, continues as a project vital to the support of Defence activities across Australia and in areas where the Defence Forces is conducting operations and exercises (ADM, 2015; ADBR, 2017).
- Regular participation by ADF personnel in Schriever Wargames in the United States, most recently in October 2018, which have made clear the dependence of modern military forces on secure and assured access to space-based services (Cozzens, 2018).
- Accumulated experience by Australian forces operating in the Middle East and elsewhere, notably precision and effects-based operations made possible by the GPS system (Layton, 2017).
- The creation of a Joint Defence Space Coordination Office (DSCO), within Air Force Headquarters in 2006 (Pathfinder, 2009), now moved to the Vice Chief of the Defence Force (VCDF) Division arising from the First Principles Review.
- Normalisation of the place and role of the joint facilities from political and military perspectives. Opponents remain, but the place of the facilities within the Australia/US alliance is accepted by the major political parties and has ceased to be a source of major argument or controversy (Beazley, 2016).
- Continued development and improvement of the Jindalee Over the horizon Radar Network (JORN) system that has a fundamental dependence on deep understanding of the behaviour of the ionosphere (Defence Connect, 2018b).
- Broader developments in computing technologies that allowed the possibility and drove home the importance of networked operations that would be essential to future military success (Layton, 2017).

- Realisation that current and future acquisitions, notably the F-35 fighter aircraft and the Triton high-altitude long-endurance unmanned surveillance aircraft, require secure and assured access to communications satellites as an integral element of the overall system (Lockheed Martin, 2018; Williams Foundation, 2014).
- An invitation issued by the United States to Australia (and issued separately to the United Kingdom) in the late 1990s, to develop a treaty level regime that would streamline the transfer of sensitive US military technologies to Australia in the context of future acquisitions (DoD, 2018a). The Defence Cooperation Treaty was signed in 2007 and eventually came into force in 2012 with the passage of supporting domestic legislation and regulations – the Defence Trade Controls Act (DTCA) and the Defence Strategic Good List (DSGL) to which the DTCA applies (Australian Government, 2012a).

In summary, since 2009, or thereabouts, space awareness and capability has no longer been regarded as discretionary or an option by the Department of Defence. It is now an essential component of capability. The 2016 White Paper added a further dimension of complexity by linking emergent threats in space to those in cyberspace.

> "Beyond the increasing regional military modernisation, the strategic environment over the next 20 years will be shaped by complex non- geographic threats, such as the threats in cyberspace and space. The security environment of the future, both in peacetime and during armed conflict, will feature increased threats from offensive cyber and space- based capabilities" (DoD, 2016b, p. 51).

The White Paper also stated that 900 new positions would be created to bolster the numbers of people working in intelligence, space and cyber areas of the Department (ibid, p. 147)

6.9.4 Ownership and Sovereignty

Apart from a small research satellite, launched in 2017, the Australian Department of Defence does not operate satellites of its own. It does operate defence-specific communications payloads on satellites that are owned and operated by other entities. The Optus C1 satellite, and a hosted payload on Intelsat 22, as noted above, are examples. The Australian Government also paid for the sixth and final satellite in the Wideband Global Communications (WGS) constellation operated by the USAF (Henry, 2017a). The effect of this arrangement has been to allow the ADF, and the government more generally, access to the entire WGS constellation of six satellites by paying for the cost of one of them (SMH, 2007, Wroe, 2013).

Looking back to the year 2000, the government arranged access to a US Navy satellite LEASAT 5, that was otherwise destined to be taken out of service (Henry, 2017b). This satellite was placed in a geostationary orbit north of Australia and provided communications for RAN ships operating within its field of view for a decade before the satellite was eventually taken out of service with its functions replaced by the hosted payload on Intelsat 22 (Space News, 2010).

In summary, through these various contractual mechanisms Defence, in effect, has brought down the risk on launch, the most hazardous aspect of space operations, for the satellite communications capabilities it needs. Successive governments appear to have judged that, whilst the United States remains by far the largest investor in space infrastructure in support of its national security objectives, and given the closeness of the alliance relationship, the operational and sovereign risks associated with Australia not owning, operating or being able to launch its own satellites have been acceptable.

6.9.5 Sovereign Capabilities for Earth Observation from Space

The 2009 Defence White Paper (DoD, 2009, p. 82) stated that Australia would seek to acquire and operate its own remote sensing satellite. An unusually prescriptive paragraph stated that the satellite would, "most likely be based on a high-resolution, cloud-penetrating synthetic aperture radar" (ibid, p. 82). If placed in a near equatorial orbit, which was inferred but not stated, such a satellite would orbit the Earth every 90 minutes or so and would serve as a tripwire for ships and aircraft moving south through the Indonesian archipelago and the air-sea gap. It would serve as a cross-cue sensor to JORN as well. Being an active sensor, the satellite would detect non-cooperative targets (those seeking to avoid or evade detection) and distinguish those from co-operative targets (those transmitting identifying information about themselves). -

The satellite proposal did not progress. The 2013 White Paper, in contrast to its predecessor, made only vague reference to the possibility of Defence acquiring space-based remote sensing capabilities in the future (DoD, 2013, p. 79).

6.9.6 The 2016 Defence White Paper

The 2016 Defence White Paper made frequent mention of the importance of the space and cyber domains to current and future warfare. Importantly, money was allocated to projects and there was a commitment to the creation of new space-related positions (DoD, 2016b, p. 147). Also, a new project was introduced into the Defence Investment Program, DEF799. Under this project AU$500 million has been committed by government to a two-phase project to strengthen Australia's space-based intelligence, surveillance and reconnaissance (ISR) capabilities. The first phase is to provide more timely access to imagery from commercial satellites. The second phase involves a two-year study to inform the acquisition of a sovereign geo-intelligence (GEOINT) space surveillance system (DoD, 2018b).

The 2016 *Defence Integrated Investment Program* (DIIP), which was released with the 2016 Defence White Paper, allocates in the order of AU$10 billion for space related projects in the coming 10-15 years (DoD, 2016d). The principal space projects are listed in the following table.

Table 6.8. DIIP 2016: Space and Space Related Projects.

Project	Time Frame	Amount Allocated
Space Telescope	2016 ongoing	<100m
Space Situational Awareness Systems and Radars	2018 ongoing	$1bn - $2bn
Enhanced JORN	2016-2026	$1bn - $2bn
Satellite Imagery Capability	2022 ongoing	$3bn - $4bn
Military Satellite Capability	2016-2020	$507m
Satellite and Terrestrial Comms Infrastructure	2016-2030	$2bn - $3bn
Collins Submarine Satellite Communications	2019-2026	$750m - $1bn

Beyond the size of these numbers is the complexity of the systems being acquired. All the new platforms (ships, land vehicles and aircraft) being acquired by Defence have a fundamental dependence on secure and assured access to satellites for communications and data. Satellites no longer merely enable military systems; they are integral to them.

In 2016, space capabilities were identified as one of nine research areas in which Defence would seek to make targeted investments in coming years (DST Group, 2016). In 2017, a cubesat funded by the Defence Science and Technology (DST) Group was successfully launched into orbit. The purpose of the mission, called Buccaneer, was to measure from space the performance of the Jindalee Over-the-horizon Radar Network (JORN) (DST Group, 2018b).

RAAF has contracted UNSW Canberra to build three cubesats for launch in 2018/19 to support a series of experiments related to space situational awareness (Ellis, 2017).

In an important policy shift, the 2016 White Paper recognised defence industry as a ninth "Fundamental Input to Capability" (FIC). The other FIC are: Personnel; Organisation; Collective Training; Major Systems; Supplies; Facilities and Training Areas; Support; and Command and Management (DoD, 2016b). To quote the White Paper:

> "Recognising that an internationally competitive Australian defence industry is a Fundamental Input to Capability means that it will be mandatory to consider Australian defence industry in the formal capability development process, helping to

better match the development of new capabilities with Australian defence industry's ability to deliver them" (ibid, p 109).

The Defence Industry Policy Statement (DIPS) also complemented the 2016 White Paper. The DIPS outlined a set of funded mechanisms to encourage Australian companies to invest in innovative Defence technologies. The Next Generation Technology Fund (NGTF) is one such initiative that is designed to:

> "…enable Defence to better position itself to respond to strategic challenges, retain a technology 'edge' against adversaries and provide game changing Defence capabilities for the future" (DoD, 2016e, p. 72).

"Space capabilities" are listed as one of nine priority themes to which Defence is seeking to invest through the NGTF (ibid, p. 72).

The defence innovation system more broadly has been developed in parallel with a range of civil innovation programs to be discussed in a later section of this Chapter.

A public consultation process was one method by which the authors of the 2016 White Paper sought to engage the broader community in the White Paper process. In addition to a series of facilitated meetings written submissions were called for and 268 were received. Of this number 185 are openly available. Table 6.9 shows, by category, the originators of these submissions.

Table 6.9. 2016 Defence White Paper: Public Submissions by Category.

2016 Defence White Paper: Public Submissions

		n - 185	n - 268
Commonwealth Depts Agencies	4	2%	1%
State Governments	7	4%	3%
City and Regional Govts and Organisations	17	9%	6%
Industry Associations/Groups	10	5%	4%
Professional Associations	3	2%	1%
Defence Support Organisations	7	4%	3%
Major System Integrators (MSI)/Large Companies	6	3%	2%
Other companies, including SMEs and Start-ups	17	9%	6%
University Sector/Learned Academies	7	4%	3%
Anti-War/Anti US/Peace and Humanitarian Organisations	17	9%	6%
Private Submissions	90	49%	34%
SUBTOTAL	185		
No consent to publish or considered but not published	83		31%
TOTAL	268		100%

Only a handful of the submissions referred to space capabilities. One major Defence company spoke about the importance of enhanced SATCOM capabilities (Submission 26). Many submissions were focussed on defence industry development and defence presence, especially locations, mainly to boost local economies. Many of the private submissions were simply lists of the types and numbers of platforms the writers felt were necessary for Australia to have a credible defence force. Some submissions spoke specifically about cyber security. Only one private submission, written by a student from the Australian National University, spoke specifically to a space-related topic (Submission 81). This submission raised the problem of over-reliance on vulnerable and readily disturbed satellite systems, notably GPS, and argued for an alternative approach to PNT to mitigate the operational risks associated with over-reliance. Some of the most carefully argued and documented submissions came from anti-war, anti-US groups, several of which called for the closure of Pine Gap. Submissions 98, 107, 127, 151 and 223 are examples (DoD, 2016f).

The submissions point to a bifurcation that exists in Australia between the military and civil space sectors in two ways. One indicator is that industry associations, that represent companies and other organisations that work in both upstream and downstream elements of the space economy, including the SIAA, SIBA and the SSSI, did not make submissions on behalf of their members, notwithstanding the substantial investments that Defence makes, and is projecting to make, in space. A second indicator is there is no evidence that individuals who are interested in space and who have made submissions to the various space-related inquiries (discussed later in this Chapter) contributed to the Defence White Paper process. The challenges and the opportunities that ‘dual use’ technologies present were not addressed in any private submission that is in the public domain (DoD, 2016f).

6.9.7 The First Principles Review

Just in advance of the 2016 White Paper was a major review of the internal workings of Defence. Called the *First Principles Review*, this activity was overseen by a committee of senior business executives. The review focused on major organisational, procedural and cultural reforms to create what the review called “One Defence” (DoD, 2017). The review made six key recommendations and 70 specific recommendations. Although the *First Principles Review* made no direct reference to Defence space activities, three recommendations were pertinent. Paraphrased, these were that:

2.19 The Defence Science and Technology Organisation strengthens partnerships with academic and research institutions to leverage knowledge and create pathways with academia and industry;

3.4 The Associate Secretary be directed and resourced to implement enterprise information management that provides Defence with trusted information to inform decision-making and military interoperability, with the Vice Chief of the Defence Force as the design authority for the next generation of Command, Control, Communications, Intelligence, Surveillance and Reconnaissance (C3ISR); and

3.10 Geospatial information functions be consolidated into the Australian Geospatial-Intelligence Organisation following improved resourcing and connectivity.

By the time the review was complete, and consistent with Recommendation 2.19 of the *First Principles Review*, DSTO (since renamed DST Group) was already working closely with some universities, including on space projects. For example, DSTO was a partner with the University of New South Wales in the SAR Formation Flying satellite project that was funded under the Australian Space Research Program (ASRP). Defence space policy and capability definition now rests with the Vice Chief of the Defence Force (consistent with Recommendation 3.4). And, geospatial information functions that had been distributed are now concentrated within the Geospatial Intelligence Organisation (consistent with Recommendation 3.10).

6.10 Review of the Space Activities Act

Although no follow-on funding was provided by government for a second round of the Australian Space Research Program (ASRP), the program provoked legislative review and reform. Several universities, either within or parallel to the ASRP, had built or were building small satellites that would need to be launched. Some start-up companies had also formed with plans to build and launch small satellites and others had formed to conduct launch activities from Australia.

An impediment was the 1998 Space Activities Act. As noted already, the legislation had been drawn up specifically to support the development of a heavy lift launch industry in Australia. The liability provisions, especially those relating to insurance cover, were considered to impose unrealistic costs on organisations seeking to launch small satellites, especially for educational and research purposes (SIAA, 2016a, SIAA, 2016b).

Consistent with Coalition policy to reduce red tape and to create a less burdensome regulatory environment for business, a review of the Space Activities Act was commissioned towards the end of 2015 with a view to reducing barriers of entry to upstream space activities by Australian companies, universities and others who were seeking opportunities to benefit from the burgeoning international space economy. The first two points in the Review's Terms of Reference emphasised innovation, entrepreneurship and private investment (DIIS, 2016a).

The review had several steps including public consultations led by Professor Steven Freeland from the University of Western Sydney. In response to an Issues Paper released early in 2016 (DIIS, 2016b), 69 responses were lodged of which information was released about 58 (DIIS. 2016a).

Table 6.10. Responses to Review of Space Activities Act by Type of Respondent.

SUBMISSION BREAKDOWN BY TYPE OF RESPONDENT (ADJUSTED)

	Total
Commonwealth Departments/Agencies	0
State Governments	0
Universities	5
Secondary Education (STEM)	0
Private Submissions	30
Large Profit Companies	3
Small and Medium Enterprises	11
Professional Bodies, Industry Associations, Outreach	9
	58

The next step in the review process was a Legislative Proposals Paper that was released in March 2017 with responses called for in a window of less than one month (DIIS, 2017a). In June 2018, a draft *Space Activities (Launches and Returns) Bill* was referred to the Senate Economic Legislation Committee for consideration. The Committee called for written submissions and received 22 responses, one of which was confidential.

Table 6.11. Responses to the Senate Economic Legislation Committee by Type of Respondent.

SUBMISSION BREAKDOWN BY TYPE OF RESPONDENT (ADJUSTED)

	Total
Commonwealth Departments/Agencies	0
State/Territory Governments	1
Universities	3
Secondary Education (STEM)	0
Private Submissions	1
Large Profit Companies	0
Small and Medium Enterprises	13
Professional Bodies, Industry Associations, Outreach	4
	21

The responses were mixed. Unlike previous reviews only one private submission was received. No large companies provided comment. However, start-ups and SMEs, although generally welcoming reform, expressed caution about elements of the Bill that were unclear or that could still impact negatively on their businesses.

Professor de Zwart from the University of Adelaide Law School described the *Space Activities Act* as a "general failure" and that its replacement would need to be substantially reformed if it were to assist the development of a vibrant space industry in Australia (de Zwart, 2018). The Professor acknowledged that the draft *Space Activities (Launches and Returns) Bill* was an improvement over the existing legislation in some areas. However, she was critical of the Bill on two main grounds:

- Many of the amendments proposed were cosmetic and not substantial as had been discussed in the Legislative Proposals Paper; and
- A great deal of detail remained to be dealt with in Rules yet to be written.

She wrote that the Bill "does not adopt a modern approach to domestic space law that would promote commercial activity in a modern and controlled manner" (de Zwart, 2018).

One of the more comprehensive submissions was made by the Space Industry Association of Australia (SIAA). It argued that the proposed legislation lacked a strong statement of purpose as does, for example, the US Commercial Space Launch Activities Act (SIAA, 2018a). The SIAA argued that the legislation should state, as one of its objects, that the "Parliament wishes to create a supportive regulatory environment for the growth and encouragement of Australian space activities" (SIAA, 2018a). Beyond this aspirational statement, the submission provided a detailed critique of those sections of the Bill that, from the SIAA's perspective, needed to be strengthened or reconsidered.

Having considered the submissions, the Committee recommended that the Bill be passed (CPD, Senate, 2018, p. 25). Labor members of the Committee made additional comments to the Committee's report, but recommended that the "Senate support the Bill, noting its deficiencies and lack of clarification from the government in a number of areas" (CPD, Senate, 2018, p. 30).

The Review of the Act led to it being renamed and some revisions, helpful to industry, have been made. The revised legislation passed through the Parliament unopposed in August 2018 although several speakers from the Opposition, including Mr Tony Zappia, were critical that the proposed amendments were more in form than substance and were not as helpful to the developing space industry sector as they could have been. (CPD, H of R, 20 Aug 2018, pp. 7777-7779). The Bill will not become law until new Regulations have been drafted and accepted, which may take a year. This delay has also drawn criticism (CPD, H of R, 20 Aug 2018, p. 7796).

The review of the 1998 Act took three years and provided the legislative backdrop for some other activities that were more political in their nature and impact.

6.11 The 'Tiger Team'

Toward the end of 2016 the then Minister for Industry, Innovation and Science, The Hon Greg Hunt MP, asked some people who were immersed in the space industry whether he should propose to Cabinet that an Australian space agency be formed. The Minister made clear that he was seeking a case that was comprehensive and coherent and had wide industry support (Biddington, 2016c). His interest would seem to have been piqued by a conference held in September 2016 in Sydney, for which he provided a letter of welcome (GAP, 2016). The conference, with the title *A Vision for Australia 2016: Space of Australian Innovation*, was organised by Global Access Partners (GAP). Mr Peter Fritz is the Group General Manager of GAP. Following the conference, Mr Fritz formed a Tiger Team to assist him to continue the momentum generated at the conference and to move quickly on policy development.

On 14 February 2017, a Science Meets Parliament breakfast meeting was held in Canberra (Biddington, 2017f). The main speakers were from the Tiger Team and they made a 'pitch' for a space agency as a necessary first step for Australia to become a participant in the global space market that, as indicated in Chapter Two, is growing rapidly. The argument put to the parliamentarians was straightforward.

Proposition 1.	Space competent nations have space agencies.
Proposition 2.	Australia does not have a space agency.
Conclusion:	Australia is not a space competent nation.
Proposed solution:	Form a space agency.

The opportunity to present a more nuanced and possibly more persuasive argument for a space agency was not taken.

The work of the Tiger Team resulted in a report that was published in August 2017. The report was titled *The Australian Space Initiative: GAP Taskforce on Space Industry Report* (GAP, 2017). The report made 12 recommendations all with a strong industry development focus. The first was that Australia should:

> “Establish a modest Australian Space Agency, funded by public-private partnership, to coordinate existing and emerging civilian efforts and leverage current public spending. This would not remove funding from other agencies, but would maximise value for money and develop opportunities for the domestic industry to grow” (ibid, p. 24).

The last, with a 10-year horizon, was that Australia should:

> “Begin the domestic manufacture of large satellites capable of handling Australian national data needs on the scale of the AU$2 billion NBN Co satellite” (ibid, p. 24).

The GAP Taskforce Report noted that the Space Tiger Team, “met six times between October 2016 and January 2017 and delivered three policy submissions to the Australian Government”. In April 2017, with government support, GAP launched its *Australian Space Initiative* and set up a *Taskforce on Space Industry* to succeed the Tiger Team (GAP, 2017, p. 8). This initiative was not widely publicised and most of the members of the task force came from Sydney.

The Tiger Team operated independently of other initiatives. Notably, the Tiger Team chose not to engage with the Space Industry Association Australia which was host to the International Astronautical Congress (IAC2017) scheduled to be held in Adelaide in September of 2017. The Congress is discussed below.

6.12 The Expert Reference Group

In July 2017, the government announced the formation of a panel, to be known as the Expert Reference Group (ERG) to conduct a *Review of Australia’s Space Industry Capability* (DIIS, 2018b). Acknowledging past work, one of the Review’s terms of reference was to:

> “Build on the principles set out in the existing *Australia’s Satellite Utilisation Policy* by developing a strategic framework for the Australian space sector that supports leadership, innovation, opportunity and entrepreneurship across the sector along with our broader national interests” (DIIS, 2018b, Appendix 1).

The Review was expressly tasked to address eight matters, that related to Australia’s current industry capability and areas of comparative advantage for Australia to develop,

- “Technologies and practices that promote innovation in both the downstream (users of space technologies) and upstream (providers of space technologies) elements of space activities, particularly in areas of niche capability and competitive advantage,

- Australia’s level of regional engagement and international collaboration, including identifying critical future and existing partnerships,
- Identifying capability gaps to support the global competitiveness of Australian firms in the civil space sector,
- Strategies to promote Australian firms engaged in the civil space sector, both domestically and internationally,
- Risks and opportunities, including ongoing access to space data and associated infrastructure essential to our national interests,
- Alignment with other sectors and Australian Government priorities, including Defence and cyber security, and meeting Australia’s international obligations, and
- The most effective institutional arrangements to support the strategic direction of Australia’s space industry” (ibid, Appendix 1).

The ERG was directed to consult widely and to present a formal report by the end of March 2018.

Dr Megan Clark, a former CEO of CSIRO was invited to Chair the group that included representatives from SMEs, the start-up community, academia (space law, space engineering and astronomy) and public sector stakeholders. The Chair of the Space Industry Association of Australia (SIAA), represented the broader private sector (ibid, Appendix 1). There were notable omissions, including representatives from one or more of Australia’s larger companies, such as Optus or BAE Systems, with interests in space and representatives from downstream elements of the space sector, such as the geo-spatial services sector.

The timing of the Review was prompted, in part at least, by the International Astronautical Congress (IAC) that was due to be held in Adelaide in the last week of September in 2017. The Minister for Industry, Innovation and Science (Senator, the Hon Arthur Sinodinos) asked Dr Clark to provide him with summary findings in the week before the IAC as these would influence the content of the keynote address he was scheduled to deliver at the Congress.

On 3 August 2017, an Issues Paper was released by the ERG to which written submissions were sought by 22 August – an exceptionally short period for responses to be prepared and submitted. The Issues Paper also informed round-table meetings in every State and Territory capital city that were held in the latter part of August and early September. Almost 200 written submissions were received, 140 of which are openly available, and 400 people attended the meetings (DIIS 2018b, Appendix 2). Table 6.12 below is a breakdown of the 140 written submissions that are open to the public.

As with Table 6.3, which summarised the submissions to the 2008 Senate Inquiry, so with Table 6.12, some judgement has been applied in deciding where submissions best fit. Several submissions were received from single person companies and these have been counted as individual submissions. Also, several submissions from the university sector reflected the private views of individual academics rather than the view of their institution. These also have been counted as private submissions.

Table 6.12. Responses to ERG Review by Type of Respondent.

SUBMISSION BREAKDOWN BY TYPE OF RESPONDENT (ADJUSTED)

	Total
Commonwealth Departments/Agencies	16
State Governments	7
Universities	15
Secondary Education (STEM)	0
Private Submissions	50
Large Profit Companies	10
Small and Medium Enterprises	26
Professional, Industry and Outreach groups	23
	140

The striking difference between Table 6.3 and Table 6.12 is the increased number of Small and Medium Enterprises, including start-ups; from just four in 2008 to 26 in 2017. This number represents almost 20% of the 140 written responses that are openly available.

Dr Clark drew on the material from these submissions and consultations in her briefing to Ministers in the weeks and days before the IAC.

A week before the Congress, illness forced Minister Sinodinos to stand down from his Ministerial and parliamentary duties. His place was taken at the Opening Ceremony by Senator, the Hon Simon Birmingham, the Minister for Education and Training. Drawing on Dr Clark's advice, and following discussion among senior Ministers, Senator Birmingham announced at the Opening Ceremony of IAC2017 that Australia would establish a national space agency in 2018 (Birmingham, 2017). This announcement was greeted with a standing ovation among the more than 3,000 delegates in the auditorium (more than 4,400 delegates attended the Congress, but the auditorium's capacity was limited to 3,000).

Senator, the Hon Michaelia Cash, assumed the portfolio responsibilities of Minister Sinodinos, initially on an acting basis. Senator Cash addressed an industry lunch on the second day of the IAC and made the point in a brief private discussion that she and other members of the government had been flooded with emails and phone calls congratulating the government on its announcement (Biddington, 2017g). The impression she gave was that the government had been surprised by this response and possibly emboldened by it as well. In December 2017, in the context of a wider Cabinet re-shuffle, Senator Cash was confirmed as the Minister for Jobs and Innovation, which included responsibility for civil and commercial space matters (DPMC, 2017).

The Labor Party announced just hours before the Opening Ceremony of the IAC that a future Labor government would establish a space agency as a statutory body. Senator Kim Carr, the Opposition spokesperson and shadow Minister made the announcement in Adelaide (Carr, 2017a). The Senator 's announcement was quickly swamped by the government's announcement. However, largely through happenstance, both major parties had arrived at a position of bipartisan support for a space agency.

Following the IAC, the tasking of the ERG was changed to recommend to government in somewhat more specific terms that originally envisaged the form that the space agency should take to include recommendations about its functions. The ERG presented its final report to government in March 2018 (DIIS, 2018b).

The ERG claimed that the Australian space sector had the potential to treble its size by 2030, from being a AU$3-4 billion industry in 2016 to something greater than AU$10 billion in 2030 and from employing 10,000 or so people in 2016 to employing an additional 10,000 – 20,000 people also by 2030 (DIIS, 2018b, p. 5).

This growth is set against global projections indicating that the space industry will be a US$ 1.1 trillion industry by 2040 (ibid, p. 6).

The ERG recommended that a dedicated space agency be established to assist in promoting the growth of an Australian space industry (ibid, p. 12).

6.13 The States and Territories

More than 12 months before the International Astronautical Congress was due to be held in Adelaide, several State and Territory governments began to plan for the event and began to work together, at least to some limited extent. The Governments of the ACT and South Australia initiated the move and a paper was put to the Industry and Skills Council of the Council of Australian Governments (COAG) which is the principal mechanism for coordinating the overlapping interests of the Commonwealth, State and Territory governments (ACTSSDC, 2017; COAG, 2017; COAG, 2018).

6.14 The International Astronautical Congress of 2017

6.14.1 Background

The International Astronautical Congress (IAC), is one of the world's largest space meetings. The first IAC was held in 1950 in Paris and the Congress has been held annually since then. Heads of space agencies, former astronauts, space company executives, academics and researchers typically attend the Congress. It also attracts many early career professionals and students. The 49th IAC was held in Melbourne in 1998 (IAF, 2019).

The Government of South Australia, through the Adelaide Convention Bureau (ACB), seeks to attract large international conferences to the Adelaide Convention Centre (ACC) that has been re-developed and expanded over the past six years (ACB, 2019; ACC, 2019). In 2011, the ACB sponsored a small team from Adelaide, including a well-connected local lawyer, Michael Davis, to attend the International Astronautical Congress (IAC) that was held that year in Cape Town, South Africa. The team was tasked to assess whether the IAC would be a suitable Congress to bring to Adelaide in the future. Mr Davis is a passionate advocate for space education and space industry development in Australia. He was a long-time Chair of the Advisory Board of the Institute for Telecommunications Research (ITR) at the University of South Australia (UniSA) and was instrumental in bringing the Summer Session of the International Space University (ISU) to Adelaide in 2004 (Lawyers Weekly, 2011; UADL, 2004).

In the normal course of events, IAF members would have decided in Cape Town which city would host the IAC three years hence, in 2014. However, there was no suitable candidate.

On returning to Adelaide, the review team reported that Adelaide was well suited to host an IAC and a decision was taken to submit a bid into an extraordinary bidding process, held early in 2012, to select a host city for 2014. CSIRO agreed to lead the bid, which was unsuccessful. Toronto in Canada, and a team that had delivered two IACs in the past, was chosen ahead of Adelaide. A consequence of this decision was that no further bid could be launched to host an IAC in Adelaide until 2014, with the aim of hosting the 68th IAC in 2017, due to the extension and refurbishment of the ACC. CSIRO declined to lead any further bid and the SIAA stepped in (Biddington, 2012).

Representatives of the Australian bidding team attended the IACs in Naples in 2012 and in Beijing in 2013 (Biddington, 2013b). They also attended the Spring Meetings of the IAC held annually in March in Paris. The time was used to learn about the IAF and the IAC and to become known to many IAF members. In 2013, the Lockheed Martin Corporation advised the SIAA that, if its bid in 2014 to host the IAC in Adelaide in 2017 were successful, Lockheed would welcome the opportunity to become the Industry Anchor Sponsor for the event. In 2014, Adelaide was in competition to host IAC2017 against bids from Bremen (Germany), Istanbul (Turkey), and Orlando Florida (USA). Adelaide was selected, Lockheed Martin became the Industry Anchor Sponsor and a small team was assembled to plan and deliver the event.

Points to take from the above outline of events are:

- The impetus to bid to host the Congress came from an organisation seeking to fill a convention centre, based on the initiative, connections and determination of one individual. It did not come from government or industry seeking to develop or expand the space sector in the economy.
- The bid was opportunistic and not linked to or part of any national strategy to promote space activities or broader goals around innovation, STEM education or the development of international partnerships.
- Funds for the bid process were constrained, with the State government bearing most of the costs. The Commonwealth provided modest support to the bid in 2012 and 2013. This ceased with the election of the Abbott Government in 2013. Modest university and private sector sponsorship was obtained to ensure the Australian presence in Toronto was adequate in 2014.
- Some individuals provided in-kind support and contributed to the costs of their domestic and international travel.
- Having failed in 2012 to host the IAC in 2014, the bid team used the intervening years to refine and more carefully articulate its strategy that led, in 2014, to the SIAA being selected to host the 68th IAC in Adelaide in 2017.

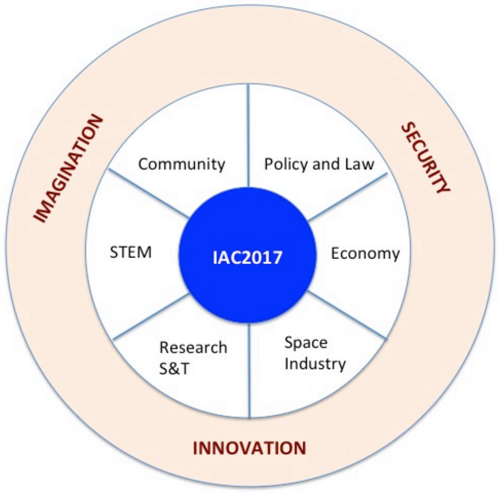
6.14.2 The IAC2017 Strategy

Potential IAC hosts are required to develop a theme or tagline that captures the essence of what they plan to deliver in case their bid is successful. The theme developed in 2013 by the Australian bid team for IAC2017 was: *'Space: Unlocking Imagination, Fostering Innovation and Strengthening Security'*; three nouns and three verbs that were considered to capture the essence of Australia's past, present and future interests and activities in space. The theme was considered broad enough to be relevant to other nations and participants whilst meeting local needs.

The theme drove the engagement and marketing strategy of the Congress.

The strategy is captured in the graphic overleaf.

Figure 6.1. IAC2017: Schematic of Strategic Plan.



Source: IAC2017 Strategic Planning Document

The three nouns, "Security", "Innovation" and "Imagination" from the theme relate to the six core groups or constituencies all of which needed to be engaged for the Congress to be a success. Beyond a clear obligation to deliver a successful Congress, the higher goal, was to ensure that the Congress delivered a worthwhile and enduring legacy.

With specific reference to Australia, six distinct constituencies were identified by the SIAA. Each needed to be made aware of IAC2017 and engaged as partners in the event as investors, and as potential beneficiaries.

- The policy and law segment referred to the government departments and agencies with policy, legal and regulatory responsibilities for space. A small group of academics is also interested in these matters.
- The economy segment referred to the dependencies that global supply chains have on secure and assured access to the services and data provided by satellites. The focus in Australia is on the value-added services provided by government agencies such as GA and BoM and by the for-profit companies that provide SATCOM services, and products based on Earth observation data combined with data from timing and positioning satellites. These are downstream services on which regional and national economies, as well as the global economy, depend.
- The space industry segment referred to the small number of Australian companies and other organisations whose business is directly related to space.

Various studies have revealed indicative numbers of between 5,000 to 10,000 Australians occupying positions that would qualify for inclusion in this segment, which embraces upstream and downstream elements. They include the Optus technicians who 'fly' the Optus fleet of satellites, the Defence imagery analysts who glean intelligence from satellite imagery that is available to them from a variety of sources, and many in between.

- The Research, Science and Technology segment referred to the space science and engineering research conducted in CSIRO, DST Group and in several Australian universities as well. This is the segment that gained the most direct benefit from the ASRP.
- The STEM segment referred to the strenuous efforts being made across the world to educate many more people to become more competent and confident in the disciplines of Science, Technology, Engineering and Mathematics (STEM). There is a commonly held belief that students are inspired by space and a substantial STEM program was developed specifically to support IAC2017 with activities scheduled both inside and adjacent to the Congress (Oliver, 2017).
- The Community segment related to the broader community. The Congress injected in the order of AU$20 million into Adelaide's economy and perhaps that much again into the national economy as many delegates spent additional time as tourists in Australia before they returned to their homes. The local organisers were obliged to make some elements of the Congress accessible to the wider community. This was achieved through a series of public lectures and by inviting the public to attend the exhibition on the last day of the Congress free of charge.

The point is that the space sector in Australia comprises disparate elements that have specific interests, activities and ambitions all of which needed to be acknowledged and addressed in the context of IAC2017. The complexity identified was further compounded by Australia's federal system of government and by the numerous interest groups that spoke just for their element with not a great deal of regard for, or interest in, the space sector as a whole.

Winning the IAC for Adelaide was not the result of a conscious or deliberate plan or strategy to grow the Australian space sector. Rather it was a somewhat *ad hoc* process in which some parties were sufficiently interested in collaborating and investing, largely for their own quite disparate reasons, to bring the event to Adelaide and to make it a success. A coalition of interests was created which developed momentum and support especially during the bid and planning phases of the Congress.

The motives of some of the organisations that brought the IAC to Adelaide had little to do with prestige or with demonstrating Australia's space credentials to a global audience. For some of those most closely involved, the Congress was an end. For others, it was a means. And for others, it was both an end and a means. For the Government of South Australia, holding the IAC in Adelaide was both an end and a means. Working through the ACB, the government was keen to attract the IAC to Adelaide to fill the Convention Centre and to bring revenue into the State. The government also used the Congress, to foster the development of a State-based space industry sector which built on existing capabilities and was especially encouraging of start-ups and entrepreneurs. For Lockheed Martin, the Congress was a means, to remind delegates of the company's role as one of the world's leading space companies. For the SIAA, IAC2017 was both an end and a means. The organisation was contracted to deliver a successful Congress, an end. However, the SIAA was keen to focus national and international attention on the potential for commercial space industry development in Australia including in upstream elements of this industry. A further objective was to provide a venue in which global space leaders might encourage Australian Ministers and senior officials to have Australia become a more active participant in global civil and commercial space activities to the mutual benefit of the nation and the wider international space community. In this regard the Congress was a means to a longer-term end.

Some large companies with significant space interests or aspirations in Australia, including Optus, NBNCo, BAE Systems and Thales chose not to exhibit or to serve as sponsors for the Congress. Their absence pointed to a capability hole, in terms of commitment at least, to the Australian space enterprise.

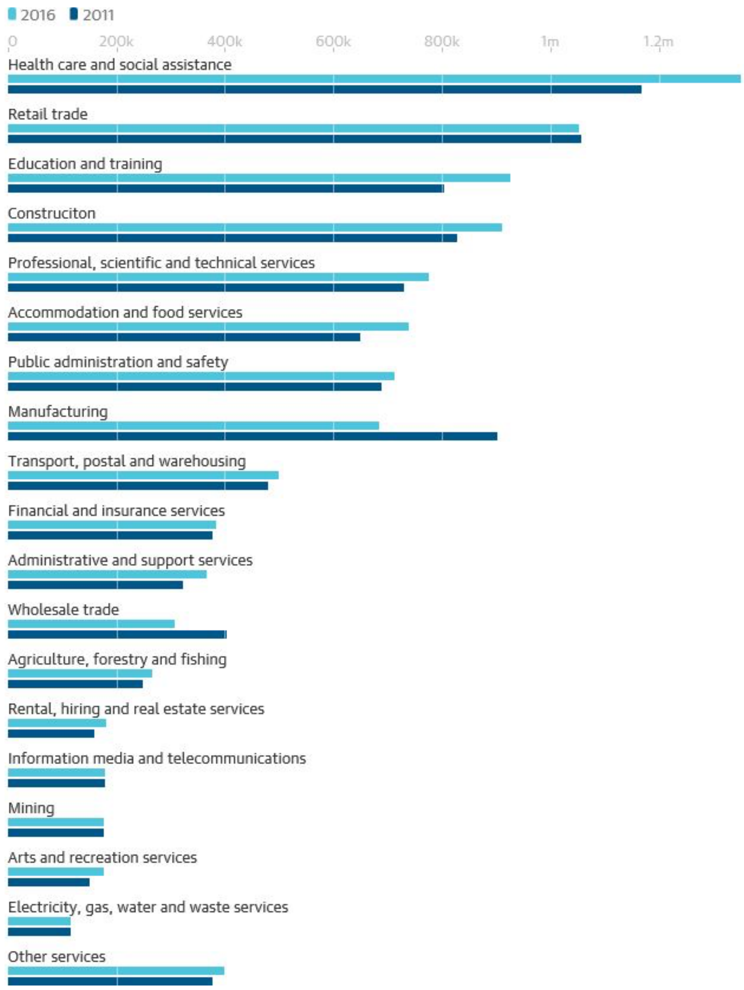
Leaving aside the question of how the decision to host IAC2017 came about, the Congress did serve as a catalyst for change. It prompted, in part at least, the establishment of the Expert Reference Group, which led to government announcing that a space agency would be created in 2018.

The Congress pointed to a larger truth about public policy processes in Australia. Since the 1980s, many of those who have advocated for Australia to do more in space have invariably called on the government to take the lead. This was a common theme in many submissions to the Senate and later inquiries. In organising the Congress, elements of the space sector, led by the SIAA, manifestly stepped to the fore. Government was involved as a partner and was not expected to bear all the financial risk or to do all the work itself.

6.15 Innovation, Research and Space

Since 2007, the Australian economy has undergone major changes in response to globalisation and the rise of global supply chains. The graph below, derived from Census data shows in particular the almost 25% decline in manufacturing jobs from 2011 to 2016 (Hutchens, 2017).

Figure 6.2 Changes to Numbers Employed in Sectors of the Australian Economy: 2011-2016



Guardian graphic | Source: Australian Bureau of Statistics

To offset the loss of these jobs and the more general transformation in work that has been driven by globalisation and information technologies considerable emphasis has been given by governments to the concept of innovation. Since 2010, the Department of Industry Science and Technology (and its predecessors) has published annually the *Australian Innovation System Report*. These documents make no mention of the space domain or the innovation potential of space technologies. In his foreword to the 2017 Report, Mr Mark Cully, DIISR's Chief Economist wrote:

> “Our firms are amongst the most innovation-active in the world and our research has global impact. From what we can see of the future — new digital technologies like 3D printing, quantum computing, blockchain and artificial intelligence — it holds enticing opportunities for our innovators and entrepreneurs to capitalise on” (DIIS, 2017b, p. i).

There is no mention of space.

The 2017 Report was a detailed analysis of High Growth Firms (HGF) in Australia. Recalling that the global space industry is expected to grow rapidly from being a US$345 billion industry today to a US$1.1 trillion industry in 2040 (Chapter Two), a not unreasonable expectation is that some of the Australian space start-up companies will become HGFs. The report says this may take five years from the time the company is established. The high rate of growth period typically lasts for three to five years. Another important finding of the report, relevant to the aspirations of the space industry, is that investment in research and development “appears to have an important impact on firm performance” (DIIS 2017c, p. 74). More specifically:

> “R&D-active firms had substantially increased growth in turnover and wages compared to all firms . . . Growth in the turnover, labour productivity and wages of R&D firms was more pronounced over time, demonstrating the relatively long-term impact of R&D (ibid, p. 74).

In 2015, a report with the title *National Innovation and Science Agenda: Welcome to the Ideas Boom* (DPMC, 2015) was published. The opening sentence of the report was the phrase coined by Malcolm Turnbull when he became Prime Minister and already quoted:

> “There has never been a more exciting time to be an Australian” (ibid, p. 2).

This short document (20 pages of text), outlined a raft of measures that promised to place “innovation and science at the heart of policy making” (ibid, p. 15). Radio astronomy, cyber security and quantum computing received specific mentions. Space did not (ibid).

Separate reviews and mechanisms have been instituted into Australian research infrastructure, leading to national research investment plans being released in 2012 and 2016. They are silent about space investment *per se*. The 2012 Report listed 10 Global Challenges. There was no direct reference to any space related topic, however several of the challenges, including research into environmental and energy issues, climate change new sensor technologies and data management and processing, simply could not be met unless researchers had secure and assured access to data and services from satellites (DIISTRE, 2012, p. 10). “Space and astronomy” were mentioned as one area within the “Technology Domain” that enable research capability and the Square Kilometre Array radio telescope project was specifically mentioned as a major infrastructure investment (ibid, p. 62 and p. 77).

The 2016 National Research Infrastructure Roadmap listed nine focus areas that require ongoing support to ensure that Australia will be able to maintain its position as an emerging or established global leader:

- Digital Data and eResearch Platforms
- Platforms for Humanities, Arts and Social Sciences
- Characterisation
- Advanced Fabrication and Manufacturing
- Advanced Physics and Astronomy
- Earth and Environmental Systems
- Biosecurity
- Complex Biology
- Therapeutic Development (DET, 2017).

In the government's formal response to the 2016 Roadmap, no specific non-astronomy space research infrastructure was identified for funding. However, there was a hint that this could change and that some of the additional money that the government plans to commit to research infrastructure could be used to:

> "…harness the opportunities of space, through building CubeSats and other space-based instruments" (ibid, p. 2).

Several capabilities that, from a space industry point of view, would be regarded as downstream applications, were funded, including:

- The continuous improvement of a project called AuScope , which is an "an online live, four-dimensional Earth Model for the Australian Continent and its immediate environs";
- The Integrated Marine Observing System (IMOS); and
- The Terrestrial Ecosystem Research Network (TERN) (ibid, pp. 14-17).

The space and radio science community spans disparate disciplines and there is no evidence that its collective view carries weight in the discussions that lead to research infrastructure funding decisions. A review of the biographies of members of the Expert Working Group, that led development of the 2016 National Research Infrastructure Roadmap, indicates that none had a space science background, although some of the members may have used data from satellites in their own research (DET, 2017, p. 84).

6.15.1 The Australian Academy of Science: National Committee for Space and Radio Science (NCSRS)

The peak body for space science in Australia is the National Committee for Space and Radio Science (NCSRS), which is a committee of the Australian Academy of Science. In 2005, the NCSRS embarked on an ambitious project to develop a Space Science Decadal Plan (SSDP) similar in concept to Decadal Plan produced by the Australian astronomy community. The plan was eventually launched in 2010 (AAS, 2010). Parts of the plan fitted well with projects that had been funded under the Australian Space Research Program (discussed earlier in this Chapter). Other parts were ambitious, notably a long-term research satellite project called Sundiver aimed primarily at solar science and a system for the Coordination of Australia Space Science (CASS) which sounded like a surrogate space agency. Another proposal was to participate with China in the Meridian Project, which seeks to characterise the ionosphere along a meridian of longitude. This proposal raised concerns in Defence because of its potential to reveal classified aspects of the JORN's capability to another nation (Biddington, 2011). The SSDP was not embraced by policy makers. However, it gave the disparate elements of the space science community a sense of common purpose and, arguably, this was its most important legacy.

At the researcher level, there was a perceived tension between the space science community and the astronomy community. In broad terms the space scientists were concerned that in any competition for funds between space science and astronomy, the astronomers would prevail, leaving space science under-funded (Biddington, 2006c). At the political level these distinctions are blurred. In their public pronouncements, Ministers count astronomy investments, such as the Square Kilometre Array radio telescope project, as part of Australia's commitment to space.

Australia's location on Earth and its geology make it especially attractive for some of the space science disciplines including solar and planetary science and astrobiology. As already noted, both NASA and ESA have major ground stations in Australia at Tidbinbilla near Canberra and at New Norcia in Western Australia respectively. The ancient rocks of the Pilbara contain fossils that provide convincing evidence of the earliest life on Earth, dated at 3.5 billion years of age.

These formations have been carefully studied by NASA and others to inform decisions about how and where to look for evidence of life on Mars (Walter, 1999).

The 2010 SSDP was revised and updated in 2017. A new document, *A Vision for Space Science and Technology in Australia: Securing and Advancing Australia's Interests Through Space Research* was launched at IAC2017 (AAS, 2017). This document is aspirational and devotes more space to the need for coordination than it does discussing science. Evidence that the Australian space science community has an effective voice in the higher councils that govern the directions and funding of research in Australia was not found. This points to the need for a champion whose credentials and legitimacy are beyond question.

An important function of the NCSRS is that it co-hosts, with the National Space Society of Australia, the annual Australian Space Research Conference (ASRC). Since the IAC, the ASRC has gathered strength and legitimacy as the principal event around with the Australian space sector as a whole, gathers to measure progress and to discuss issues of concern (NSSA, 2019).

6.16 The Need for a Champion

Mr Roy Gibson was the first Director General of the European Space Agency and an adviser to the Australian Government in the 1980s and early 1990s about civil and commercial space matters (ESA, 2014). Mr. Gibson was a member of the expert panel from which the report *An Integrated National Space Program*, was published in 1992 for the Commonwealth Department of Industry, Technology and Commerce (DITAC). At a meeting in Paris in 2007, he was adamant that no substantial developments in civil and commercial space activities in Australia were likely to occur unless and until a champion emerged in the Commonwealth Government (Biddington, 2007). This would need to be an individual, a Minister in Mr Gibson's view, who would make the case for space to his or her colleagues in such a compelling way that an enduring institutional mechanism, such as a space agency, would be established that would then be responsible to implement a government funded space program.

Mr Chris Schacht is a former Labor Senator from South Australia and a former Minister, responsible for civil space activities in the Hawke/Keating governments. In numerous public forums, including the South Australian Space Summit (Chapter Five), he has made the point that he was not able to win the unqualified support of key policy departments in Canberra for an adequately funded national space program. In his experience, without the support of the Departments of Prime Minister and Cabinet, the Treasury, and Finance no initiative put forward by any Minister, however deserving the cause, had much chance of gaining the support needed in Cabinet to be funded.

Dr Megan Clark chaired the Expert Reference Group established by the Australian Government in mid-2017 that recommended to the government that a space agency be established. Later, she was appointed as the inaugural head of the Australian Space Agency. She is a Companion in the Order of Australia (AC), the nation's highest civilian honour. She led CSIRO, Australia's premier research organisation, and she has a distinguished career as a mining engineer and is now a director of several very large companies. No other person in the past with explicit responsibilities for space activities in Australia has had a *curriculum vitae* as distinguished as that of Dr Clark. She is, arguably, the first person with the standing, gravitas and mandate to be considered a 'champion' in the sense spoken about by Mr Gibson.

How the Agency has progressed since September 2017 is discussed in Chapter Eight.

6.17 Chapter Summary

The research question addressed in this chapter concerned public policy spending priorities in the context of developments in the Australian space sector that took place between the election of the Rudd Labor government in November 2007 and the announcement in September 2017 that an Australian Space Agency would be established in 2018. Did the increased level of policy attention to space activities represented policy continuity or discontinuity from the years before? There is evidence of both.

The evidence presented paints a mixed and confusing picture. There were substantial developments in Australian space policy and capabilities in the civil and national security domains, leading to the government announcing, in September 2017, that an Australian space agency would be established in 2018.

In 2009, the precarious state of the global economy during the GFC opened the door, somewhat opportunistically, to government making a modest, but valuable investment in space education and industry development in Australia. The GFC was an extraneous factor over which Australia had no direct influence or control, however, it led to a 'tipping' point moment when a range of political, economic, industry and scientific interests coalesced. A modest investment by government in a civil space policy unit and a dedicated space research program reaped worthwhile rewards. Follow-on money to allow the ASRP to continue was not provided by government, which meant that momentum gained between 2009 and 2013 was lost. There were similarities between this start/stop approach and that which had applied to the Australian Space Office in the 1980s and 1990s, leading to the question whether the government was committed to developing the civil space sector in Australia.

There was no single plan or strategy. Rather, some individuals and organisations, acting largely in their own interests and on their own initiative were able to achieve their immediate goals and, in so doing, contribute to developments that had wider impact.

In Charles Lindblom's terms, the process was disjointedly incremental and was a case of 'muddling through'.

More organisations, public and private, were invested in space activities in 2017 than in 2007. Whether a critical mass of interests had come to exist by the end of 2017, however, was not clear. The major government research agencies and several universities were investing in space science and space engineering research and education but some companies, notably large Australian companies with space heritage, seemed to be unsure of the business opportunities. Several chose not to become involved in IAC2017 as sponsors or exhibitors, not convinced that they would benefit from being present or that their presence would advance space industry development in Australia.

Technological change, as already noted, especially the miniaturisation of electronics and advances in computing, materials science and precision manufacturing reduced barriers of entry into space markets by countries and companies that previously had stood aside. The impact of these changes was evident especially in the downstream elements of the space sector, notably in those areas concerned with the manipulation of Earth observation and positioning data provided by satellites. Many tasks once performed by people are now performed by machines. The nature of work in these areas of human and commercial endeavour is changing. The review of the Space Activities Act led to the drafting of a new Act that has attracted criticism because of the amount of detail left to be resolved in the regulations that have yet to be drafted and approved before they and the Act can come into force.

A coalition of initially loosely connected interests led to the IAC being held in Adelaide in September 2017. Domestically, the IAC built on the momentum generated by the ASRP. Internationally, IAC2017 placed Australia squarely in front of the global space community. Here, the nation would be held to account for what others considered to be its indifference to space activities in general and to civil and commercial space development as a whole.

Although Australia has well-developed downstream capabilities, access to the upstream capabilities of others is assumed and the development of sovereign or shared capabilities has not been a policy priority for innovation or research infrastructure investment. As evidenced by CSIRO's purchase of 10% of NovaSAR-1, this situation may be changing.

Aware of the opprobrium that could come its way at the IAC, government created the Expert Reference Group, found a champion and crafted a message that Australia was seeking its share of the revenues that the global space sector is expected to deliver in the coming decades in the upstream as well as the downstream domains. The means of delivery would be a national space agency. Beyond an in-principle announcement that an agency would be established no details were provided at IAC2017 about the size of the agency, its role or location. This suggests that the immediate purpose of the decision was tactical, to allow the government of the day to get past the IAC without undue criticism. Whether the decision to create the space agency had a strategic goal in mind is unclear.

Finally, against the background of China's emergence as a great power, the prospects of war in space started to occupy the minds of senior Ministers as did the question of the future safety and security of the space environment. These issues were raised principally in the context of Australia's alliance with the US. They have led to two space surveillance sensors being relocated, one from the Caribbean and one from mainland US to North West Cape. Closer to home, the Defence Science and Technology Group (DSTG), in association with UNSW, built a cubesat that was launched successfully in March 2017. Whether this is a 'one-off' event or the first in a continuous series of experiments and concept demonstrators remains to be seen.

The next chapter, Chapter Seven, concerns Australia's space industry with emphasis on the reliability of the data on which the argument for the Australian Space Agency has been made.

CHAPTER 7

THE AUSTRALIAN SPACE INDUSTRY

Chapter Seven addresses the fourth research question, which asks whether the growth of a domestic space industry provides sufficient and compelling justification for the establishment of the Australian Space Agency.

This Chapter has two sections. The first is an investigation of the Australian space economy, its overall size and shape. The second is an analysis of Australian space industry focussing on for-profit companies.

7.1 The Australian Space Economy

In Chapter Two, the difficulty of defining the space economy and its contributing components was discussed. The difficulty arises because of the many dependencies that exist throughout all economies on secure and assured access to space-based services. The question becomes where to draw the boundary between activities that are unambiguously space-related and others that may have a dependency on space-based capabilities and space-derived data, but are not space activities in their own right.

The difficulties discussed in general terms in Chapter Two are apparent in the data available for Australia as this Chapter will show. The inaccuracies, as also will be shown, have public policy implications and consequences.

7.1.1 OECD Assessments of the Australian Space Economy

The OECD has encountered problems in measuring the Australian space economy. For example, in the *Handbook on Measuring the Space Economy* (2012), there are two references to Australia, both in tables. The first is in a table (4.1) of industry associations that publish aerospace statistics (OECD, 2012, p. 52). The Australian Association of Aviation and Aerospace Industries (AAAAI), now called Aviation/Aerospace Australia, is included as a source of data on relevant Australian industry activities. A check of the organisation's website indicates that it is concerned exclusively with aviation and not with space, a point confirmed in 2017 in a discussion with the Association's Executive Director (Aviation/Aerospace Australia) Ms Tamara Bell (Biddington, 2017h). The second reference is in Table 5.2, with the title *Conservative estimates of space budgets of G20 countries, 2010*. The table indicates that the Australian Government spent US$11.83 million on space activities in 2010. This is the second lowest amount spent by any government in the OECD (OECD, 2012, p. 66). This figure would seem to have been taken from the 2010/11 Annual Report of the Department of Innovation Industry and Science (DIISR) as the department was then known. It would seem to relate mainly, if not entirely, to a sum of AU$11.2 million allocated to the Australian Space Research Program (ASRP) in that year (DIISR, 2011b). The variation in the figures may be due to variations in the exchange rate between US and Australian dollars. In 2010, one Australian dollar was worth marginally more than one US dollar. Expenditure by other government departments and agencies, including Geoscience Australia (GA), the Bureau of Meteorology (BoM), CSIRO (Australia's national civil science research organisation) and Defence, would seem to have been overlooked.

Other reports prepared at the same time indicate that the Australian space economy was considerably larger than reported by the OECD. A 2010 report indicated that the economic value of Earth observation from space contributed at least AU$3.3 billion to Australian GDP in 2008-09 (ACIL Tasman, 2010). A further report prepared by the Futron Corporation in 2012 indicated that in 2011 the Australian Government spent US$330 million on civil space activities (Futron, 2012, p. 35). These figures would not seem to account for the activities of the States and Territories (mainly as users of satellite communications services and remote sensing data) nor of commercial activities. Futron reported that Singtel Optus, the Australian subsidiary of the Singapore based and owned Singtel Corporation, recorded sales of US$287 million in 2010 (ibid, p. 37).

Past OECD estimates about the size of the Australian space economy lend credence to Hertzfeld's general point that accurate data about the space economy is hard to find.

7.1.2 Addressable, Available and Obtainable Markets

The Final Report of the Expert Reference Group (ERG) that was established in 2017 by the Australian Government to review Australia's space industry capability (DIIS, 2018b) published the figures below, from research by other parties, to describe the size and predicted growth of the global space market. These top line figures are often quoted by Ministers, industry figures, and others to emphasise the size of the opportunity open to Australian space companies.

- The value of the global space economy was US$345 billion (AU$486 billion) in 2016 (Bryce, 2017a)
- Three-quarters of this sum, US$259 billion (AU$365 billion) is generated within the private sector (Bryce, 2017a).
- The global space economy is expected to treble in size, reaching US$1.1 trillion (AU$1.55 trillion) in 2040 (Morgan Stanley, quoted in DIIS, 2018b, p. 6).

The Morgan Stanley study estimated that satellite broadband will represent 50% or more of the projected growth of the global space economy by 2040 (Morgan Stanley, 2018).

A question that has not been addressed is how much of this putative multi-billion-dollar market is likely to be accessible to and addressable by Australian firms. Figure 7.1 captures the principle of markets within markets.

Figure 7.1. The Addressable Market Concept.

Source: Corporate Finance Institute website

If the total addressable global space market in 2040 will exceed AU$1.5 trillion what of that amount, in realistic terms, is likely to be open to companies that are based in Australia?

The Australian Government's Expert Reference Group (ERG) Final Report did not address this question.

According to the ERG, the Australian space economy generated AU$3.94 billion in revenues in 2015-16.

> "The ERG has estimated Australia's space market size in the 2015–2016 financial year at AU$3.94 billion. This amount comprises Defence-related expenditure of AU$175 million; non-Defence Government expenditure in agencies such as the CSIRO, the Bureau of Meteorology, Geoscience Australia, and the Australian Communications and

> Media Authority (ACMA) of AU$126 million; university space-related research of AU$44 million; and a commercial segment of AU$3.598 billion" (DIIS, 2018b, p. 18).

The ERG proposed two goals;

> "…to triple the size of Australia's nascent space industry to AU$10-$12 billion per year by 2030, [and to] provide an additional 10,000 to 20,000 high-level jobs across Australia" (DIIS, 2018b, p. 5).

These goals have been embraced by government. In launching the space agency, on 1 July 2018, the Minister, Senator the Hon Michaelia Cash said:

> "By 2030, the Turnbull Government hopes to have tripled the size of Australia's space industry to be worth around AU$10-12 billion, resulting in the creation of jobs for Australians and generating further economic growth.
>
> "We have an extraordinary opportunity to grow the size of our domestic space industry by up to AU$12 billion by 2030," Minister Cash said. "This means up to 20,000 high-level jobs created across Australia" (Cash, 2018b).

Five points arise from these figures and the Minister's media release:

- Based on the figures quoted above, Australia's share of the Global space economy in 2015-16 was about 0.8% of the total (AU$3-4 billion in a market estimated at AU$486 billion in 2016).
- If the Australian space economy trebles in size by 2030 (to AU$10-12 billion) this will keep the Australian share of the global space economy at about 1% in a global economy that may be valued in the order of AU$1 trillion in 2030. In other words, the government's ambition for the space sector would seem to be to maintain the *status quo*, or something close to it, in terms of Australia's share of the global addressable market. The SIAA in its 2017 White Paper, *Advancing Australia in* Space, proposed that a 2% share of the global market would be a goal to which Australia should aspire (SIAA, 2017). The 2% target was proposed on the basis that this is the amount that Australia contributes to the global GDP. There is no apparent evidence that government is interested to pursue this more ambitious goal.
- There is no apparent evidence that explains how the revenue and workforce growth targets proposed for the Australian space sector were reached. Nor does there appear to be any evidence on the public record that assessments of

the sizes and growth prospects of the Service Addressable Market (SAM) and the Service Obtainable Market (SOM), as shown in Figure 7.1, have been made for the Australian space sector as a whole, taking account of the domestic and export markets and upstream and downstream market segments.

- Beyond an assertion that 10,000-20,000 new jobs will be created no explanation has been provided about the nature and location of these positions. Will they be in the upstream or downstream elements of the space sector, or, are they likely to be established across the broader economy in jobs that may increase the dependence of the entire economy on secure and assured access to the data and services proved by satellites?
- The Minister expressed 'hope' that a certain outcome would be achieved, not that this would or could be achieved (Cash, 2018a).

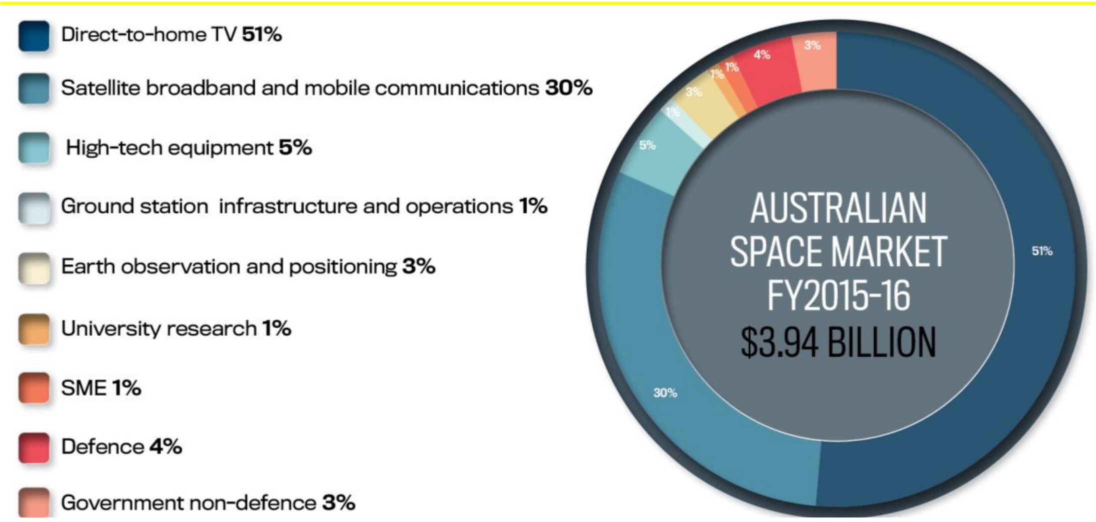
The ERG:

> "…found that the main segments of Australia's commercial space industry in the 2015–2016 financial year were direct-to-home TV (49 per cent); satellite communications and broadband (23 per cent); ground station infrastructure and operations (8 per cent); and high-technology equipment manufacturing and services (5 per cent)" (DIIS, 2018b, p. 18).

These ratios sum to 85% of Australia's commercial space industry, leaving 15% unaccounted for. In her Executive Summary to the ERG, Final Report, Dr Clark states that the private sector accounted for 88% of the value of Australia's space economy in 2015-16 (DIIS, 2018b, p. 6), an apparent discrepancy of 3% from the figures that sum to 85% that are quoted elsewhere in the report and shown above.

There are several discrepancies between the figures quoted in the text reproduced above and the figures quoted in Figure 4 in the ERG Report. Figure 4 is reproduced as Figure 7.2 below.

Figure 7.2. Australian space market estimate for FY2015-16.



Source: *Review of Australia's Industry Capability: Report from the Expert Reference Group for the Review*, March 2018, p 19.

The figures from the text of the ERG report and from Figure 4 of the ERG report are collated in Table 7.1 below.

The first four columns in Table 7.1 relate to data provided from the text of the ERG Report. The last two columns relate to data derived from Figure 7.2 above. The headings are not consistent between the two sources of data. For example, the text makes no reference to "Earth observation and positioning" or to "SME", both categories shown in Figure 7.2. "Equipment manufacturing and services" mentioned in the text has been assumed, for the purposes of the table, to refer to the same parts of the industry as "high-tech equipment" mentioned in Figure 7.2.

As noted above, Dr Clark stated that 88% of the worth of the Australian space sector was contributed by the private sector in 2015-16 (DISS, 2018d, p. 6). This figure falls out from the figures taken from the text and is evident in the sub-total row in Table 7.1 below.

Some of these discrepancies might be considered trivial because they do not alter the high-level numbers in any major way. One discrepancy, however, is not trivial. This is highlighted in red text in Table 7.1 and concerns the contribution made by ground station infrastructure and operations to the Australian space economy. The text cites a figure of 8%, whereas Figure 7.2 cites a figure of 1%. Both cannot be correct and raise questions about the overall reliability of the data presented in the ERG Final Report.

The importance of satellite ground stations and the investment by numerous companies and nations in such facilities in Australia is a persistent theme in the ERG Report (DISS, 2017d). There is no way of telling from the ERG report which of the two figures is correct.

Table 7.1. The Australian Space Economy 2015-16: Summary of ERG Data.

The Australian Space Economy 2015-16: Summary of ERG Data

	From Text				From Figure 4	
	$ bn		**Totals**	**%**	**$ bn**	**%**
Defence	0.175				0.158	4%
Government Non-Defence	0.126				0.118	3%
Research	0.044				0.039	1%
					0.315	8%
	0.345		0.345	9%	0.345	9%
Commercial	3.598					
DTH TV	1.763	49%			2.011	51%
Satcoms and broadband	0.828	23%			1.183	30%
Ground Station infrastructure & Operations	0.288	8%			0.039	1%
Equipment Manufacturing and Services	0.180	5%			0.197	5%
Unspecified Commercial	0.108	3%				
Earth observation and positioning					0.118	3%
SME					0.039	1%
Sub-total	3.166	88%				
Unspecified	0.432	12%				
Sub total	3.598	100%	3.598	91%		
Total			**3.94**	**100%**	**3.93**	**100%**

One final point from the ERG Final Report is the finding that:

> "…established Australian companies account for 87 per cent of the total Australian space market, and global space companies such as ViaSat, Northrop Grumman, Airbus, and Boeing have a significant presence in Australia" (ibid, p18).

Although no definition is provided for an "established company", the inference is that the remaining 13% of the market is served by companies that are not mature or fully established. Yet, Figure 7.2 above indicates that only 1% of the market is served by "SME" (small and medium enterprises).

Putting aside questions of internal consistency, the ERG determined the size of the Australian space economy based on data from 51 companies and a small number of government departments and agencies. Of the 51 companies, two thirds (34) were described as "medium and large" and one third (17) as being SMEs and start-ups (DISS, 2018d, p. 18). No basis for these categorisations nor for the selection of the companies is provided.

7.1.3 Reports Commissioned by the ERG

The Expert Reference Group commissioned three reports to assist with its work. One was prepared by an Australian economic consulting company, ACIL Allen and two were produced by a US-based company, Bryce Space and Technology LLC. The ACIL Allen Report is especially relevant in the present context because it refers to earlier studies into the Australian space sector, thus providing elements of heritage and continuity.

7.1.4 The 2017 ACIL Allen Review

The top-line finding of the ACIL Allen Review was that:

> "The space industry in Australia generates total revenues of around AU$3 billion to AU$4 billion and employs around 10,000 full-time equivalents. It comprises around 388 companies, 56 education and research institutions and directly involves around 24 government agencies" (ACIL Allen, 2017, p. i).

These numbers were noted without comment in the Final Report of the ERG (DIIS, 2018b, p. 18). They generally accord with the figures the ERG derived from its own means.

ACIL Allen drew on the findings of earlier reports prepared by Asia Pacific Aerospace Consultants (APAC) and on a series of reports prepared by ACIL Tasman (the predecessor company to ACIL Allen) into Australia's geo-spatial industry (ACIL Tasman, 2008 and 2010).

7.1.5 The 2010 and 2011 APAC Reviews

In 2010, a Sydney-based consulting company, Asia Pacific Aerospace Consultants (APAC) prepared *A Review of Current Australian Space Activities* for the Australian Government. The Review was revised and updated in 2011. Data for the original and follow-up Reviews were gathered mainly by on-line surveys.

Only the Executive summaries of the two Reviews have been released into the public domain. Comparative data from these Executive Summaries are provided in the table on the following page.

Table 7.2. Comparison of selected data from APAC reports of 2010 and 2011.

Asia Pacific Aerospace Consultants: Summary of Selected Data from 2010 and 2011 Reports						
Item for Comparison	**2010 Review**		**2011 Review**		**Year/Year Increase**	**Comment**
Surveys	**#**	**%**	**#**	**%**	**%**	
Surveys distributed	832		1000+			
Surveys returned	266	32%	346	35%	30%	
Consolidated responses	183	69%	232	67%	27%	no rationale provided
Number of organisations	456		631		38%	
Number of space activities	1136		1433		26%	activities not defined
Growth Forecasts	**Pessimistic**	**Optimistic**	**Pessimistic**	**Optimistic**	**%**	
Dollars	0.8bn	1.6bn	1.0bn	2.2bn		
Total No of Employees	6453		8418		30%	
Full Time Equivalent	4339		6039		39%	
Difference	2114	33%	2379	28%		

The Executive Summary of the second APAC report offers no explanation for why the second survey uncovered so many more organisations said to be involved in space activities in Australia than did the first. There is no rationale provided for the process that APAC undertook when consolidating the returned surveys. Was information omitted or added because of the consolidation process? No definition of what APAC defined as a space activity is provided. Were quantitative measures, such as a minimum dollar value or the hours allocated to a task, part of the definition? Or, were survey respondents simply invited to self-assess?

7.1.6 The 2015 APAC Review

In 2015, APAC was commissioned by the Department of Industry Innovation and Science to conduct a further review, called *A Selective Review of Australia's Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services* (APAC, 2015). Forty-six organisations were interviewed for the 2015 study. Forty-five of the organisations interviewed were for-profit companies and one, the Advanced Instrumentation and Technology Centre (AITC), is an element of the Australian National University in Canberra. Included among the companies were the major satellite communications companies, including Optus, NBN and Intelsat and the major prime systems integrators, including Boeing and Lockheed Martin. In aggregate, these organisations were said to have generated “nearly AU$2 billion in annual revenues from their space products and services” (APAC, 2015, p. 11).

The names of the 46 organisations that are the basis of the 2015 review are listed at Annex A.

If 46 organisations, including the larger companies, generated just under AU$2 billion in 2015, a question arises about the contributions of the almost 600 other organisations that were found by APAC to be conducting space activities in Australia in 2011 (Table 7.2 above refers). What contribution did these other organisations make in 2015?

The APAC 2015 review confirmed the finding of the 2010 and 2011 studies that the Australian space industry was firmly located in the downstream or applications end of the industry. The review report observed that:

> “Based on the data from the 2011 study and the more specific information on corporate revenue gained from this study APAC estimates that the total Australian space industry is now generating revenue in the range of AU$3 billion - AU$4 billion per annum” (ibid, p. 11).

Two further findings in APAC’s 2015 review were:

> “…the total Australian space industry employs between 9,500 – 11,500 staff” (ibid, p. 11).

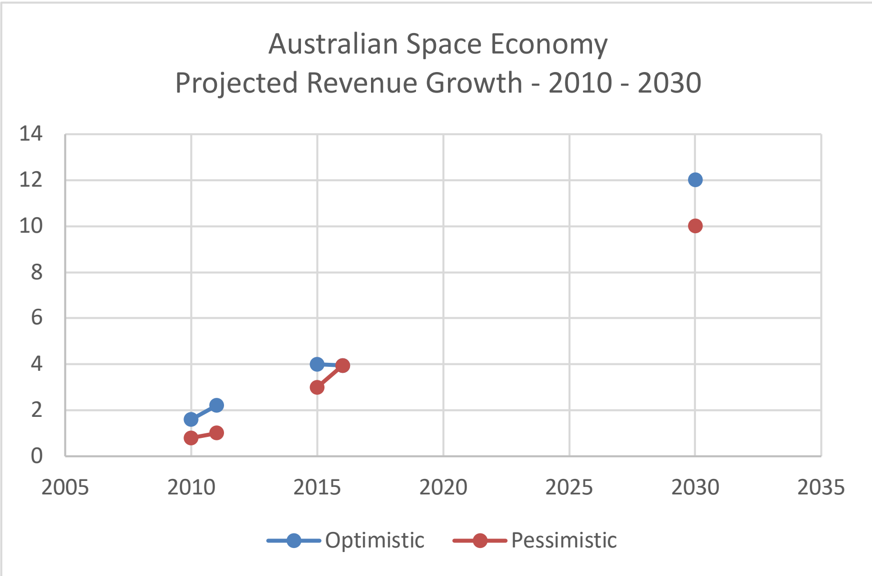
> “Defence is clearly the major industry sector for space companies in this study as 72% of the interviewed companies have Defence as a customer…” (ibid, p 39).

This finding about the dependence of the space sector on Defence seems at odds with the ERG finding that 72% of Australian space sector revenues are generated by the Direct to Home (DTH) television broadcast and mobile communications markets (Figure 7.2). Eleven of the 46 organisations referenced in the 2015 APAC review provide DTH and satellite communications services, including large companies such as Optus, NBN, Viasat, Intelsat and Foxtel.

A conclusion can be drawn that a different selection of companies might have produced quite different results. What both reports make clear is that all parts of the Australian economy are dependent to some degree on secure and assured access to the data provided by satellites (APAC, 2015, pp 38-39; DIIS, 2018b, p. 23), which is relevant to the hypothesis of the thesis that states Australia is obligated to invest in long-term security of the orbital space environment.

Such limited data as are in the public domain about the present and projected size of the Australian space economy is presented graphically below. The 2010-11 and 2015 data come from APAC reviews, the 2016 data and the 2030 estimate are from the ERG report. Note that the ERG Final Report gave the size of the Australian space economy in 2015-16 as AU$3.94 billion – shown in the graph below as a common point in both the optimistic and pessimistic estimates. The optimistic estimates are shown in blue in the Figure below and the pessimistic estimates in red. The common point referred to in the previous sentence is coloured red.

Figure 7.3. Projected Growth of the Australian Space Economy.



The APAC and ACIL Allen reports are the genesis of numbers that have gained broad acceptance and are the baseline adopted by the Australian Government in announcing the creation of a national space agency. The ERG Final Report concluded that the value of the Australian space economy in 2016 was almost AU$4 billion. The reviews and studies used to derive the figures about size are based on samples of data and the methods by which assessments have been made are not capable of independent replication and verification.

Although presented as a growth strategy, the economic rationale for the creation of the space agency indicates that the amount of growth sought will serve to preserve the *status quo* and to have Australia contribute about the same proportion of the total value of the global space economy in 2030, as would seem to be the case today.

7.2 Australian Space Companies

This section contains an analysis of the shape and size of the Australian space industry, with an explicit focus on for-profit companies. The section has two parts. The first considers data that were collected before the space agency was established and which contributed to the rationale for the agency's creation. Particular reference is made to the 2017 ACIL Allen Review mentioned above since the evidence shows the ACIL Allen data is treated in government as correct. The second, is a comparative review of current data, including data developed by most of the States and the Australian Capital Territory (ACT) to strengthen their claims to host the space agency. Tasmania and the Northern Territory asserted, in general terms, the advantages they could provide, based largely on their locations, to a developing space industry. Specific references in the public domain to companies conducting space activities in both jurisdictions was not found.

Varying data between space industry related reports indicated that the following research was required to identify flaws in our present understanding of the current size and shape of the Australian space industry.

7.2.1 Part 1. Defining the Australian Space Industry: Information Available to the Expert Review Group

The 2017 ACIL Allen Review ACIL Allen, and its predecessor organisation, ACIL Tasman, has produced a number of reports about the size, shape and potential of the Australian space sector.

In a 2010 Report, *Earth Observation from Space in Australia*, ACIL Tasman estimated that Earth observation from space contributed at least AU$3.3 billion to Australian GDP in 2008-09. The direct contribution was estimated as being AU$1.4 billion and the productivity impact as being AU$1.9 billion. The figure of AU$3.3 billion for just one segment of the space economy is a similar figure to that quoted by ACIL Allen (2017) for the contribution of the entire space economy almost a decade later - AU$3-4 billion. These figures seem difficult to reconcile.

The 2017 ACIL Allen Review was commissioned to inform the decisions of the Expert Reference Group. Table C1 of the ACIL Allen Review was headed "Space Industry Companies" and listed 388 entities (ACIL Allen, 2017). ACIL Allen stated that the sources of data for Table C1 were:

> "Space Industry Association of Australia, Spatial Information Business Association, (Defence SA, 2016) (Defence ACT, Undated)" (ibid).

ACIL Allen provided no caution to readers about the veracity of the data although the Space Industry Association of Australia (SIAA) alerts those who may access the online database maintained by the Association that the data may not be accurate (SIAA, 2018b).

There were two further tables in the ACIL Allen report:

Table C2	Government and Defence Organisations Relevant to Space Activities and Capabilities, with 25 entries.
Table C3	Education and Research Institutions that Report Involvement in Space Activities and Capabilities, with 56 entries.

The 388 entities listed by ACIL Allen in Table C1, The Space Industry Companies table, were checked for currency and accuracy via an internet search in December 2018. A list of the 388 entities, is at Annex B. The internet search indicated that numerous discrepancies were present in Table C1.

Limitations of this Investigation

- Information could not be found on 12 entities (3% of the total).
- In the time between when the data was originally collected by ACIL Allen, probably in July-September of 2017, and when it was reviewed in December 2018, the circumstances of some of the entities may have changed.

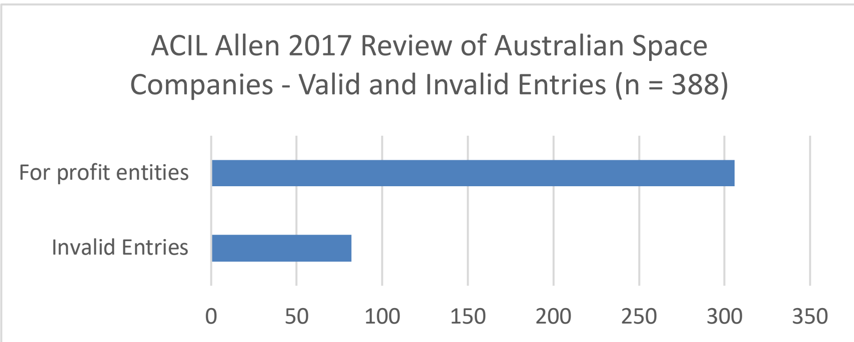
Summary of the ACIL Allen Data Table C1 of the ACIL Allen report appears to contain numerous inaccuracies which have the cumulative effect of overstating the size of the Australian space industry sector. This assessment is based on five points.

- 14 (4%) of organisations listed in Table C1 were not-for-profit entities. If listed in the report at all, they should have been in Tables C2 or C3. A small number of entities appeared in both Table C1 and in either Table C2 or C3. They appear, therefore, to have been double-counted in the ACIL Allen study.
- 49 (11%) of the listed entities had ceased to exist, many before ACIL Allen collected the data for its review. Evidence, from the Australian Securities and Investments Commission (ASIC) indicated that these entities had been wound-up or taken over. In numerous cases, the companies ceased trading well before ACIL Allen collected the material for its review. The Australian Government's business register indicates, for example, that Apogee formally ceased trading in 2011 and Astrovision in 2014 (ABR, 2019).

- The internet search indicated that one in five of the 388 records appeared to refer to entities that either did not belong in Table C1 or that had ceased to exist.
- 19 single-person consultancies were among the 388 entities in Appendix C1.
- The websites of many of the for-profit companies listed in Table C1 give no explicit indication that these companies have any direct, or even indirect, involvement in space activities. To cite two examples, Cray is a US-based manufacturer of supercomputers. These devices may be used to support space activities, but Cray makes no claim on its website to be a space company. IMP Printed Circuits Pty Ltd is an Adelaide-based company, with a subsidiary in China, that manufactures electronic components, sub-assemblies and assemblies that are integrated into more complex systems. There is nothing on the company's website to suggest it has an interest in space or that it is in the supply chain of satellite manufacturers.

Figure 7.4 is a first order summary of the December 2018 analysis.

Figure 7.4. ACIL Allen database: Valid and Invalid Entries.



The level of credence placed by the Expert Reference Group in the ACIL Allen 2017 Review is not known. The Final Report of the ERG makes no explicit reference to ACIL Allen's Table C1. Instead, the ERG Final Report refers to a list of space companies operating in Australia that is published as Appendix 4 to the ERG Final Report (DIIS 2018d, Appendix 4). This Appendix is compared with other records in the section that follows.

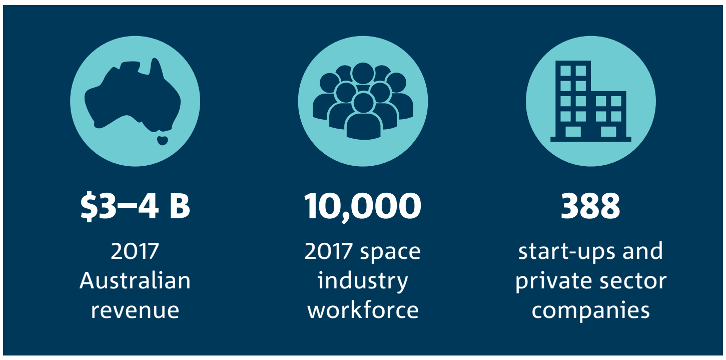
The apparently poor quality of the data in Table C1 serves as a reminder of Dr Hertzfeld's comment in Chapter Two about the unreliability of economic data involving the space sector (p. 48). However, the question of what to include and not include in Australia's space sector becomes increasingly relevant as government seeks to grow the space sector by a factor of three by 2030. Based on the above arguments, a defensible baseline from which the government can report progress does not seem to have been firmly established. Without a firm baseline, it will be difficult for the government to measure growth and to determine whether its aim has been achieved.

The apparent inaccuracies notwithstanding, Table C1 from the ACIL Allen report has been used to justify new Australian space initiatives. In September 2018, CSIRO launched its space research roadmap, *Space: A Roadmap for unlocking future growth opportunities for Australia* (CSIRO, 2018d).

The roadmap has a diagram, reproduced below (Figure 7.5), indicating that part of CSIRO's commitment to space research under the Future Science Platforms program is justified based on the number of Australian companies said to be involved in space activities. CSIRO refers to the 388 organisations in Table C1 of the ACIL Allen study as "start-ups and private sector companies". This heading misrepresents the data presented in the Table, serves to compound the errors noted above, and may be seen by some as potentially harming CSIRO's reputation as a reliable source of information.

Figure 7.5. Australian Space Industry Snapshot.

AUSTRALIAN SPACE INDUSTRY SNAPSHOT



The space value chain is broad, covering upstream activities which focus on ground systems, launch and operating objects in space, together with downstream activities that utilise space data and technologies across a range of applications (Figure 1). Downstream activities will continue to expand as the role of the space industry in the broader economy grows.

Source: *Space: A Roadmap for unlocking future growth opportunities for Australia* (CSIRO, 2018d).

The ERG Final Report: Appendix 4 The ERG conducted its own review of the Australian space sector and formed the view, discussed in the first section of this chapter that the value of the sector was in the order of AU$3.94 billion in 2015-16. This judgement was based, in part, on data from 51 companies drawn from those listed in Appendix 4 of the ERG Final Report. This Appendix divided space companies operating in Australia into three broad categories shown in the Table below.

Table 7.3. ERG Final Report: Summary of Appendix 4: Snapshot of Australian space companies whose activities were reviewed as part of this Review.

Type	Number of Entries
Start-up and small to medium-sized companies	62
Established Australian Companies	59
International Companies	31
TOTAL	**152**

Three points about this data are:

- The ERG Final Report does not explain the criteria that were used to select the companies reviewed rather than others that might have been approached instead.
- The ERG Final Report does not explain the criteria by which a company was categorised as a Start-up or an SME on the one hand or an Established Australian company on the other.
- Among the listed international companies, are the major satellite communications companies and the major systems integrators such as Boeing and Lockheed Martin. These are the companies that account for much of the size of the Australian space economy.

In summarising this section, the information available to the ERG about the size and structure of the Australian industry, based on material available in the public domain, would seem to have been incomplete. The estimate, that the size of the Australian space economy in 2015-16 was in the order of AU$3-4 billion may be a reasonable conclusion. However, the level of confidence around that figure is diminished because some data are in conflict and sample sizes are relatively small. Important definitions have been excluded and estimation methods are obscure and not transparent, meaning that the results are not capable of independent review or verification.

Large top line numbers about the global and national space sectors are derived by including the contributions to the space economy of Direct to Home TV and satellite communications and broadband. If these sectors are excluded, both of which are dominated by large, foreign-owned multi-national companies, a more modest, and potentially more realistic baseline emerges from which the growth of the Australian space sector might be measured.

The second section of the review of Australian space companies evaluates data most of which has been published since the ERG Final Report was released in March 2018.

7.2.2 Part 2. A Review of Data About Australian Space Companies from Various Sources

This section of Chapter Seven is a review of nine separate Australian space industry databases. Records from the SIAA database, as it stood at the end of February 2019, have been collated with records from eight other sources into one large database, which is reproduced at Annex C. The eight other sources of data are:

1. 2015. *A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services*, APAC, 2015.
2. 2018. *Review of Australia's Space Industry Capability,* Department of Industry, Innovation and Science, March 2018, Canberra (DISS 2018d).
3. 2019. *Canberra Region Space Industry Capability Directory*, ACT Government (ACT Government, 2019)
4. 2017. *New South Wales Government Submission to the Review of Australia's Space Industry Capability*, Department of Industry, Sydney, November 2017 (NSW Government, 2017).
5. 2019. *Sky is Not the Limit: Building Queensland's Space Economy*, Deloitte Access Economics (Deloitte, 2019).
6. 2019. *Space Capability Directory*, South Australian Space Industry Centre, Government of South Australia, 48 entries accessed under the headings "Private Companies" and "Private Consultancies" (SASIC, 2019).
7. 2018. *Victoria: The Case for Space*, Department of Economic Development, Jobs, Transport and Resources, Melbourne (Victoria, 2018, Sadler, 2018).
8. 2018. *Space Industry Capability in Western Australia: A Review*, ACIL Allen, May 2018 (ACIL Allen, 2018).

The purpose of this exercise was to see if there is any consensus about a group of companies that might be considered to constitute the core of the Australian space industry? If so, what can be said about these companies? Conversely, are there companies that claim to belong to the space industry, or are claimed by others to belong to the space industry, but about which there is no consensus?

Procedural Matters There are two matters of procedure to clarify ahead of the analysis.

- The SIAA database, would seem to have been carefully reviewed at some point after it was accessed by ACIL Allen and seemingly used as the basis for Table C1 in ACIL Allen's 2017 Review. Obsolete records, including those provided as examples in the previous section of this Chapter, had been removed. A note of caution remains. Companies add their details to the SIAA database on their own initiative and without any formal adjudication process as to their relevance or contribution to the Australian space sector. The database, therefore, may still contain inaccurate information about the extent to which some of the companies listed do or do not contribute to the Australian space industry (SIAA, 2019).

- The names of some companies, the large ones especially, are recorded differently in the various databases. Boeing, for example, is referred to as "Boeing", "Boeing Australia", "Boeing Australia Holdings Pty Ltd". In some cases, the titles refer to separate legal entities. However, for the current purposes, multiple references to one principal entity have been combined into a single record.

The States and Territories The 2017 announcement that Australia would have a space agency sparked considerable interest in the States and Territories, especially when it became apparent that the government was not necessarily wedded to locating the headquarters of the Agency in Canberra. All States (except Tasmania) and the Australian Capital Territory developed capability statements to support submissions they made to the Commonwealth to have the agency located in their State or Territory. Data for each State, except Tasmania and for the ACT has been drawn from these submissions. Information from the Northern Territory has not been found.

The Database Table 7.4 is a high-level summary of the database reproduced at Annex C. This table indicates that, across the nine reference databases, 612 individual companies were listed and that they were referred to 913 times. There are 301 instances where a company is listed in more than one database (913 records less 612 company records = 301).

Table 7.4. The Australian Space Industry: Summary of Records collated at Annex C.

Source of Record	**Number of Records**
Companies from all databases	612
Total number of records	913
SIAA Feb 2019	323
APAC 2017	46
ERG Appendix 4	145
States and Territories (aggregate)	399

Table 7.5 shows that 439 records (48% of the 913 records in the database) were unique. Of the 612 companies listed in the database 439, or 72%, were mentioned only once.

Table 7.5. Individual Records contained in the Annex C database.

Database	**Records**		
	Total Records	Unique Records	%
SIAA Feb 2019	323	168	52%
APAC 2017	46	3	7%
ERG	145	29	20%
ACT	38	16	42%
NSW	128	106	83%
QLD	51	36	71%
SA	48	11	23%
VIC	39	3	8%
WA	95	67	71%
TOTALS	**913**	**439**	**48%**

Each unique record refers to an individual company. If these 439 unique records are subtracted from the 612 companies in the database, 173 companies remain.

A question is why are there are so many unique records? There are several explanations that are specific to the reference databases that have been combined to form Annex C.

- The SIAA database is not moderated. This means that any company, including some with no space capability, can create a record in the database, perhaps to indicate interest in space or simply as a free marketing opportunity.
- In developing their bids to host the space agency, several States, in addition to listing local space start-ups, invoked the names of large companies, that often rely on space-based services but are not of themselves space companies. New South Wales, for example, listed several television stations and other media companies that are based in the State as elements of the local space industry. Television companies make extensive use of communications satellites to receive and transmit data to and from foreign destinations and to support remote broadcasts of news and sport. The ACT and some of the States referred to global information technology companies, including Cisco and IBM. These companies may support the space sector as they support many other sectors in the economy. Whether they belong to the space sector is a different question.
- The States and the ACT typically confined the companies they listed to those based, or with a presence, in their jurisdictions. Many of these companies are not well known for their space activities and not well known beyond their home State or territory. One company on the Queensland list, for example, is Beaudesert and Boonah Cranes. Quite why the Queensland Government considered a crane company to be part of the State's space industry is not clear.

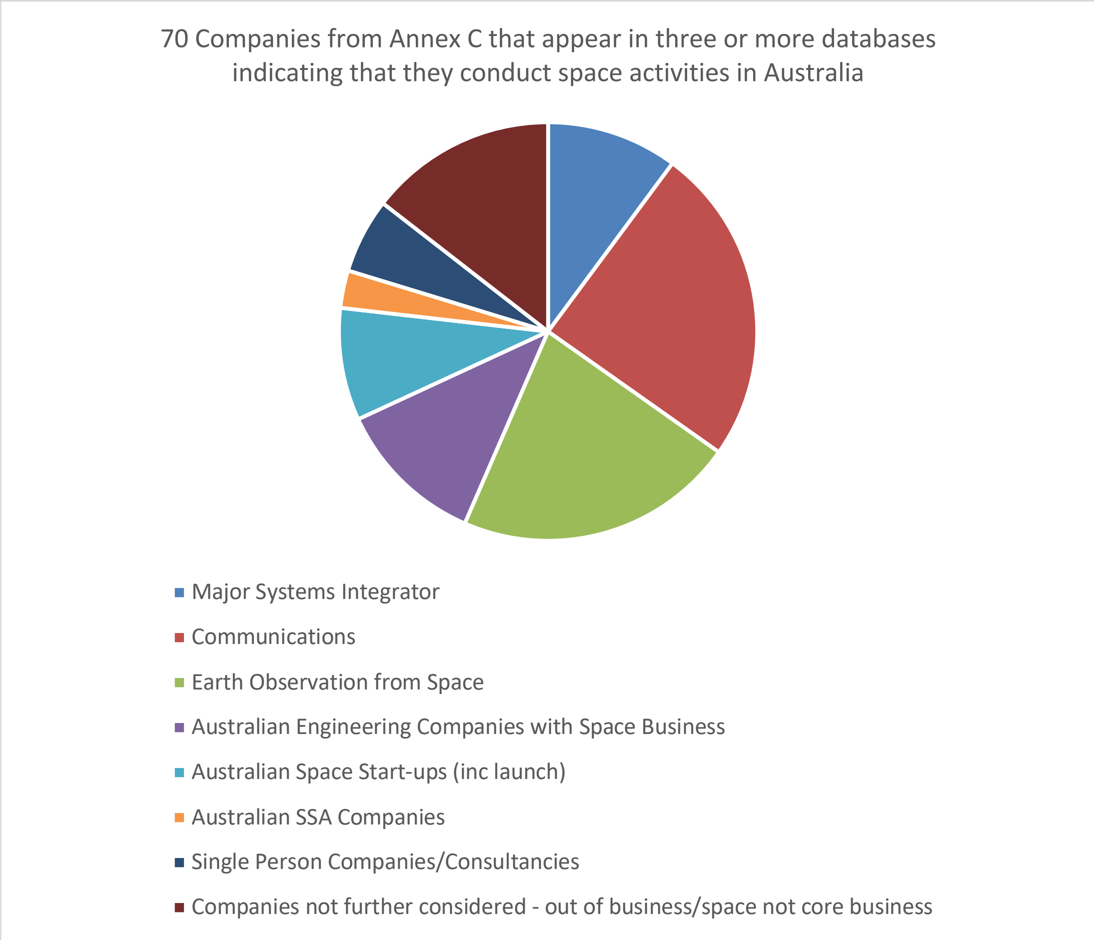
No company was listed in all nine databases. The four most-mentioned companies were Airbus, Boeing, Lockheed Martin and Nova Systems. The first three are major systems integrators. Nova is the only Australian owned company to have been accorded this level of recognition. Each of these four companies appeared in seven databases.

A provisional conclusion is that there is no consensus in Australia about what to include and exclude from studies of the space industry.

Three of the companies for which two records were created had those records created by two States. The remaining 100 companies for which there were two records, were evenly split between those referred to in two of the industry databases but not by a State or the ACT and those that were referred to in one of the industry bases and by a State or the ACT.

If the 103 companies for which there are just two entries in Annex C are not considered further, 70 companies remain. They are listed at Annex D. Figure 7.6 provides a first order breakdown of these companies.

Figure 7.6. Companies Conducting Space Related Activities in Australia.



Nine companies that were mentioned in three or more of the databases in Annex C are not primarily space companies. Cisco and IBM, as noted above, are two examples. Cobham Aviation Services is based in Adelaide and uses satellite communications to assist in executing the border protection contract it holds with the Australian Government. Jacobs is a US-based engineering services company that, in the US, provides vital support to NASA. However, in Australia, Jacobs conducts no space business at all (Biddington, 2019c). One company Irriscan, applied for de-registration as a company in 2018.

This elimination process leaves 60 companies, seven of which are major system integrators: Airbus Defence and Space, BAE Systems, Boeing, Lockheed Martin, Northrop Grumman, Raytheon and Thales. Each of these companies has Australian subsidiaries and their principal Australian customer is the Australian Government, notably Defence. Their principal business is the sale and in-service support of military hardware, ships, armoured vehicles and aircraft and their associated combat support and communications systems. All have dependencies on space-based data and services. The space elements of these military systems, although often mission critical, are relatively small subsets of the overall system in terms of dollars, employment opportunities in Australia, technology transfer and the development and integration of Australian intellectual property into these systems.

The final step in this analysis puts the major systems integrators to the side together with a further set of companies that are headquartered outside Australia, some individual consultants and an enthusiast. The rationale is to focus on Australian companies that develop intellectual property in Australia and that have been identified in at least three of the databases as being part of the Australian space industry. This leaves 37 companies. They are listed at Annex E.

Tables 7.6 is a summary representation of the place occupied by these companies in the Australian space industry. Almost two in three operate in downstream areas, a quarter, mostly start-ups, are in the upstream area and there is a group of engineering companies that can support upstream activities if and when that segment of the market grows.

Table 7.6. Summary data from Annex E. Australian Owned and Operated Space Companies Identified in Three or More Databases in Annex C.

Principal Activity of Company	**Upstream**	**Upstream Potential**	**Downstream**
Satellite Operators (Optus, NBN, Fleet)	3		
Satellite/In-space systems start-ups	4		
Launch start-ups	3		
Engineering service providers and Precision tooling and manufacturing companies capable of supporting upstream design and manufacture		6	
Satellite communications providers, including terminals,			7
Earth Observation and Positioning			11
Entrepreneurship			1
Space Situation Awareness			2
Sub Total	10	6	21
TOTAL			**37**

A limitation of the above analysis is that some start-ups have not been included in Annex E because they were not mentioned in three or more of the individual databases. Black Sky Aerospace, Skykraft and Equatorial Launch Australia are examples.

The purpose of the analysis is not to provide a current or accurate list of companies that collectively comprise the Australian space industry, but rather to show that previous attempts to quantify the size of the Australian space sector, are flawed. Policy announcements and growth predictions have been made based on these data.

The 2015 APAC report concluded:

> "Australian companies have capabilities in most segments of space activity but the greatest concentration of capability lies in the areas of 'Ground Systems' and 'Space Enabled Services'. While the 'Space Systems' segment and the 'Launch Systems' segment remain largely capital intensive, the emergence of new applications for cubesats and a move to field much smaller launch vehicles for them has opened the door for possibly greater Australian participation in these segments. Nevertheless, the primary area of opportunity for Australian companies lies in the fastest growing area of the global space economy which is in 'Space-Enabled Services' " (APAC, 2015, p. 109).

The "Space-Enabled Services" referred to in the report are provided by companies and agencies operating in the downstream part of the space economy, which includes satellite communications service providers, broadcast and navigation service providers Earth observation value adding companies and those who provide insurance and financial services. Table 7.6 would seem to confirm the assessment of the 2015 APAC report.

The Role of the Primes Lockheed Martin and Airbus Defense are two major systems integrators (MSIs) that are investing in the Australian civil space sector. Lockheed has signed an agreement with Curtin University to develop the Desert Opal sensor network that tracks the trajectories of objects falling towards Earth from space (Curtin, 2018). Europe-based Airbus Defense and Space is a major investor in a proposed Cooperative Research Centre called the SMARTSat CRC (Blenkin, 2018). Airbus is also investing in the thruster technologies being developed by Neumann Space in Adelaide (Airbus Defense, 2016). These are project-based investments that are consistent with the aims and ambitions of the MSIs involved. How they might translate to the space industry development aims and ambitions of the Australian Government, expressed through the space agency remains to be seen.

Several members of the board of the Australian Defence Information and Electronic Systems Association (ADIESA) have indicated that the companies they represent and that support Defence activities, including space activities, are not yet convinced that a civil space market is going to emerge in Australia of sufficient size to justify investment (Biddington, 2019d).

Presently, and noted in Chapter Six, the only substantial future space projects being planned in Australia are in Defence and these total around AU$10 billion in the Department's forward investment program (DoD, 2016d). One of the larger space projects is a satellite-based imaging project with a projected value of between AU$3-4 billion (DoD, 2016d, p. 36). AU$500 million was allocated to a precursor project, DEF799, in the May 2018 Budget (DoD 2018d).

DEF799 has two phases. Phase 1 of the project proposes to acquire commercial imagery and Phase 2 is a two-year study into space capability.

One indicator that large companies are not convinced about the viability of an Australian space industry sector comes from the experience of the International Astronautical Congress (IAC) in 2017. An exhibition was an integral element of the Congress. Only one of the 62 exhibitors listed in the Congress Program, Nova Systems, was an Australian company with a line of space business within its portfolio (IAF, 2017, p. 135). Lockheed Martin, through its corporate headquarters in Bethesda Maryland, was the industry anchor sponsor for the Congress. Except for Boeing and Airbus, the remaining major systems integrators, including BAE Systems, Northrop Grumman, Raytheon and Thales, as previously noted, chose not to exhibit. These companies conduct space-related business in Australia, often with Defence. Optus and NBNCo are Australian companies that operate large communications satellites. Neither chose to exhibit at the IAC in 2017 (ibid), informing the Congress organisers that they could see no material advantage would flow to their businesses by making the investments that would have been needed (Biddington, 2017i).

In contrast to the reticence of the private sector, IAC2017 provided an opportunity for Dr Clark and the small team supporting her to meet the heads of many of the world's space agencies and major space companies as well. An international network was built quickly that allowed the Agency to negotiate and sign various Memoranda of Understanding in the months shortly after the Agency was constituted on 1 July 2018. These letters are published on the Agency's website (DIIS, 2019).

7.3 Chapter Summary

Chapter Seven, provides evidence in support of comments made by the Senate Committee in 2008, and others since, that Australia's space industry is small and lacks coherence. The Chapter also provided evidence that calls into question the robustness of numbers, quoted by Ministers and others that the Australian space industry generated AU$3-4 billion in revenue in 2015-16. The intent of government is to grow the industry by a factor of three by 2030 and this is the public rationale for the creation of the Australian Space Agency. A threefold increase by 2030 will maintain Australia's share of the global space economy at around 1%, if projections about the growth of the global space economy are realised. In other words, a *status quo* strategy and not a growth strategy is being pursued.

The reviews and reports that have been prepared about the Australian space sector and that have been discussed in this Chapter are opaque with respect to methodology and several contain errors and inaccuracies. All appear to exaggerate or overstate the size of the industry. Large companies, that governments perceive as being important (they appear in numerous of the reference databases), notably the major systems integrators, and the two major satellite owners and operators, Optus and NBN, would seem to be taking a cautious approach and have yet to make major direct investments in space industry development in Australia.

Only two Australian companies, EOS Space Systems and Silentium Defence have achieved some degree of national recognition as being committed to developing technologies that are relevant to space security. Lockheed Martin, through the arrangement it has with Curtin University, to develop the Desert Opal network is also contributing.

It seems that by accident more than design, Australia now has a space agency, justified on an economic growth mantra derived from data that is demonstrably weak.

This is a concern because the Agency is a welcome addition to Australia's machinery of government, filling a long-standing and embarrassing gap. A question is whether the Agency's capacity to be an authoritative and respected voice in international space governance will be hampered by the limited funds for which it is responsible and by the opportunistic and serendipitous process by which it was founded. In 2017, an industry facilitation and promotion mantra may have been the only 'hook' open to the government to justify the Agency's creation. The Agency's future substantive contribution, however, may lie in taking a prominent role in international space governance, bringing into play a long-absent perspective from the southern hemisphere. In other words, the Australian Space Agency may be the right answer (space governance) but for the wrong reason (industry). This assumes that future governments, consistent with long standing policy, will continue to not invest in a publicly funded space program (a space program being fundamentally different from the development of a space agency). Chapter Eight, the next Chapter, is a discussion of space security developments in Australia focusing on the potential role of the space agency.

CHAPTER 8

SPACE SECURITY AND THE AUSTRALIAN SPACE AGENCY

Chapter Eight addresses the final research question.

> What are the implications for Australia's commitment to space security of recent initiatives by Australian departments and agencies including the new space agency?

The Chapter is bounded in time from the announcement that Australia would have a space agency in September 2017 until the end of March 2019.

The Chapter has three sections.

The first is a brief account of space security developments in government and Research sectors in the period under consideration.

The second is an assessment of the Australian Space Agency. Does the Agency's creation represent a fundamental shift in policy or an adjustment to a long-established position that was needed to accommodate the changes occurring to the global space economy more generally?

The third considers the potential impact of recent statements by a Minister and officials that may confuse the emerging narratives around developing the space economy and space security.

8.1 Space Security Developments in Government and Research

In the 18 months from September 2017 to March 2019, there were numerous developments in space security in Australia in the diplomatic, defence capability and research domains.

8.1.1 Space Diplomacy

The major public policy documents, the Defence White Paper of 2016 and the Foreign Affairs White Paper of 2017, remained in place.

In October 2018, the Secretary of the Department of Foreign Affairs and Trade, Ms Frances Adamson, delivered a speech in Canberra about space security. She said that Australian officials are participating in an initiative sponsored by the Secretary-General of the UN meeting concerning space security, known as the Group of Governmental Experts on Further Practical Measures for the Prevention of an Arms Race in Outer Space. She remarked that:

> "The Group has been mandated to consider and make recommendations on substantial elements of an international legally binding instrument on the prevention of an arms race in outer space, including, inter alia, on the prevention of the

> placement of weapons in outer space. Assuming that consensus can be reached, the Group will deliver its report to the Secretary-General in 2019" (DFAT, 2018c).

She also noted that Australia has:

> "…enhanced our Defence cooperation on space with Canada, New Zealand, the United Kingdom and the United States by establishing a partnership through the Combined Space Operations Initiative. This grouping allows for more effective and coordinated use of military space capabilities and better cooperation on, for instance, identifying and understanding what objects are in space, and protecting our access to vital military space systems (ibid).

The Combined Space Operations Initiative (CSOI) is an evolution of an organisation located at Vandenberg Air Force Base in California, previously known as the Joint Space Operations Centre (JSpOC). Under the CSOI, the JSpOC has been renamed the CSpOC (Combine Space Operations Centre) to indicate the deepened involvement of allies in the space security mission of the organisation. Australia has participated for many years in the JSpOC (JDSCCPA, 2018).

Australia's participation in the Group of Experts on the one hand and the CSOI on the other, demonstrates the duality of space activities and of space security initiatives. One is looking at space through the lens of the peaceful uses of outer space and the prevention of weaponisation. The other refers to efforts by the United States and its close allies to characterise and preserve interests in space considered vital to national security.

8.1.2 Defence Capability

The Defence Industrial Capability Plan, issued in the context of the 2016 Defence White Paper, was explicit that Australia has a small number of Sovereign Industrial Capability Priorities (SCIP) (DoD, 2018c). These are areas where Australia needs in country capability. One of the original 10 SCIP is "Surveillance and intelligence data collection, analysis dissemination and complex systems integration," of which a subset is "space situational awareness systems" (ibid).

Consistent with this aim, in 2018 and the first part of 2019, Defence efforts with respect to SSA were focussed on building capability:

- Commissioning the C-Band Radar and continuing with the installation of the space telescope; at North West Cape and
- Preparing project documentation under Joint Project 9350 Ph 1 for an Australian SSA mission system and under Joint project 9351 Ph 1 for indigenous SSA

sensors (May, 2017; Crozier, 2018). In February 2019, Defence issued a formal Request for Information (RFI) for “sensor technologies available from Australian Industry vendors or under research and development” (Austender, 2019). The importance of this RFI is that Defence is expressly encouraging Australian companies to bring their technologies, even if under development, to the table.

8.1.3 The Research Sector

In the research domain, there were several developments.

The Space Environment CRC continued its work and arranged for its operations to be extended to the end of 2019 to ensure that a series of ‘on sky’ experiments could be conducted (SERC, 2019). These experiments involve firing a ground-based laser at a known object in orbit and aim to use the photonic pressure from the laser to change the attitude of the target object in its trajectory.

In December 2018, the RAAF M1 satellite that was constructed at the University of New South Wales, Canberra was launched. SERC planned to use this satellite as a known object on the SERC experimental program. The M1 satellite has never established contact with its control station and would seem to have failed (Gunter, 2019a).

Nova Systems, in conjunction with the University of South Australia, is leading a bid for a new space-focussed Cooperative Research Centre (CRC), known as the SMARTSat CRC (SMARTSat, 2018). The CRC program is highly competitive and the outcome of the SMARTSat CRC application may not be known until mid-2019.[7]

DST Group has named SSA as an area of research priority (DST Group, 2016). DST Group in conjunction with universities and industry has established the Emerging Disruptive Technologies Assessment Symposium (EDTAS). This is an ongoing set of meetings that aim to help to future-proof Australian Defence looking to a 20+ year timeframe, including in the space domain (DST Group, 2019).

CSIRO, in the research roadmap for space mentioned in Chapter Seven, has also announced that SSA is a research area of developing interest (CSIRO, 2018d, p. 13). In December 2018, CSIRO committed a further AU$16 million, via the Future Science Platforms program to the development the “science to leapfrog traditional technologies and find new areas for

[7] In April 2019, the Government announced that the SMARTSAT CRC bid had been successful.

Australian industry to work in" (CSIRO, 2018e). Space object tracking was mentioned as one possible area for research (ibid).

Neither DST Group nor CSIRO has provided further detail about the research they plan to conduct that is relevant to SSA.

8.2 The Australian Space Agency

In the May 2018 budget, the Australian Government allocated AU$41 million to establish the Australian Space Agency.

- AU$26 million was allocated over four years (the period of the forward estimates) to cover staffing and operating costs. This equates to AU6.5 million annually ($26m/4 years).
- AU$15 million was allocated over three years, to be available from 1 July 2019. These funds were dedicated to partnering with international space agencies (Cash, 2018b).

The Minister stated that the purpose of the AU$15 million was "dedicated to partnering with international space agencies to enable Australian businesses to compete in the global space economy" (ibid). A nexus was drawn between international engagement and industry growth.

In March 2018, Senator Carr, the Opposition spokesperson responsible for civil space matters, announced that a future Labor government would commit AU$35 million to civil space sector development in Australia. This would be supplemented by industry and university co-investments. Looking ahead, the Government and Opposition are in essential agreement about the amount of money they are prepared to commit to civil space development in Australia (Carr, 2018).

The Australian Space Agency came into existence on 1 July 2018, with offices in the Department of Industry, Innovation and Science in Canberra. As noted in the previous Chapter, in announcing funding for the agency, government left open the question of the location of the headquarters. The ACT, South Australian and Western Australia Governments bid to host the agency. They were joined later by New South Wales, Queensland and Victoria. The ACT and Western Australian bids are referenced as exemplars (ACT, 2018; ACIL Allen, 2018). In December, Adelaide was named as the permanent home of the agency (Andrews, 2018c; ABC, 2018d).

Dr Megan Clark is the Agency's inaugural head. In remarks to a conference that was hosted by the Perth USAsia Centre in October 2018, Dr Clark described the Agency as being different to any other in the world because of its explicit focus on industry development (Clark M, 2018). The Australian Space Agency, like some and unlike others, does not administer a national space program.

The document that defines the Agency's governance, roles and responsibilities is the Charter, released in October 2018 (DIIS, 2018d). The Charter, the text of which is reproduced at Annex F, outlines the Agency's purpose, values, roles and responsibilities, governance and organisational and reporting arrangements.

The Charter makes no reference to space security. It does, however, provide the framework in which the Agency will pursue its priorities, which are listed on the agency's website as:

- Communications technologies, services and ground stations
- Space Situational Awareness (SSA) and debris monitoring
- Positioning, Navigation and Timing (PNT) infrastructure
- Earth Observation (EO) services
- Research and development
- Remote asset management
- Developing a strategy to position Australia as an international leader in specialised space capabilities (DIIS, 2018e)

These priorities are a repeat of the first recommendation of the ERG Final Report and are said to "…build on Australia's strengths and utilise national competitive advantage and capabilities" (DIIS, 2018b, p. 28).

What the Agency plans to do with respect to Space Situational Awareness (SSA) and debris monitoring has yet to be announced.

The Charter expressly confines the remit of the Agency to civil space matters.

> "The Agency is responsible for whole-of-government coordination of civil space matters and is the prime source of advice to the Australian Government on civil space policy" (DIIS, 2018c).

In four places, the Charter provides for the Prime Minister to become directly involved in the affairs of the agency:

- “The statutory basis for the Agency will be considered after a review of its operations, which will commence within four years of its establishment. This review will be considered by the Prime Minister.”
- “The Charter is approved by the Minister responsible for civil space activities (the Minister. At the discretion of the Prime Minister, the Prime Minister may also approve the Charter.”
- “Members [of the Advisory Board] are appointed by the Minister, on recommendation by the Agency Head. At the discretion of the Prime Minister, the Prime Minister may also approve members.”
- “The Terms of Reference [of the Advisory Board] will be formulated to be consistent with the Charter. At the discretion of the Prime Minister, the Prime Minister may also approve the Terms of Reference” (ibid).

In mentioning the Prime Minister, there is an echo in the Charter of the 2005 Chapman report which proposed that responsibility for Australian space policy reside with a part of government “accustomed to managing broader national issues such as the Department of Prime Minister and Cabinet” (Chapman, 2005, p. 22)

The potential for the Prime Minister to become involved matters for at least three reasons, all of which stem from the authority of the office within the Australian political system and discussed by Strangio (Strangio et al., 2017). The Prime Minister may elect to use the authority of his or her office to:

- Insist that the intelligence agencies, Defence and other Departments with national security responsibilities are necessarily and sufficiently engaged with the space agency.
- Direct the development of a national space policy and a national space strategy that account for the disparate interests and responsibilities of the numerous departments and agencies with space responsibilities. In evidence to the 2008 Senate Inquiry, Dr John Boyd, the former deputy director of the Australian Space Office, said that some departments and agencies had been less than cooperative with the ASO. He cited Defence, BoM and CSIRO as prime examples (Senate Report, 2008, pp. 49-50).
- Provide a compelling demonstration to the national and international space communities that Australia is serious about space in all its aspects.

The Charter also provides for a "senior Department of Defence representative with responsibilities that include space" to be a member of the Advisory Board.

There is no reference in the Charter to the dual use nature of many space activities, and the reality that many companies support defence and civil space activities simultaneously.

8.2.1 The Space Agency and Industry Development

That Australia now has an organisation that bears the title 'space agency' has been welcomed nationally and internationally. In the latter part of 2018 and early 2019, the Australian Space Agency signed Memoranda of Understanding with the space agencies of France, the United Kingdom Canada and the United Arab Emirates (DIIS, 2019). Also, on 13 November 2018, the US House of Representatives adopted a Resolution commending Australia for having established agency and "Affirming United States – Australia cooperation on space research, exploration and utilisation" (Andrews, 2018d). The Resolution begins by affirming the ANZUS Treaty and the importance of AUSMIN before discussing a range of civil space activities in which the two countries cooperate (US Congress, 2018).

The Agency has also signed 'statements of strategic intent and cooperation' with some companies including Airbus, Nova Systems, Sitael, Goonhilly Earth Stations, Lockheed Martin and Woodside Energy (Space & Satellite AU, 2019a). Such statements are consistent with the Agency's mission to attract international companies to invest in Australia (Andrews, 2018e; Andrews 2018f; ASA, 2019).

Finally, the Agency has signed an agreement with the ACT Government, the first of several anticipated with the States and the Northern Territory to facilitate space industry development (ADM, 2019).

The Commonwealth has announced several modest additional investments in space activities that aim to support space industry development. An investment of AU$12 million is proposed for Adelaide to be funded from a cities' development program. Six million dollars will be used to establish a satellite control centre that will be available to operators of small satellites. The remaining AU$6 million will be used to fund a space discovery centre for education and outreach (Space & Satellite AU, 2019b; The Lead, 2019). A grant of AU$2 million has been made by the Commonwealth to the Government of New South Wales to promote space industry development in western Sydney (Space & Satellite AU, 2019c). These allocations may be intended to serve a political purpose in the context of the forthcoming federal election more than an industry development purpose that is part of a coherent space industry development plan. The Government of Western Australia has questioned the motives of the

Commonwealth in locating the satellite control centre in Adelaide (Space & Satellite AU, 2019b).

8.2.2 The Space Agency and Industry: Policy Continuity

The evidence from earlier chapters indicates that Australian governments have been consistent on four civil space policy matters and the development of a national space industry. These are:

- Separation of civil and military space policy;
- Private sector companies and not government should fund civil space activities in Australia;
- Private space companies operating in Australia should not be accorded special treatment;
- A nexus exists between space science and research and a sustainable national space industry.

Five examples, some recapped from previous Chapters, from 1990 to the present, with special reference to the role of the private sector, indicate the similarity of approach by numerous governments over nearly 30 years.

1. In 1990 the Australian Space Office published an *Australian Space Industry Development Strategy* (DITAC, 1990). Senator John Button (Labor, Victoria) was the responsible Minister and in a lengthy statement at the front of the document he made clear that space industry development would not be accorded special treatment over any other industry sector. He noted:

   "…some would say that there has been insufficient financial and general support for space industry activities by Australian Governments in recent years. I do not accept these arguments . . . the level of assistance provided to any particular activity must be such that it remains consistent with the Government's overall industry objectives."
   And
   "Ultimately, it is up to individual companies to determine whether resources should be allocated in pursuit of space industry related opportunities" (ibid, pp. 4-5).

2. In 2003, *The Australian Government Space Engagement: Policy Framework and Overview* promulgated by the Howard Coalition Government said:

"The Australian Government's space engagement is user- and market-driven rather than supply-driven or "technology push" . . ."

And

"There is no strategic, economic or social reason for the Australian Government to pursue self-sufficiency in space. . . The Australian Government encourages commercially viable and sustainable endeavours in the space sector" (DITR, 2003)

3. In 2013, *Australia's Satellite Utilisation Policy*, released by the Gillard Labor government, stated that Australia's national goal in space was to "Achieve on-going, cost-effective access to the space capabilities on which we rely" (DIISTRE, 2013, p. 6). About industry development, the Policy stated:

"…the Australian Government does not see an Australia satellite manufacturing or launch capability as an essential element of its approach to assured access to critical space-enabled services." (ibid, p. 11)

And

"Consistent with the Australian Industry Participation National Framework, the Australian Government will encourage industry participation in its space activities" (ibid).

4. In 2016, ahead of the election of that year, the ALP inserted a paragraph into its policy platform about support for civil space (ALP, 2016). This was followed, in 2017, by Labor's announcement in 2017 that it would support the establishment of a space agency if it were to win office in the next election, due in 2019 (Carr, 2017b).

5. In the context of the May 2018 Budget, the Minister responsible for civil space matters at the time, Senator the Hon Michaelia Cash (Liberal, WA) said the following in a media release:

"To help our businesses win a greater share of the US$345 billion global space market, we are establishing the first Australian Space Agency with funding of AU$41.0 million over the next four years. This funding includes AU$15.0 million dedicated to partnering with international space agencies to enable Australian businesses to compete in the global space economy.

> Space technologies are not just about taking people to the moon, they underpin the long-term competitiveness of many other industries, including communication, agriculture, mining, oil and gas" (Cash, 2018b).

The first of these five statements, made by John Button, occurred against a background of substantial micro-economic reform led by the Labor Prime Minister of the day, Paul Keating (Strangio et al., 1917). Button challenged the efficacy of the Australian Space Office and its activities (DITAC, 1990) and set the tone for later studies into the utility of Australia's civil space arrangements that were conducted by the Bureau of Industry Economics and the Expert Panel appointed by the Australian Space Office (BIE, 1992; DITAC, 1992). These events and their aftermath were discussed in Chapter Five.

The second statement above was produced during the period of Coalition government under Prime Minister John Howard's leadership and affirmed the position taken by John Button. The third statement, released by the Gillard Labor government occurred after the GFC and after the Australian Space Research Program, discussed in Chapter Six, had concluded and been judged a success (DIIS, 2015). Universities that had participated in the ASRP were keen to conduct follow-on projects and some start-ups were formed, to take advantage of the opportunities presented by the changing space economy (GAP, 2017). The fourth and fifth statements by Senator Carr and Minister Cash respectively also point to job creation in the private sector as the reason for establishing a space agency (Carr, 2017a; Cash, 2018b).

The agency, from being resisted in the past by the major parties, is now supported in pursuit of a stated policy goal to create jobs and wealth in an emerging market. The government's intent for the Agency is stated in the first paragraph of the Agency's Charter:

> "It [the Agency] was established to put in place a long-term structure to support the growth and transformation of Australia's space industry" (DIIS, 2018d).

The space agency has been established, *prima facie*, as a specialised business development and promotion organisation. It has not been established or funded to develop and lead a publicly-funded national space program. Space related projects in which government invests will continue to be administered through the departments and agencies that have principal operational responsibility for the capabilities that new investments support. For example, the 2018-19 Budget provided more than AU$260 million to Geoscience Australia for three space related projects. The first was an allocation of AU$224.9 million to establish a precise positioning capability across the Australian continent and all areas of land and sea for which Australia has sovereign obligations or other responsibilities, such as the safety of life at sea.

The second was an allocation of AU$64 million to upgrade GA's ground station network and the third was AU$36.9 million to further develop the Digital Earth Australia imagery database (GA, 2018b).

The Agency's roles and responsibilities with respect to space security, notably SSA and debris monitoring, have yet to be announced.

8.2.3 Exports and Dual Use Technologies.

As already indicated, the Australian space sector accounts for less than 1% of the global space economy. The emphasis placed by government on the space agency developing a wide range of international partnerships is a pointer to the perceived potential for and importance of sales beyond the domestic market (DIIS, 2018c).

A significant barrier to exporting space technologies, some of which may well be sensitive, is the Australian Government's stringent export control regime (DoD 2019a). Among the space technologies and technology areas that fall within the ambit of the Australian export control regime are:

- Composite structures or laminates
- Composite structures in the form of tubes
- Liquid rocket propulsion systems
- Components for space launch vehicles and spacecraft (DSGL 2019).

Australia's close security relationship with the United States presents further challenges. The United States regulates the export of its space technologies under two sets of regulations:

- The International Traffic in Arms Regulations (ITAR), controlled by the State Department (USG, 2019); and
- The Export Administration Regulations (EAR), controlled by the Department of Commerce (USG, 2016).

The ITAR apply to military goods (including intellectual property). The EAR apply to commercial goods and are less stringent. The dual use aspect of many space technologies presents further complications where export is concerned (USG, 2016).

In the late 1990s, the US and Australian Governments formed the AUSMIN Defence Acquisition Committee (ADAC) to explore ways in which sensitive US military technologies could be transferred more expeditiously to Australia (DFAT, 1999). ADAC was the precursor to a treaty signed between the US and Australia to facilitate the flow of ITAR protected sensitive goods and associated intellectual property, from the US to Australia (DID, 2012).

Following complex negotiations, the US Australia Defence Trade Cooperation Treaty was signed between the Governments of Australia and the United States in 2007 (Australian Government, 2012a). The Treaty was given effect in Australian domestic law with the passage of the Defence Trade Controls Act in 2012 (Australian Government 2012b; DID 2012).

The DTCA raised major concerns, especially in universities, because the Act was considered restrictive of the free flow of knowledge, including that of a fundamental nature, around the world (ITA, 2012). The DTCA has severe penalties, including lengthy prison terms for individuals who breach disclosure obligations they may have under the DTCA. A comprehensive review of the Act was conducted in 2016-2018 with the report being published in February 2019 (DoD, 2019b). The report has identified gaps in the Act that may lead to continuing tension between Defence and the broader scientific and research communities about the breadth of application of the Act (Go8, 2019).

Beyond its bilateral obligations to the United States, Australia is also a signatory to several international arms control and non-proliferation agreements. Two of the more important from the viewpoint of space activities are:

The Missile Technology Control Regime (MTCR 2018); and

The Wassenaar Arrangement (WA, 2019).

In addition to the Defence Trade Controls Act, Australia is also bound by international obligations to uphold sanctions placed by the international community on a small number of countries and their citizens (DFAT, 2019b). Sanctions usually apply to nations where export potential is limited, including North Korea and Iran. However, Iranian students, for example, sometimes seek to enrol in degree programs at Australian universities. Australia is obliged to ensure that these students do not undertake research in areas where they may obtain knowledge that effectively breaches Australia's international obligations under sanctions and non-proliferation agreements (DFAT, 2019c).

The DTCA is the basis of Australia's export control regime (Australian Government 2012b). The Act is administered by an office, known as Defence Export Controls (DEC), within the Department of Defence. This office manages the Defence and Strategic Goods List (DSGL), which is an exceptionally detailed list of items that may be prohibited from export altogether or may be exported only under carefully defined conditions (DSGL, 2019a). The DSGL makes numerous direct references to spacecraft and missiles. It also refers to technologies such as various types of radio receivers that may apply to spacecraft in the future, if not today.

Companies that wish to export goods, or even intellectual property, that falls within the ambit of the DSGL must apply to DEC for permission to do so before they can proceed to export (DoD, 2019b).

The DEC may prohibit the export under all circumstances or permit the export to some specified countries or prohibit the export to specified countries (DSGL, 2019b).

A great deal of military technology in use in Australia has been released to Australia by other countries, notably the United States (Greene, 2017). Australia is bound by international agreements and arrangements, including those mentioned above, to not re-export to third parties except with the express approval of the country of origin of the technology in question. Australian companies, therefore, need to understand the provenance of systems and sub-systems, hardware, firmware and software, that might be integrated into an Australian developed product that might be offered for sale on the international market (DoD, 2019a). The process can be time-consuming and challenging, especially for small companies with limited staff and resources (DoD, 2019b). In summary, a desire to export space-related technology or intellectual property developed in Australia may be hampered or prevented by the controls mentioned above.

The Commonwealth is seeking to promote Australia as an exporter of military equipment and the structures and processes outlined above have been established to support this ambition (DoD, 2018d). Space technology exports, whether intended for military, civil and commercial customers, would be processed through this system.

As shown in Chapter Seven, and putting rhetoric to one side, there are very few space companies in Australia. Those focussed on upstream activities are a smaller sub-set again. A specialised export facilitation role may emerge for the agency as it becomes more mature.

8.2.4 International Governance and Legislative Responsibilities

Two of the six roles and responsibilities of the space agency are:

> "Leading international civil space engagement", and
>
> Administering space activities legislation and delivering on our international obligations " (DIIS, 2018c).

The current domestic legislation, and proposed changes to it, was discussed in Chapter Six. The new legislation, the *Space Activities (Launches and Returns) Act* was passed by the

Parliament towards the end of 2018 but Assent has been delayed for a year until new regulations have been written. From an industry perspective, one of the most important aspects of the regulations concerns liability and associated licensing and insurance costs. If the approval processes are burdensome and the costs too high, the stated industry development *raison d'etre* for the Agency may be compromised. This point was made by representatives of four of Australia's space launch start-up companies at a panel session about space launch from Australia at the Australian Space Industry Conference that was held in conjunction with the Avalon Airshow, in February 2019, in Victoria.

The current modest budget and limited size and remit of the agency may constrain its ability to effectively perform all of its allocated roles and functions. The agency will have initially 20 staff (Jacobs, 2018). A reasonable estimate of the annual salaries and entitlements bill is approximately AU$3 million, leaving AU$1.5 million annually to cover travel, office and other expenses.

The review of the Agency's performance, in the 2021 timeframe, that is mandated in the Agency's Charter, may provide an opportunity to assess the relative importance of the narrow goal to develop the Australian space sector with the Agency's broader legislative and international responsibilities. The latter potentially impact the security of the space environment. As previous Chapters have noted, the global economy, as well as regional and national economies, depend on secure and assured access to the services and data provided by satellites. One view could be that an agency that is expert in the physical and political geography of the space domain and that is confident to be heard in the international councils of space may do much more for Australia's economic and broader security than will an agency that has as its main aim to facilitate the growth of a domestic space industry from a very low base.

8.3 Inflated Expectations and Confused Messages

Minister Cash, in the context of the IAC, said that she and other Ministers had received an unusually large number of calls and emails congratulating the government for announcing that a space agency would be established; she perceived this as public support (Biddington, 2017g). Dr Clark has stated in public that there is evidence that four out of five Australians know that the space agency has been established (Clark, 2018) but has not provided the source of that data.

Both CSIRO's space road map and a statement by The Hon. Karen Andrews, Minister for Industry, Innovation and Science, raise the prospect of Australian involvement in planetary exploration and lunar settlement sometime after 2030.

Under the heading, *Australia in the 2030s: Lunar Habitats Featuring Australian Technologies*, the CSIRO roadmap postulates the following scene:

> "Ambition and curiosity have driven the quest for space exploration with multiple public and private rockets transporting humans into lunar orbit, making the first steps towards becoming a multi-planetary species. The Lunar Orbital Platform Gateway, developed during the 2020s, provides a staging post for lunar surface shuttles and is preparing to send human missions to Mars. Collaborative exploration missions have mapped the far side of the Moon yielding the first comprehensive resource assessments, and Australian scientists, engineers and astronauts, in partnership with a diverse international community, are using the Gateway to colonise the lunar environment.
>
> Australia's space industry has been an invaluable source of technologies and partners for the development of the first lunar habitat, and continues to develop technologies for the first Martian explorers, who will face at least 150 days of travel in deep space and a hostile environment upon their arrival. Many developments for space have now diffused into everyday life, and many Earth-based technologies have been spun in to the space industry." (CSIRO, 2018d, p. 17).

Towards the end of December 2018, in a media interview, Minister Andrews said that she:

> "…wouldn't rule out that we will have astronauts, in time, launching from Australian sites - and that would be wonderful" (ABC, 2018e).

This is the first time that any Australian Minister, certainly within the last decade, has even hinted at the possibility of such an expansive role for Australia in space.

In the same ABC News item, Mr Warwick Holmes, an Australian space engineer with a distinguished record at the European Space Agency (ESA) and now the executive director of space engineering at the University of Sydney, described the Minister's remarks as 'optimistic' and argued that there were more immediate and higher priorities for Australia, especially in the remote sensing domain. Mr Holmes also took the opportunity to point out the geographic and economic challenges that will need to be overcome for an Australian launch industry to be established.

Dr Sarah Pearce, from CSIRO, in contrast, to Mr Holmes, told the ABC of the geographic advantages that Australia offers for launch, making no mention of the economic challenges raised by Mr Holmes (ibid).

8.4 Chapter Summary

From September 2017 to the end of March 2019, Australia's space sector advanced. Progress and investment continued to occur in the Defence and research sectors and several start-up companies attracted new investors and received injections of capital.

The Australian Space Agency is operational and busy on many fronts that seem to be focussed on gaining presence (brand recognition) and legitimacy. The Agency's core document is its Charter and perhaps the core strength of that document derives from the repeated references to the possible involvement of the Prime Minister. His or her ability to intervene in the high-level governance of the agency may be regarded as a counter-narrative to the opportunistic and somewhat haphazard and unplanned process that led to the agency being established at all. The gravitas that goes with the office of the Prime Minister may indicate that the government has grasped the importance of a safe and secure space environment and the policy complexities and trade-offs that are involved to ensure Australia's economic and national security. There is, however, no mention of the threats to the orbital space environment that potentially affect civilian and military activities in equal measure.

Dual use technologies, and export control regimes present special challenges. The rules can be difficult to navigate. However, the Department of Defence has created an organisation specifically to assist companies and research organisations to understand what they may and may not export, to whom and under what circumstances.

There would seem to be some confusion in government about the public narrative about Australia's future space ambitions. References to direct Australian involvement in human exploration of the moon and Mars are well beyond the pragmatic industry facilitation roles and responsibilities presently performed by the agency.

CHAPTER 9

LOOKING AHEAD: FUTURE AUSTRALIAN CONTRIBUTIONS TO SPACE SECURITY

The hypothesis that has been proposed and tested in the previous Chapters is:

> To defend and promote its national interests domestically and as a middle power, Australia, by virtue of its geography, extant capabilities and commitment to the international rules-based order, is obligated to invest in the long-term safety and security of the Space environment.

Five research questions have guided the arguments and the presentation of evidence in each of the preceding seven Chapters. Those questions are repeated below.

1. Why is a safe and secure orbital space environment important for humanity?
2. Is Australia capable of making a significant contribution to the security of the space environment?
3. If so, should the security of orbital space become a public policy priority that attracts funding and political attention beyond that devoted in the past?
4. Does the growth of a domestic space industry provide sufficient and compelling justification for the Australian Space Agency?
5. What are the implications for Australia's commitment to space security of recent initiatives by Australian departments and agencies including the Australian Space Agency?

Human society is increasingly reliant on secure and assured to the data and services provided by satellites. This point is well understood globally, including by the Australian Government (DIIS, 2018b). What is also well understood is that the space domain is undergoing rapid and substantial change (ibid). The *status quo*, established during the Cold War, that space was fundamentally the preserve of a small number of nation states, is under challenge by processes of "democratisation" and "commercialisation" that have been substantially enabled by "technology transformation."

- *"Democratisation"* is the word used to indicate that more nations are launching more satellites. More than 80 nations (approximately two of every five that belong to the United Nations) have satellites in orbit and the number of satellites being launched annually continues to grow (Wicht, 2018).

- *"Commercialisation"* refers to the increasing proportion of the space economy that is in the hands of the private sector. Commercial activities today account for approximately 75% of the total space economy (Bryce, 2017).
- *"Technology transformation*" refers to a set of developments that cumulatively have brought the costs of satellites and launches within reach of many more nations and entities seeking a presence in the space domain. Using language from the internet, the Space 1.0 era, which was characterised by large, exquisitely crafted satellites, is moving to the Space 2.0 era, which is characterised by small, mass-produced satellites, many of which do already or will operate in large constellations (Alleven, 2017; Werner, 2018).

The evidence shows Space 2.0 provides opportunities but is not without risks and challenges. Increased pressure on radio spectrum and a substantial increase in the amount of space debris is anticipated (ESA, 2018d). Most satellites operate in the Low Earth Orbits (LEO), and these are the orbits most at risk from being cluttered with debris (UCS, 2018). Predictive, Space Situational Awareness (SSA) capabilities are likely to be an important step towards creating a Space Traffic Management (STM) regime that has global legitimacy and support (AIAA, 2017). Both are steps towards the introduction into use of Active Debris Removal (ADR) techniques. (Maguire, 2019).

The changes noted above are occurring against economic, political, institutional and regulatory backgrounds, the basic lines of which were drawn in the 1960s – 60 years ago much of which is established in this thesis:

- *The Space Economy* is firmly anchored in the northern hemisphere. Ten nations, all located north of the Equator, account for 98% of the global space economy. Fifty percent of the global space economy is generated in the United States (OECD, 2012). The global space economy generated US$345 billion in revenues in 2016 and is expected to treble by 2040 to US$1.1 trillion. The Space 2.0 economy is also based in the northern hemisphere, especially in the United States, led by companies such as SpaceX, Blue Origin and Planet (Davenport, 2018).
- *The Political Dynamic* is fractious, especially between the major spacefaring nations. To use the well-worn phrase, space is "contested, congested and

competitive." (USG, 2011). In 2018, President Trump unveiled an "America First National Space Strategy" which seeks to retain US pre-eminence in space and to take such means as are necessary to defeat emergent threats (White House, 2018a) To this end, President Trump is seeking to develop a Space Force as a separate fifth arm of the US military to counter emerging Russian and Chinese technologies (White House 2018b; Seligman, 2018).

- *Institutions* are deadlocked. The United Nations, through the First and Fourth Committees, seems presently incapable of reconciling arguments about how to prevent space from being weaponised with arguments about the peaceful uses of space (UNOOSA, 2013). The Fourth Committee, through COPUOS, speaks to "Trust and Confidence Building Measures" (TCBM) and other practical initiatives designed to ensure that space is open and accessible to all. These initiatives, including discussions about an International Code of Conduct (ICoC) to regulate human activities in space, collapsed in 2015 (Listener, 2015). Presently, a Group of Government Experts (GGE), which includes an Australian representative, is attempting to find common ground before reporting to the Secretary General later in 2019 (DFAT, 2018c).
- *The Regulatory Regime* is under pressure. The foundation document that governs human behaviour in space is the Outer Space Treaty (OST). It expresses behavioural ideals and principles but lacks detail. The OST was written at the height of the Cold War where the two protagonists, the United States and the USSR, saw mutual benefit in codifying their space activities as a means of reducing the possibility of strategic surprise that might trigger nuclear war (McDougall, 1985). There are four further treaties, the last of which, the Moon Treaty, has been ratified by very few nations. Australia, however, is one of those nations (UNOOSA, 2019a; UNOOSA 2019c).

The tensions evident in the points above are due to the duality of human activity in space.

The Outer Space Treaty makes plain that space is a commons, to be shared by all of humanity for purposes of good. The first sentence of Article 1, states:

> "The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind" (UNOOSA, 2019a).

Outer space is also the high ground of diplomacy, of peace and war. The strategic and military potential of space has been the stronger and best resourced of the two narratives (McDougall, 1985; Dolman, 2002). In 2008, Moltz used the phrase 'strategic restraint' to characterise the actual behaviour of states in their pursuit of strategic advantage in outer space. Developments in the decade since 2008, lead to questions about the continued application or relevance of the phrase.

The rise of China, as a near peer to the United States and India's successful test of a direct ascent anti-satellite (ASAT) weapon in March 2019 complicate the regional and global power balance in space (Allison, 2017; Salazar, 2019). The proliferation of space actors, including Australia, is a further complicating factor in the geo-political landscape of space, notably orbital space.

Australia regards itself and is recognised by others as middle power (Cotton & Ravenhill, 2011). Middle powers exert influence within the international system. They have a vested interest in upholding the *status quo* of the international rules based order and in seeking to sometimes mediate between the divergent interests of the great powers (Gilley & O'Neil, 2014). The evidence suggests that middle powers sometimes effect improvements within structures set by the great powers but that influence on the structures themselves is beyond middle power influence (Chapter Four). Australians chaired the Technical sub-committee of COPUOS from 1962 for more than thirty years, making a valued contribution to space governance (Chapter Four). There followed two decades of reduced influence and interest with respect to space. However, Australian Ministers and officials remained active in counter-nuclear proliferation initiatives (Reynolds W & Lee D, 2013). More recently Australia would seem to have become more interested in space security matters by taking a more active role in COPUOS, participating in the ICoC discussions and now being directly involved in the Group of Government Experts (GGE) meetings sponsored by the Secretary-General of the United Nations (DFAT 2018c).

In summary, middle power status confers some influence in world affairs, but that influence is limited. However, as mentioned in Chapters Three and Four, Australia has achieved a degree of influence and recognition such as in the contribution it made in establishing the United Nations and later, with specific reference to space, as the long-standing chair of the Science and Technology Committee of COPUOS. Australia, as the last NASA representative Neal Newman said, is "Fair, Bare and There".

There are five drivers for Australia's approach to space identified in the preceding chapters: physical circumstances, alliance relationships, political system, commitment to the international system and opportunity costs.

Australia's geography; the continent's location and size, when coupled with a small population that is concentrated in coastal cities, goes quite some way to explaining Australia's space journey. This was discussed in Chapter Four. The Final Report of the Expert Review Group describes Australia as a "prime location for space innovation" and notes that:

> "Australia's unique geography covers one-third of Earth's rotation, and we are located in a region that is currently experiencing two-thirds of the global economic growth. This makes us ideally located to support satellite communications and Earth observing satellites in the Asia-Pacific region and beyond. Australia's geography is important for SSA techniques that include multiple deployment of optical and infrared telescopes to determine the precise orbits of space-borne objects" (DIIS, 2018b, pp. 19-20).

During the Cold War, and still relevant today, the US needed ground stations in Australia to support satellites that were vital to US national security. The importance of these ground stations is encapsulated in the titles, and the contents, of two monographs written in the 1980s, *A Suitable Piece of Real Estate* (Ball, 1980) and *The Ties that Bind*: *Intelligence Cooperation Between the UKUSA Countries* (Richelson & Ball, 1985). All Australian governments in the nearly 40 years that have passed since the first of these books was published have been steadfast in their support for the US alliance at the heart of which is the UKUSA, now called the Five Eyes, intelligence relationship.

Chapters Five, Six and Eight make plain that successive Australian governments have not considered investments in space capabilities, or a national space program, to be a priority for public investment. Private companies seeking to create space-related businesses in Australia have been welcomed in principle and given access to the same government-sponsored industry support programs as any other company starting out in some other sector of the economy. A reasonable inference is that successive government have not been persuaded that spending public money on space activities has been more important than investments, for example, in schools, hospitals, roads and other infrastructure. The opportunity costs, to use different language, and discussed in Chapter Five, have been too high.

Australia's vital security interests in space have been met through the US alliance and Australia's contribution, as noted above and especially in Chapter Five, has been to host satellite ground stations and other infrastructure to support civil as well as national security missions. The explicit role of the space agency, discussed in Chapter Eight, is to create opportunities and a business-friendly environment in which private companies seeking to establish space businesses in Australia are encouraged to do so. The space agency has neither the remit nor the funds to lead a national space program funded from the public purse (DIIS, 2018c; Cash, 2018b).

9.1 The Public and Defence Space Narratives

The public narrative from defence and the security community about space is not extensive because so much has been and remains classified. Not until 1983, was the Australian Prime Minister (Hawke) able to stand in Parliament and provide an honest, if brief, statement of the true purpose of the Joint Facilities (CPD, H of R, 1984. p. 2983). The joint facilities hosted in Australia are vital to the security of the United States and the *quid pro quo* for their presence in Australia during the Cold War, and even today was an implied extended nuclear guarantee (CPD, H of R, 2013, pp. 7071-7779). This bargain may have become less compelling in the post-Cold War era. However, new threats and new technologies have emerged that have given the joint facilities new purpose and, possibly direct value to Australia as well (Beazley, 2016).

Very little was said about space in government documents such as Defence White Papers until 2009 (as indicated in Chapter Six, Table 6.7) when the importance of the space domain to future Australian military capabilities and operations was acknowledged.

The AUSMIN meeting of 2010 represents a turning point in the national security narrative because it acknowledges a potential future role in space security, notably through space situational awareness, for Australia (DFAT, 2010a, b & c). Defence is now acquiring space surveillance capabilities and the forward investment program makes provision for AU$10 billion in space investments in the coming decade, including in space surveillance (DoD, 2016d).

The second narrative, concerning Australia's use of space for peaceful purposes is complex because so many different interests are involved as discussed in Chapter Five. Different government departments and agencies are responsible for different parts of Australia's civil space engagement domestically and internationally. Satellite communications policy and regulations are the responsibility of the Department of Communications (and its predecessors), complicated by the Commonwealth purchasing capable satellites through government owned business enterprises to serve remote and regional Australia. Three statutory authorities, BoM, GA and CSIRO have separate but sometimes related interests in remote sensing data. CSIRO, separately, is Australia's principal radio astronomy agency. CSIRO and BoM have interests in selected areas of space science as well. Another statutory authority, ACMA, is responsible for spectrum allocation and for representing Australia's collective interests about space communications to the international community through the ITU. The Department of Transport (and its successors), with constitutional responsibilities for navigation, is the regulator for satellite navigation systems as they have become the standard method of navigation for ships and aircraft. The regulation of Australian companies seeking to launch and operate satellites is the responsibility of the Department of Industry.

The primary interest of the agencies mentioned in the previous paragraph is to gain access to data that enables them to better meet their statutory obligations. In 2017, CSIRO purchased a 10% stake in the UK NovaSAR-1 satellite, which includes the ability to task the satellite. The media release about this investment focussed on improvements to CSIRO's downstream capabilities. The investment:

> "…provides significant opportunities to support a wide range of existing research, further develop Australia's Earth observation data analytics expertise, and create new opportunities in the field of remote sensing" (CSIRO, 2018a).

In its submission to the 2008 Senate Inquiry, BoM raised the possibility of satellite sensor development in Australia but the focus of the policy options it raised were enhancements to ground-based capabilities (Senate Submission, 2008, #65). In the 2018 Budget, GA was allocated substantial funds to augment ground-based capabilities with satellite based precision navigation and for the Digital Earth Australia (DEA) project (GA, 2018b). The initial focus of the precision navigation investment is to support aviation by providing ground infrastructure to support an Australian Satellite Based Augmentation System (SBAS). This will assist with aircraft navigation, but the capability has much wider application. (GA, 2018c). The processes and methodology developed for the DEA Project is being made available to other nations, notably in Africa (GA, 2018d).

Several State and Territory Governments have established small programs to encourage space companies to establish their operations within their jurisdictions (Chapter Eight). The Government of South Australia has been the most active in this regard (Government of South Australia, 2018).

Beyond government are various business associations, enthusiast groups and some persistent individuals who believe that Australia has, to use Kingwell's phrase, 'punched below its weight' where space investment is concerned (Kingwell, 2005). They have argued in the past that

Australia needs its own publicly funded civil space program run by an Australian space agency (Senate Submissions, 2008).

9.2 Concluding Remarks: Where to Next?

In Chapter Six, 2009 was described as a 'tipping point' moment in Australia's space journey because, as part of its response to the Global Financial Crisis (GFC) the Commonwealth committed modest funds to civil space activities. The Australian Space Research Program (ASRP) was established together with a Space Policy Unit within the Department of Innovation, Industry Science and Research (DIISR) and a Space Industry Innovation Council. Although follow-on funds were not made available, the genie was out of the bottle.

The 2017 International Astronautical Congress provided further impetus, so much so that the Commonwealth announced that a space agency would be created in 2018. This has occurred and Australia now has a space agency of 20 or so staff with an explicit industry facilitation and regulatory mandate. These developments were not the result of a deliberate government led policy development process but rather were responses by government to external factors over which it had little or no control.

The question is whether a domestic space industry that is self-sustaining and has the potential for growth will emerge or evolve from these initiatives. Chapters seven and eight presented evidence to the effect that the consensus that exists about the shape and size of the commercial space sector in Australia (generating AU$3-4 billion in revenue annually and employing 10,000-12,000 people) is derived from data that is not defensible. This represents a potential risk if growth targets that have been announced by the government are not met.

There is no question that the Australian Space Agency has been extremely active in the brief months of its existence as it has worked to establish its identity and purpose domestically and internationally. It has signed agreements with a number of space agencies and several companies all designed to promote and encourage private investment in the Australian space sector. It is too soon to tell whether these initiatives will be successful.

Optimistically, if companies do invest and do become profitable, the investment made by government in the Agency will be demonstrably justified. Pessimistically, if some of the start-up companies begin to struggle and even fail, they may be tempted to blame the government and the Agency for lack of adequate financial and other support – support that government has steadfastly said it will not provide through a space program funded from the public purse. This policy position has been a constant of both Labor and Liberal governments since the 1980s and, there is no evidence of any shift in this position, the creation of the Agency notwithstanding. Indeed, as noted in Chapter Eight, the Charter of the Agency is explicit on this point.

For more than 50 years, Australia's alliance with the United States has been the cornerstone of Australia's involvement with space. National security aspects have been paramount, and the establishment of the space agency does not alter this emphasis. The bifurcated narrative of the past seems set to continue at least for the next few years. However, the governance arrangements, outlined in the Agency's Charter, contain the potential for change and for the creation of a unified narrative that acknowledges the challenges imposed by the profoundly dual use nature of the space enterprise.

Australia's most important differentiators regarding space activities derive from its location on Earth and its continental geography. If a self-sustaining Australian space industry is to develop it is likely to do so on the back of these differentiators, which deliver competitive advantage at least to some aspects of global endeavour in space. Two obvious areas where Australia's location and geography provide advantage are in space situational awareness and the better understanding of both space and Earth weather.

Location and geography, when combined with Australia's middle power status, open the possibility for Australia to play an important, even unique role in securing space for the use of humanity into the indefinite future. An Australian space agency that is focussed on these larger matters, rather than the development of a small local industry, has an opportunity to exert considerable international influence that would at once draw upon and enhance Australia's standing within the community of nations.

A space agency that is expert in the physical and political geography of the space domain, that understands export controls and other non-proliferation regimes and that is confident to be heard in the international councils of space may do much more for Australia's economic and broader security interests than will an agency that has as its main aim to encourage the growth of a boutique, privately-owned domestic, space industry. This is not to say that some Australian space companies will not flourish. Some may well find and exploit competitive advantage, especially in technology areas where Australia already has products that are globally competitive and that may be applied to or adapted for space activities. Such companies might be more accurately thought of as robotics, or software, or advanced manufacturing companies with customers in the space sector than as space companies *per se*.

The hypothesis tested in this thesis includes the proposition that Australia has an obligation to use its natural advantages for space security. Australia has a mix of attributes, including geography, international standing and technological capacity, that with coherent policy and coordinated investment, holds the prospect of a significant contribution to the Trust and Confidence Building Measures (TCBM) that must be created if the security of the space environment is to be assured into the longer future. From a practical perspective, further public and private investment in civil and military space situational awareness capabilities and strengthened participation in the international councils of space might be achievable first steps. Some new jobs would be created, and a workforce would develop with skills and experience that would be specialised, highly differentiated and potentially sought after, including by the major space faring nations. The moral dimension arises from Australia's status as a middle power, putting such attributes as it has at its disposal to the benefit of humanity by making a contribution to the future security of the space environment that is not only substantial, but is unique. No other nation on Earth has this same opportunity.

The question is whether we have the imagination, courage and will to commit to this task. Only time will tell.

APAC 2015 Study: Organisations Interviewed.

Appendix A – Companies Interviewed and Their Space Capabilities

Company Name	Space Systems	Launch Systems	Ground Systems	Space Enabled Services	Support Services	Space R&D	Education & Training
ABS Satellite	●			●			●
Airbus Defense & Space			●	●			
AITC	●		●	●	●	●	●
Auspace				●		●	
Boeing Australia	●		●	●	●	●	●
Clearbox Systems			●	●		●	
Cygnus Satellite			●	●	●		●
Delta-V	●	●	●		●	●	●
Dialog Pty Ltd			●	●	●	●	
EM Solutions	●		●	●		●	
EOS	●	●	●	●		●	
ESS Weathertech			●	●	●	●	
Farmscan Ag Pty Ltd			●	●		●	
Foxtel			●	●			
Fugro Satellite Positioning			●	●	●	●	
Geoimage Jensen Bowers				●	●	●	●
GPSat		●	●	●	●	●	
HexiGeo				●	●	●	
Intelsat	●	●	●	●			●
ITC Global			●	●	●		●
iVolve			●	●		●	
Leica Geosystems Pty Ltd			●	●		●	
Locata Corporation Pty Ltd			●	●		●	
Lockheed Martin Australia	●	●	●	●	●	●	
M2MConnectivity			●	●	●		
NBN	●		●	●			
Northrop Grumman	●		●	●		●	
Nova Systems	●		●	●	●	●	●
Optus Satellite	●	●	●	●	●	●	●
Pivotel		●	●	●		●	
Pod Trackers ANZ Pty Ltd				●		●	
Position Partners			●	●		●	●
Precision Agriculture			●	●	●	●	●
Raytheon Australia Pty Ltd			●	●	●		
RPS Group			●	●		●	
Saber Astronautics	●		●		●	●	●
Silanna Semiconductor	●		●	●		●	
Skybridge			●	●	●		●
Speedcast		●	●	●	●		
Teakle Composites		●			●	●	
Telstra Global			●	●			
Tidetech Pty Ltd				●	●	●	
Toolcraft Pty Ltd	●	●				●	
Topcon Positioning Systems Inc.			●			●	
Trimble Navigation Australia			●	●	●	●	
ViaSat Australia Pty Ltd			●	●			

Annex B

Space Companies from Table C1, ACIL Allen 2017 Review

Title	Comment
Prime Systems Integrators	
Airbus Defence and Space	
ASC Pty Ltd	
BAE Systems Australia	
Boeing Australia Ltd	
Lockheed Martin Australia	
Northrop Grumman	
Raytheon Australia Pty Ltd	
Saab Systems Pty Ltd	
Thales Australia	
	9
For Profit Companies (SMEs and Start-ups)	
3Logix Pty Ltd	logistics
A.W. Bell Pty Ltd	casting/metal fabrication SkyKraft
ABS Satellite	DTH satcom HK-based
AAM	geospatial - mainly acft
Ace Satellite Systems	satcom
Adacel Technologies Ltd	ATC systems
Addcom Contact Solutions	telecoms
Advanced Composite Structures Australia Pty Ltd. (ACS Australia)	advanced manufacturing
AECOM	civil engineering
Aerometrix	geospatial - mapping
Aerospace and Defence Products Pty Ltd	lighting and electronics
Aerospace, Industrial and Marine Technology (AIMTEK) Pty Ltd	welding, US-based
Agrecon	geo-spatial UIS-based
Airborne Research Australia (ARA)	geospatial - mainly aircraft
Airbus Group Australia Pacific	helicopters
Airwave Communications Pty Ltd	telecoms
Alcatel Australia Limited	telecoms - smart phones
Almgren, J. N Pty Ltd	home and office products
Andrews Communications Systems (Delmex Pty. Ltd., trading as)	retail electrical
Andromedia Industries Pty Ltd	multi-media content US-based
Anteon Australia Pty Ltd	adult education
AON Space	space insurance
Applied Measurement Australia Pty Ltd	test and measurement suppliers
Applied Satellite Technology Australia Pty Ltd	VSAT and broadband satcom
Ashurst	commercial lawyers
Asia Pacific Aerospace Consultants (APAC)	industry consultants
Asia Pacific Aerospace Pty Ltd	turbine overhaul
Asteroid Enterprises PL	gifts, printing etc, Mumbai-based
Astra Australis	IT company
Aurega Consulting Group	cyber security UK-Based
Auspace Pty Ltd	subsidiary of Nova
Ausplex Pty Ltd	lighting and control systems
AusTest Laboratories	test services
Australian Aerospace & Defence Innovations Ltd (AADI)	defence consultants
Australian Rocketry Pty Ltd	sells rockets
Australian Technology Information Pty Ltd	engineering consultants and svcs
AV-Comm	satcom
Axiom Precision Manufacturing	precision manufacture
Ball Solutions Group Pty Ltd	management consultants
Bentley Systems Incorporated	infrastructure builders
Bigmate	IoT, telematics
Biz Hub Australia	business software
Brenco Aerospace Pty Ltd	surface coatings and engineering
Bronron Apps	IoS, Apple Apps etc.

C & L Aerospace Pty Ltd	global aviation company
Calsa Pty Ltd	training and development
CEA Technologies Pty Ltd	radars and support software
Ceanet Pty Ltd	construction test gear and software
CES Computers Pty Ltd	computer sales and repair
CGI	IT consulting Canada based
Cingulan Pty Ltd	satcom downlink services
Cisco Systems Inc.	IT company
Clearbox Systems	comms inc satcom
Cobham Aviation Services	Coastwatch contractor
Codan Pty Ltd	radio and positioning eg in mines
Codarra Advanced Systems Pty Ltd	defence co - UAS focus
Compliance Engineering	all types of testing
Comsult Australia	computer consulting and marketing
Cooper Grace and Ward	law firm
Cray Inc	high performance computers
Cygnus Satellite	Northrop Grumman ISS re-supply
CTF Solutions	Farm and Agriculture advisory
Cuberider	experiments to the ISS
Curiosat	start-up
Cubic Defence Australia Pty Ltd	modelling and simulation
Customs Agency Services Pty Ltd	customs services
Cygnus Satellite/URSYS	VSAT and related services
Cypher Research Laboratories Pty Ltd	critical comms inc satcom/GNSS
Daronmont Technologies Pty Ltd	HF radars
Deacon Communications	Satcom services
Delta-V Space Alliance	Incubator
Dialog Pty Ltd	IT software
Digital Globe International	Hi Res EOS imagery
Dronemetrex	uses drones
eB2Bcom Pty Ltd	Identity and Access Management
EBA Solutions	management consultants
EBSCO Australia	on-line database
Ebsworth & Ebsworth	law firm
Ecology and Heritage Partners Pty Ltd	environment mgt plans
Economic Futures Australia	consultancy (Peter Gordon)
Electro Optical Space Systems Pty Ltd	Laser tracking of spacecraft
EM Solutions	Satcom design and engineering
EMS Global Tracking	global tracking software/capability
Engineering and Scientific Systems Pty Ltd (ESS)	project and data mgt for defence
Environmental Systems and Services	EOS for land mgt etc
Equatorial Launch Australia Pty Ltd	Launch start up
ER Mapper	Software within Hexagon Geo
ESRI Australia Pty Ltd	GIS data science
ESS Weathertech	weather stations
ETP Pty Ltd	electron multipliers
EWA Australia Pty Ltd	electronic warfare
Farmscan AG Pty Ltd	seller of monitors, guides, etc
Fast Networks	comms
Fleet Space Technologies	small sats/IoT
Flurosat Pty Ltd	crop health - multi-spectral
Forge Holdings Pty Ltd	software, location analytics
Foxtel Management Pty Ltd	umbrella company for media
Frazer-Nash Consultancy Limited	consultancy
Fugro Spatial Solutions Pty Ltd	GIS
Fullarton Space Biotech Co. Ltd.	space micro-organism research
Future Fleet Pty Ltd	GPS in transport and logistics
Gap Geo Pty Ltd	Geophysics applications
GenaWare Pty Limited	software vendors
General Dynamics Media Ware	imagery exploitation
Geo-Maps Co	school supplies
Geodata Information Systems	located at Maitland
Geodex Pty Ltd	maps

Geoimage Pty Ltd	EOS specialists
Geomatic Technologies Pty Ltd	asset management
Geoplex Pty Ltd	software, geospatial engineers
Georeality	geospatial plus VR Slovakia-based
GeoSmart Ltd	GIS NZ owned
Geospatial Intelligence Pty Ltd	geospatial intelligence
Gilat Australia	satcom services
Gilmour Space Technologies	launch vehicles
GKN Aerospace Engineering Services	engineering services
Global Innovation Centre Pty Ltd	Incubator, Ballarat
Global Vision Network	business facilitation
GPS-Ag	Auto steering technology
GPSat Systems Australia Pty Ltd.	GNSS solutions
Greenhouse Gas Monitor Australia Pty Ltd	Start-up from ASRP
Grollo Aerospace Pty Ltd	ramjet technology
Groundprobe Pty Ltd	mining probes and software
Hartec Ltd	abrasive coatings
Hawker Pacific Pty Ltd	civil and military aviation
Heliaq Advanced Engineering	start-up, former ISU Adriaan
HEO Robotics	with SkyKraft etc. sensors
Hewlett Packard Australia	Hardware and software company
Hexagon Geospatial	GIS software Intergraph parent?
Honeywell Limited (pacific)	SCADA and software
HP Invent	Hardware and software company
HTM Pty Ltd	farm management software
Huawei Australia Pty Ltd	Telecoms company
Huck Australia Pty Ltd	bolts and fasteners
Hugh Carrigg Aerospace	researcher with a website
Hydrix	medical and other measuring devices
Here	mapping and location data
Hypercubes	EOS US-based
HyVista	with SkyKraft etc. sensors
IBM Australia Ltd	IT company
IMP Printed Circuits Pty Ltd	computer hardware
IMR Technologies	vehicle automation/self-driving
1 Spatial	GIS, data apps
Indra Australia	ground based navigation systems
Inmarsat	Satcom services
Inmarsat Solutions B.V.	Satcom services
Innovative Electronics Pty Ltd	frequency mgt Richard Jacobsen
Inovor Technologies	start-up ADL-based
Intel Australia	computer chips
Intelsat Asia Pty Ltd	Satcom services
Intergraph Mapping and Geospatial Solutions	GIS software and training
International Aerospace Law & Policy Group	legal services Duncan Blake
International Aerospace Law & Practice Group	policy services Duncan Blake
Interturbine Advanced Logistics	aviation logistics
iPSTAR Australia Pty Ltd	DTH satcom using NBN sats
Israel Aircraft Industries Ltd (IAI)	hi tech engineering
ITC Global	VSAT services
iVEC	supercomputing mgt Perth
iVolve	mine management software
Jacobs Sverdrup (JSA)	engineering consultants and svcs
Jeppesen Australasia	aviation maps and charts
Kaelus	test, measurement, RF conditioning
KAZ Technology Services Pty Ltd	education and IT services
Kia Consulting	lifestyle consultant
L-3 Communications Australia Pty Ltd	tier 2 Defence Prime
Laboratory of Advanced Jet Propulsion Ltd.	based in Ukraine
Launchbox Australia	education company
Leica Geosystems	measurement, surveying, GIS
Locata Corporation Pty Limited	GNSS alternatives
LSM Advanced Composites Pty Ltd	advanced manufacturing

M2M Connectivity	IoT connectivity
Macdonald Technologies International Pty Ltd	professional services
Magellan GPS Systems	GPS devices
MapInfo	GIS software
Maptel Pty Ltd	GIS software
Marsh Space Projects	space insurance
Melbourne Space Program	uni start-up Uni Melb
Mechanica Pty Ltd	engineering consultants SZ-based
MGLSAT	sat phone sales and accessories
Minter Ellison	law firm
Mitchell Resource Intelligence	environmental/resources consultant
MITEC Ltd	critical comms inc satcom
Moonshot X	Troy McCann
Motorola Australia Pty Ltd	mobile phones
MPA Communications Pty Ltd	building industry - internal spaces
Myriota Pty Ltd	remote monitoring (bores etc)
Navigate Pty Ltd	consultancy service and training
NBNCo Limited	Satcom services - Skymuster
Neumann Space	ion engine
NGIS	digital mapping services and training
NextAero	Aerospike engine Woodside/Monash
Nova Systems Pty Ltd	satcom etc
Obelisk Systems	for profit STEM education
OmniSTAR Pty Ltd	precision GPS
Omnilink	property and location mgt
Opaque Space	video game developer
Optus Satellite Services (Singtel Optus Pty Limited)	Satcom services
Oracle Corporation Australia	IT company
Orbis Technology	high tech consulting US-based
Orbit Australia Pty Ltd	nothing about space on the website
Otus Intel	value driven intel - risk
Ovass	geo-spatial analytics inc from space
Ozius Spatial	remote sensing inc from space
OzQube-1	start-up Perth based
Pegasus Aeromedical Consulting	aerospace medicine
Picosat Systems	Start-up Perth based
Pivotel Satellite Services	satellite phones
PlusComms Pty Ltd	Robert Brand - lunar project
Pod Trackers ANZ Pty Ltd	track your dog
Position and Navigation Systems Pty Ltd	distribute Motorola PNT products
Position Partners	positioning and control solutions
Precision Agriculture	precision agriculture
Proximity	legal, commercial, governance
Precision Pastoral Pty Ltd	NT-based sat data to manage stns
Price Waterhouse Coopers	accounting/business advice
Project Thunderstruck	launch vehicles (Robert Brand)
Provideo	video production
Pynfall Pty Ltd	consultancy connects people
QinietiQ	eng in domains other than space
Radarsat International	radar imagery provider
RCR Laser (Formally Applied Laser Pty Ltd)	manufacture laser cutting
Red Hat Asia Pacific	open source tech for the enterprise
ResearchSat	start up for biology and chem resch
Rohde and Schwarz (Australia) Pty Ltd	comms infosec, EW
RPS Group Plc	energy/env consultancy, UK-based
Rutex	controllers motherboards US-based
SA Satellite	sat equipment and services
Saber Astronautics Australia Pty Ltd	mission software
Seaskip Pty Ltd	UNSW Start-up
Schweizer Kobras	law firm
Shoal Group Pty Ltd	engineering, complex systems mgt
Siemens Pty Ltd	industrial control systems
Silanna Semiconductor	hardened computer chips/FPGA

Silicon Cocoon Pty Ltd	IT services company
Sirion Global	livestock tracker
SkyKraft Pty Ltd	UNSW start-up
Sky and Space Global Limited	LEO cubesat constellation ASX listed
Skybridge Group Pty Ltd	IoT remote devices
Small World Communications	encoders/decoders FPGA
Soliton Network Consulting	IT services company
Space Adventures Ltd (USA)	space tourism US-based
Space-Industry.com	industry directory US-based
Spacelink Consulting	engineers/inventors
SpaceOps	start-up
Spatial Vision	spatial analysis and visualisation
Spatial Solutions	geospatial technology/mapping
SpecTerra Services Pty Ltd	geospatial technology/mapping
SpeedCast Ltd	satcom downlink services
Station Innovation	remote monitoring (bores etc)
STEP Electronics	comms inc satcom
Swedish Space Corporation Australia	satcom downlink services
SYPAQ	engineering recruitment
Tait Electronics	radio comms
Takor Group	geospatial technology/mapping
Talk Satellite	space media
Teakle Composites	carbon fibre spinners
Technik Group	packaging solutions
Telstra Corporation Limited	telecoms - little Satcom
Tetracom	radio on the move
Tidetech Commercial Marine Pty Ltd	small boats
Toolcraft Precision Engineering	precision engineering
Topcon Precision Agriculture	precision agriculture
TR Corporation	technology solutions company
Transfield Pty Ltd	investment, construction
Transponder Technologies Pty Ltd	remote meters, pumps, etc
Trimble Navigation Australia	GPS devices
TRS Engineered Solutions	engineering recruitment
Unisys Australia Limited	global IT company
V-Com	cloud-based software
Verison Enterprises	Technology solutions
Viasat	Satcom
Vipac Engineers and Scientists Ltd	consult, test, certify
Visual Analysis	analysis training
Vision Uplink Australia Pty Ltd	Ku band uplink trucks/ events spt
Visionstream Pty Ltd	mission critical comms
VRT Systems	IoT building control systems

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Single Person Consultancies

Aria Colton Consulting	enthusiast
AU Launch Services	Brett Burford
Biddington Research Pty Ltd	space consultant
Coutts Communications	Reg Coutts
Crystal Forrester	works at DST Group
Earthspace	Roger Franzen
Elementrex	Brett Burford
Embedded Pty Ltd	graphics design
Geocode Mapping and Analysis P/L	GIS training and education
KasComm Pty Ltd	Jeff Kasparian
Lumsden Consulting	business consulting
Nodesat	Brett Burford
Ryan Faulkner	no info on the web
Sach Initiatives	single person consultancy
Southern Cross Space and Communications Pty Ltd	Jan King consultant
Space Qualified Ltd	consultancy UK-based
Spaceport Australia	research and education - start-up
Stavros Georgiadis	financial/accounting services

Strategic Effects		professional services
	19	

Government Departments and Agencies

Crown Lands Division (NSW)		no longer this name
Geoscience Australia		
Royal Australian Air Force (RAAF) - Woomera		
	3	

Not for Profits/Industry Associations

Australasian SKA Industry Cluster		industry group
Australasian Society of Aerospace Medicine		like-minded researchers
Australian Academy of Science		learned academy
Australian Industry & Defence Network Inc		industry group
Geological Society of Australia		Professional society
Mars Society Australia Inc		NFP
One Giant Leap		education group to US space camp
Spatial Sciences Institute		professional association
STEM Network		STEM collaboration
Telecommunications Association Inc (TelSoc)		Telecoms society
	10	

Research Organisations/Universities

iMove CRC		research
International Center For Radio Astronomy Research (ICRAR)		radio astronomy research
Mullard Space Science Laboratory, Australia (UCL)		university
Murdoch University		university
	4	

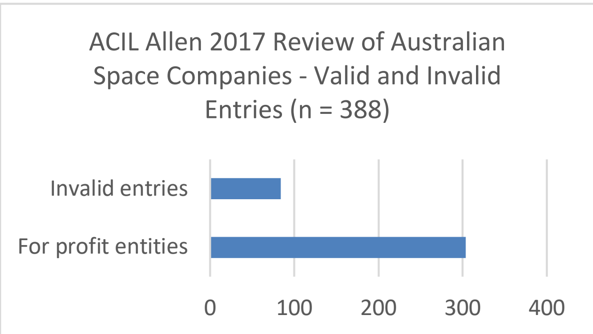
Ceased Trading/ Taken Over

Apogee Imaging International	closed down 2010
Asia Pacific Space Centre (APSC)	Christmas Is launch -defunct
Astrovision Australia	defunct 2005/6?
Aurisa	Industry Assoc - closed
Australian Aerospace	rebranded - Airbus Group Aust
Broens Industries Pty Ltd	ceased trading, bankrupt
Bruxin Pty Ltd	ceased trading 2016
Capital Technic Group	ceased trading 2018
Cardno Lawson Treloar Pty Ltd	deregistered 2018
CB Aerospace	deregistered 2017
Compucat Research Pty Ltd.	taken over by Raytheon
CSC Australia Pty Ltd	rebranded as DXC Technology
EADS Australia Pacific Pty Ltd	de-registered 2017
Earthinsite.com Pty Ltd	de-registered 2017
Futron Corporation	Avascent acquired space div 2014
Geoarc Consulting Pty Ltd	de-registered 2013
Geo Digital Pty Ltd	de-registered 2010
Geo Mapping Technologies	de-registered 2017
Geomet Pty Ltd	de-registered 2003
Geospectrum Pty Ltd	company wound up
Globecast Australia Pty Ltd	acquired by Telstra 2015
Hawker de Havilland Pty Ltd	Boeing subsidiary
Hexigeo	proposed for de-registration 2017
Integrated Spectronics Pty Ltd	de-registered 2012
Irriscan Australia Pty Ltd	proposed for de-registration 2018
KaComm Communications	de-registered 2016
Kel Aerospace Pty Ltd	registration cancelled 2004
LandStar DGPS (Thales GeoSolutions)	sold to Fugro 2003
Logica Pty Limited	defunct 2012
Macquarie Communications Infrastructure Group / Broadcast Australia	now a Canadian Super fund
Micreo Limited	acquired by L3 - now L3-Micreo
Miraxis Australasia Pty Ltd	de-registered 2010
Nortel Networks Australia Pty Ltd	insolvent 2016
Pacific Satellite Pty Ltd	app to de-register 2018
Peregrine Semi-Conductor Australia (PSA)	now Raytheon
Relken Engineering	now KPMG

RLM Systems Pty Limited		now Lockheed Martin
Rosebank Engineering Australia		now RUAG
SES World Skies		Now SES S.A.
SMS Consulting Group Limited		delisted now ASG
Spaceguard Pty Ltd		de-registered 1999
Spatial Industries Business Association		now SIBA/GITA
Sun Microsystems Australia		acquired by Oracle
TC Communications		Now Inmarsat
Technology Industry Association SA		merged with DTC
Tenix Defence Pty Ltd		out of business
Terranean Mapping Technologies Pty Ltd		de-registration proposed 2017
Think N Tinker Pty Ltd		de-registration proposed 2014
Ubiquitus Solutions		de-registration proposed 2014
Webmap Pty Ltd		ABN cancelled 2014
Weebill Space		failed start-up
	51	
No information or information ambiguous		
AFiO Group Pty Ltd		no info on the web
Allied Signals Aerospace Pty Ltd		no info on the web
Astro Explore		yacht sailing the world
Cansyd Australia Pty Ltd		no info on the web
Cypher-Howe Associates		no info on the web
Ericsson Defense Systems		no info on the web
Future Materials		no info on the web
Geospatial Applications Solutions Pty Ltd		no info on the web
Gps Solutions		not clear which company
ICIA consultants		accountants??
Outora		start-up no current info
Position One Consulting Pty Ltd		no info on the web
SGI Australia		no info on the web
Space Images Tasmania		no info on the web
Technical and Field Survey Pty Ltd		only trustee info about a SMSF
Virtual Reality Astronaut Training		astronaut training - Swinburne?
	16	
TOTAL	**388**	

Summary

For profit entities	304	78%
Invalid entries	84	22%
	388	100%



Annex C

Master Database: Aggregating Data from Nine Sources

		SIAA	APAC 2015	ERG	ACT	NSW	QLD	SA	VIC	WA	Totals	%
1Spatial Australia Pty Ltd	1	1										
2CR China Radio Network	1					1						
2SG Technology Group Pty Ltd	1	1		1								
3Logix Pty Ltd	1	1										
A Tech Rentals	1					1						
A.W. Bell Pty Ltd	1			1								
A Westview Electronics	1					1						
AAA Communications Solutions	1					1						
AAM Pty Ltd / AAM	1	1		1		1				1		
ABS Satellite	1		1	1								
Absolute Data Group Pty Ltd	1						1					
ACIL Allen Consulting	1	1						1				
Acoustic Imaging Pty Ltd	1	1										
ACR Technical Publication Services	1	1										
Activ8te Me	1	1		1					1			
Active Electronics Plc.	1						1					
ADACEL Technologies Ltd	1	1							1			
Addcom Contact Solutions	1	1										
Additive Rocket Corporation	1			1								
Advanced VTOL Technologies	1	1										
AECOM Australia Holdings Pty Ltd / AECOM	1	1					1					
Aero PM Pty Ltd	1				1							
Aerometrex Pty Ltd / Aerometrix	1	1						1				
Aerospace Australia	1								1			
Aerospace Materials Pty Ltd	1	1										
Aerospace Medical Services	1	1										
Aerospace Systems Pty Ltd	1	1										
Aerovalley Technology Pty Ltd	1	1										
Agile Communications	1			1								

AGIS	1				1				
Agricultural Reconnaisance Technologies Pty Ltd (Agrecon)	1	1							
Agro Meteorology	1								1
Airborne Research Australia (ARA)	1	1							
Airbus Defence and Space	1	1	1	1	1		1	1	1
Airspeed Pty Ltd	1	1							
Airwave Communications Pty Ltd	1	1							
AITC	1		1						
Ajilio	1								1
Alcatel Australia Limited (TLD Communications)	1	1							
Alexander Symonds	1								1
Altair Engineering Software Pty Ltd	1	1							
Amazon Web Services	1	1							1
Amearo Addictive Manufacturing	1	1		1					
Amphenol Australia Pty Ltd	1	1						1	
Amstar (Syngenta)	1								1
Anditi	1	1							
Andrews Communications Systems (Delmex Pty Ltd)	1					1			
Andromeda Industries Pty Ltd	1	1							
Anita	1								1
AON Risk Services Australia Ltd (AON Space)	1	1		1					
Applied Measurement Australia Pty Ltd	1	1							
Applied Satellite Technology Australia Pty Ltd (AST)	1	1							
Arcane Aerospace	1							1	
Aria Colton Consulting	1	1							
Arlula Pty Ltd	1	1		1					
Ashurst	1	1							
Asia Pacific Aerospace Consultants (APAC)	1			1		1			
Asia Pacific Aerospace Pty Ltd	1	1							
AsiaSpace	1	1						1	
Associated Press	1					1			
Asteroid Enterprises Pty Ltd	1	1							
Astro Explore	1	1							
Astron	1								1

AT Kearney Australia	1	1								
Atomic Sky	1									1
ATRAD	1							1		
AU Launch Services	1	1		1						
Aurecon	1									1
Aurega Group Pty Ltd	1	1								
Auspace Pty Ltd	1	1	1	1				1		
Auspex Strategic Advisory	1			1						
AusTest Laboratories	1	1						1		
Australia Astronomy Buy and Sell	1	1								
Australia Sky-Net Pty Ltd	1					1				
Australia Space Launch Pty Ltd	1	1		1						
Australian Aerospace & Defence Innovations Ltd (AADI)	1	1								
Australian Aerospace Engineers	1	1								
Australian Associated Press Pty Ltd	1					1				
Australian Radio Network Satellite Services	1					1				
Australian Sky and Telescope Magazine	1					1				
Australian Spectrum Consultants	1					1				
AV-Comm Pty Ltd	1	1				1				
Aventra	1					1				
Aviation Auditors Pty Ltd	1	1								
Avinet Pty Ltd	1	1								
Axiom Precision Manufacturing	1			1				1		
B&P Surveys	1									1
BAE Systems	1	1		1	1			1	1	
Balance Utilities Solutions	1									1
BAS Satellite Television	1					1				
BDGT Precision Engineering	1						1			
Beaudesert and Boonah Cranes	1						1			
Bentley Systems Pty Ltd	1	1								
BHP	1									1
Biarri Networks Pty Ltd	1	1								
Biddington Research Pty Ltd	1	1								
Bigmate	1	1		1						

Biz Hub Australia Pty Ltd	1	1			1					
Black Sky Aerospace	1	1					1			
Black tree Inc.	1									1
Blackmagic Design	1	1								
Blue Sky Consulting Australia Pty Ltd	1	1								
Boeing	1	1	1	1	1		1	1	1	
Bordernet Pty Ltd	1	1		1						
Brazier Motte	1									1
Brenco Group	1	1		1						
Broadcast Australia	1					1				
Broadcasting Australia Satellite	1					1				
Broens SA Pty Ltd / Broens Industries	1	1				1				
Bronron Apps	1	1								
BSA Limited	1					1				
BuddeComm	1					1				
Business Aspect	1									1
C. R Kennedy	1									1
Caelus	1									1
CanSyd Australia Pty Ltd	1	1								
Capricorn Space	1	1							1	
Cardno Lawson Treloar Pty Ltd	1	1								
Careers In Space	1	1								
Case IH	1									1
CEA Technologies Pty Ltd	1	1		1						
Central Coast Internet Pty Ltd	1					1				
CG Composites Australia Pty Ltd	1						1			
CGI Group, Australia	1	1								
Chime Communications Pty Ltd (iinet)	1			1						
Christie Digital Systems Australia Pty Ltd	1	1								
Cingulan Pty Ltd (Cingulan Space)	1	1			1					
CIRA	1									1
Cisco Systems Australia Pty Ltd / CISCO	1	1				1				1
Clarke & Severn Electronics	1	1								
Clarke Corporate Communications & Consulting	1	1								

Clear Networks	1			1						
Clearbox Systems Pty Ltd	1	1	1	1	1					
CNC Project Management Pty Ltd	1	1								
Coastal Aviation Pty Ltd	1						1			
Cobham Aviation Services	1	1		1				1		
Codan Ltd	1	1								
Codarra Advanced Systems Pty Ltd	1	1								
Cody Corporation Pty Ltd	1	1								
Communications Day	1	1								
Compliance Engineering Pty Ltd	1	1								
Comsult Australia	1	1								
ConceroTel	1					1				
Conor Silke	1	1								
CoolDiamond DLC by Norseld	1							1		
COSMOS Magazine	1					1				
Coutts Communications Pty Ltd	1	1		1				1		
C.R.Kennedy (possible duplicate with C. R. Kennedy – see above)	1	1								
Cray Australia Pty Ltd	1	1								
CSE	1						1			
CSE Tetracom, Crosscom / CSE	1	1								
Cuberider	1	1								
Cubic Defence Australia Pty Ltd	1	1								
Curiosat	1	1								
Custom Data Solutions	1					1				
Customs Agency Services Pty Ltd	1	1								
Cyber Technology (WA) Pty Ltd (Scientific Aerospace)	1	1								
CyberOps Pty Ltd	1	1						1		
Daronmont Technologies Pty Ltd	1	1								
Datellite Pty Ltd	1						1			
David Kennedy Newcastle Satellite Installations	1					1				
DDN	1									1
Decon Corporation Pty Ltd	1	1								
Defence Innovations	1	1								
DefendTex Pty Ltd	1	1		1					1	

Deloitte Consulting	1	1								
Delta-V Space Works Pty Ltd (Delta-V Space Alliance)	1	1	1	1						
Dematec Group	1	1								
DEWC Systems	1							1		
Dialog Pty Ltd (Dialog Information Technology)	1	1	1							
Digital Distribution Australia	1					1				
DigitalGlobe Australia Pty Ltd / DigitalGlobe	1	1					1			
DNA Anodising	1						1			
Don Alan Pty Ltd	1							1		
Downer EDI	1					1				
Downing Teal	1	1								
DXC Technology	1					1				
D□us Technology Pty Ltd	1	1								
Earth Space Robotics Pty Ltd	1	1								
Earthspace	1	1								
EAS Toolcraft Pty Ltd	1	1								
EBA Solutions Pty Ltd	1				1					
Eco Logical	1									1
Ecology and Heritage Partners Pty Ltd	1	1								
Electronic Alternatives Installation	1					1				
Elementrex Pty Ltd / Elementrex	1	1						1		
ElmTEK Pty Ltd / elmTEK	1	1						1		
EM Solutions / EM Solutions Pty Ltd	1	1	1	1			1			
Embedded GNSS Pty Ltd	1			1						
Emergent Technology	1	1								
Engineering and Scientific Systems Pty Ltd (ESSYS)	1	1								
Environmental Systems and Services (ESS)	1	1								
Eomap	1									1
EOS Space Systems Pty Ltd	1	1	1	1	1					1
Equatorial Launch Australia Pty Ltd (ELA)	1	1		1						
Ericsson Australia	1					1				
eSpatial	1									1
ESRI Australia Pty Ltd	1	1				1				
ESS Weathertech	1		1	1					1	

Etiam Engineering Pty Ltd	1	1		1						
ETMC Technologies Pty Ltd	1	1								
ETP Electron Multipliers Pty Ltd (ETP Ion Detect)	1	1								
Euro-World Network	1					1				
Exodus Space Systems Pty Ltd	1	1								
Facey Group	1									1
Farm & Co	1									1
Farmscan Ag Pty Ltd	1	1	1							
Faro Asia Pacific	1	1								
Fast Network	1	1								
Faster Networks Australia	1	1								
Fastwave Communications Pty Ltd / Fastwave	1	1								1
Fine-tech Electronic Solutions	1							1		
FireySat Remote Sensing	1	1								
Fleet Space Technologies	1	1		1				1		
Fluid Seals Pty Limited	1						1			
Flurosat Pty Ltd	1	1		1						
Fortescue Metals	1									1
Foxtel (and Austar)	1	1	1	1		1			1	
Frazer-Nash Consultancy Ltd	1	1						1		
Free TV Australia Ltd	1					1				
Frequentis Australasia	1						1			
FrontierSI	1	1							1	
Fugro	1	1	1							1
Fujitsu Australia Limited / Fujitsu	1	1								1
Fullarton Space Biotech / Fullarton Space Biotech Pty Ltd	1	1						1		
Future Engineers and Communications	1									1
Future Fleet Pty Ltd (Future Fleet International)	1	1								
Gaia Resources	1									1
Gap Geo Pty Ltd	1	1								
Gasket Solutions Pty Ltd	1						1			
GE	1					1				
GE Aviation Systems Australia Pty Ltd	1	1								
General Dynamics Mediaware	1	1		1	1					

Geodata Australia (GA)	1	1								
Geoimage Pty Ltd / Geoimage Jensen Bowers	1	1	1	1						
Geomatic Technologies Pty Ltd	1	1								
Geoplex Pty Ltd / Geoplex	1			1	1			1	1	
Geospatial Intelligence Pty Ltd	1	1		1	1		1			1
GHD	1								1	1
Gilat Australia (Gilat Satellite Networks)	1	1								
Gilbert & Tobin Lawyers	1					1				
Gilmour Space Technologies	1	1		1			1			
GIS People Pty Ltd	1	1		1						
GKN Aerospace Engineering Services	1	1								
Glassy Metal Technologies Ltd	1			1						
Global Innovation Centre Pty Ltd	1	1								
Global Vision Networks	1					1				
GlobalPOS / GlobalPOS Pty Ltd	1					1				1
Globecast Australia Pty Ltd	1			1		1				
Go	1									1
Gobal Satellite Phones & Data Comms Pty Ltd (GLOBALSAT)	1	1								
Google Australia	1			1						
Goonhilly Earth Station	1						1			
GPA Engineering	1						1			
GPS Trackers Australia	1	1								
GPSat Systems Australia Pty Ltd / GPSat	1	1	1	1					1	1
Greenhouse Gas Monitor Australia Pty Ltd (GGMA)	1	1						1		
Grollo Aerospace Pty Ltd	1	1							1	
Groundprobe Pty Ltd	1	1								
Guy Carpenter & Co	1					1				
Harbour IT	1					1				
Harvey World Travel Erina Group	1					1				
Hausfeld Consulting	1					1				
Heliaq Advanced Engineering	1	1		1						
HEO Robotics	1			1						
Hexagon Geospatial AB, APAC Region	1	1							1	
Hexigeo Group Pty Ltd / HexiGeo	1	1	1							

High Earth Orbit Robotics (HEO Robotics)	1	1							
Hillier Engineering Services	1						1		
Hills Industries Ltd	1			1		1			
Honeywell	1	1					1		
Horizon Models	1	1							
Hualin Pty Ltd	1					1			
HUMAN AEROSPACE PTY LTD	1							1	
Hydrix	1	1							
Hydrological Services Pty Ltd	1					1			
Hypercubes	1			1					
Hypersonix Pty Ltd	1	1		1			1		
HyVista Corporation Pty Ltd	1	1		1					
I Paddock	1								1
IBM Australia Ltd / IBM	1	1			1	1			1
IceInSpace	1	1							
IDS Australasia	1						1		
IMR Technologies Pty Ltd	1	1							
Inabox Group Ltd	1	1		1					
Indra Australia Pty Ltd	1	1							
Industrial Sciences Group (ISG)	1	1							
InFlight Graphics Pty Ltd	1	1							
Inmarsat	1	1		1					
Inmarsat solutions BV	1								1
Innovate Australia	1								1
Innovation Central	1								1
Innovative Electronics Pty Ltd	1	1		1					
Inovor Technologies Pty Ltd	1	1		1				1	
Insight GIS	1								1
Integrated Data Networks Australia Management Pty Ltd	1	1		1					
Integrated Systems Solutions Pty Ltd	1	1		1					
Integrated Training And Documentation	1						1		
Intel	1								1
Intelsat Asia Pty Ltd / Intelsat	1	1	1	1					
Int Aero Law and Policy Group Pty Ltd (IALPG)	1	1					1		

Interorbital Systems	1			1						
iPSTAR Australia Pty Ltd	1			1		1				
Irdeto Australia	1					1				
Irriscan Australia Pty Ltd / Irriscan Australia	1	1		1				1		
ITC Global (Australia) Pty Ltd (Panasonic) / ITC Global	1	1	1	1						
iVolve	1	1	1							
Jacobs / Jacobs Engineering	1				1				1	1
Jenkins Engineering Defence Systems Pty Ltd (JEDS)	1	1				1				
Jet Cut Tooling Solutions	1									1
Jeto Lab	1	1								
Jim's Antennas	1			1						
John Deere	1									1
John Morris Group	1	1								
Johns Electronics	1					1				
Jones Harley Toole	1	1								
Kacific Australia Pty Ltd	1	1								
Kakadu Software	1									1
KasComm	1							1		
Kellogg Brown & Root Pty Ltd	1				1					
Keysight Technologies Australia Pty Ltd	1						1			
Kiah Consulting	1				1					
King & Wood Mallesons	1	1								
Kleos Space Asia Pacific Pty Ltd	1	1								
KLX Aerospace Solutions	1	1								
KonnecTV	1					1				
Kordia Pty Ltd	1					1				
KPMG Australia Pty Ltd	1	1			1					
L3 Micreo Pty Ltd	1	1								
L3 Oceania	1									1
Land Equity International	1									1
Landwide Satellite Solutions	1					1				
Laser Central Pty Ltd	1						1			
Launchbox Australia	1			1				1		
Lazard Pty Ltd	1					1				

LBF Australia Pty Ltd	1					1				
Leica Geosystems	1	1	1							
Liquid Instruments	1	1		1	1					
Locata Corporation Pty Ltd	1	1	1	1	1					
Lockheed Martin	1	1	1	1	1			1	1	1
LSE Technology (Australia) Pty Ltd)	1					1				
Lyrebird Antenna Research Pty Ltd	1	1								
M2M Connectivity	1	1	1						1	
Macquarie Telecom	1					1				
Mad Electronics	1					1				
Madderns	1	1						1		
Madison Sport Pty Ltd	1						1			
Magellan GPS Systems (MiTAC)	1	1								
Main Sequence Ventures	1	1								
Maitec	1	1		1						
Mangoesmapping Pty Ltd	1	1								
MapInfo	1					1				
Marand Precision Engineering	1	1								
Marlec Pty Ltd	1					1				
Marsh Space Projects	1	1								
Maser Technology Group Pty Ltd	1					1				
Mastercut Technologies Pty Ltd	1						1			
Masters and Young	1	1		1						
Matchmaster Communications Pty Ltd	1					1				
Meccanica Pty Ltd	1				1					
Media Engagement Services (MES)	1	1								
Media Star Communications International	1					1				
Melbourne Space Program	1			1					1	
MEMKO Pty Ltd	1	1								
Mercury Project Solutions Miller Nitro	1									1
Metromatics Pty Ltd	1						1			
MGL Telecoms Pty Ltd (MGLSAT)	1	1							1	
Miller Nitro	1									1
Milspec Services Pty Ltd	1						1			

Miniature Bearings Australia	1						1			
Minter Ellison	1	1						1		
<u>Mirage Photonics</u>	<u>1</u>							1		
Mitsubishi Electric Australia Pty Ltd	1	1								
Moody Space Centre	1	1		1			1			
Moonshot Space Company Pty Ltd	1	1								
Moonshot X	1			1					1	
Mr Alarms	1					1				
Myriota Pty Ltd	1	1		1				1		
National Indigenous Television	1					1				
National Plastics & Rubber Pty Ltd	1						1			
Navaids	1	1		1						
Navigate Pty Ltd	1	1								
Navman Australia Pty Ltd	1					1				
Navman Wireless	1					1				
Navonix Consulting	1					1				
NBN Co Ltd / NBN	1	1	1	1					1	
Nearmap Ltd	1	1								
Neovation Advisory	1			1						
Network Ten	1					1				
Neumann Space Pty Ltd	1	1		1				1		
New Holland	1									1
New Spatial Ideascape	1	1								
Next Aero (Nextaero)	1	1		1						
NGIS Australia International (Aust) Pty Ltd	1	1		1						1
Nodesat	1	1		1				1		
Nokia Services Ltd	1	1								
Norseld Pty Ltd	1	1								
Nortel Networks Australia Pty Ltd	1					1				
Northrop Grumman	1	1	1	1	1		1	1		
Nova Systems	1	1	1	1	1		1	1	1	
Numerica	1									1
NVIDIA	1									1
Obelisk Systems Pty Ltd	1	1								

OHB-Systgem AG	1		1						
Omni Executive	1			1					
Omnilink Pty Ltd / Omnilink	1	1							1
Omnispace Australia Pty Ltd	1	1	1						
Omnispace LLC	1		1						
OmniSTAR Pty Ltd	1	1							
OnAir Solutions	1				1				
One Giant Leap Australia Pty Ltd	1	1							
Oni Group	1				1				
OneX GPS Tracking Systems	1	1							
OPAC Pty Ltd	1				1				
Opaque Space	1	1	1					1	
OpenTV Australia Pty Ltd	1				1				
Oracle Corporation Australia Pty Ltd	1	1							
Orbit Australia Pty Ltd	1	1	1		1				
Orion Satellite Systems	1	1	1						
Otus Intel / Otus Intelligence Group	1	1	1						
Outback Astronomy	1	1							
Ovass Pty Ltd	1	1	1						
Ozius Spatial	1	1	1			1			
OzSat	1		1						
Pacific Asia Express Pty Ltd	1				1				
Pacific ESI	1				1				
Pacific Media Group Co Ltd	1				1				
Pacific Satellite Networks Pty Ltd	1				1				
Pactel International	1				1				
Pangaea Spatial Pty Ltd	1	1							
PanGlobal TV	1				1				
Pegasus Aeromedical Consulting	1	1							
Peoplesafe Consulting	1					1			
PFi (Products for Industry)	1					1			
Photomapping / Photomapping Services	1	1							1
Picosat Systems	1	1	1						1
Pitcher Partners	1						1		

Pivotel Group Pty Ltd / Pivotel	1	1	1	1						
PNT Consulting	1			1						
Pod Trackers Pty Ltd / Pod Trackers ANZ Pty Ltd	1	1	1	1						
Pointerra	1									1
Position and Navigation Systems Pty Ltd	1	1								
Position Partners	1	1	1	1		1			1	1
Position, Intermedia Group	1	1								
Powerhouse Logistics Pty Ltd	1	1								
Practical Systems	1			1						
Precision Agriculture	1		1							
Primus Telecommunications	1			1						
Products for Industry Pty Ltd (PFI)	1	1								
Prompt Antennas	1					1				
Proximity	1				1					
PSMA Australia	1									1
Pynfall	1				1					
QinetiQ Australia	1	1							1	
Qualcomm International Inc	1					1				
Quickstep Holdings Ltd	1	1		1						
Quintessence Labs	1			1						
R.F.Technologies Aust Pty Ltd	1						1			
Radio Outback Pty Ltd	1					1				
Rafael Advanced Defence Systems Ltd	1	1								
RAND Australia Pty Ltd	1				1					
RapidMap Global	1	1								
Raytheon Australia Pty Ltd / Raytheon	1	1	1	1						1
RCR Laser	1	1								
REALM Solutions (SA) Pty Ltd	1	1								
Red Hat Asia Pacific Pty Ltd	1				1					
Reimage	1									1
Relken Engineering	1				1					
Remko Electronics Pty Ltd	1					1				
ResearchSat	1			1				1		
Richmond River Broadcasters Pty Ltd	1					1				

Rio Tinto Ltd / Rio Tinto	1	1							1
Ripple Aerospace	1			1					
Robert Koppelhuber	1	1							
Rocket Lab	1	1							
Rojone Pty Ltd	1	1							
Romtek	1								1
Ron S Thompson & Associates Pty Ltd	1	1							
RPS Group	1		1						
RS COMPONENTS PTY LTD	1							1	
RUAG Australia	1	1							
Rutex	1					1			
Saab Australia Pty Ltd	1	1		1					
Saber Astronautics Australia Pty Ltd	1	1	1	1		1			
Sach Initiatives / Sach Management Support	1	1				1			
Safran Pacific Pty Ltd	1	1		1					
Sagemcom Australasia Pty Ltd	1					1			
Samsung Electronics Australia	1					1			
Satcom Gadgets	1					1			
Satelectrics	1					1			
Satellite Music Australia	1					1			
SatPlus	1	1							
SatPlus Australia (Queensland Satellites)	1			1					
SBS	1					1			
Schweizer Kobras	1					1			
Scitek Australia Pty Ltd	1							1	
ScubaYorp Services	1	1							
Seaskip Pty Ltd	1			1					
Setanta Sports Australia	1					1			
SES Satellites / SES New Skies Satellites	1	1		1					
Seven Network	1					1			
Sew Simple Australia	1				1				
SGI Systems	1								1
Shapecut Pty Ltd	1						1		
Shoal	1	1		1	1			1	

Silanna Semiconductor Pty Ltd / Silanna Semiconductor	1	1	1	1	1				
Silentium Defence Pty Ltd	1	1		1			1		
Silicon Cocoon Pty Ltd	1	1							
Silicon Graphics Industry (SGI)	1								1
Singtel/Optus	1	1	1	1	1			1	
Sirion Global	1	1							
SITAonAir	1	1							
Sky and Space Global Ltd (SAS)	1	1		1					1
SKY Channel Pty Ltd	1				1				
Skybridge Group Pty Ltd	1	1	1	1				1	
SkyKraft Pty Ltd	1	1		1					
SkyMesh Pty Ltd	1	1		1					
SkyNet Satellite Communications Pty Ltd	1	1							
Small World Communications	1	1		1			1		
SmartNet Aus	1							1	
SMS Management and Technology (ASG Group)	1	1							
Solinnov Pty Ltd	1	1		1					
Soliton Network Consulting	1	1							
Solvay Interox Pty Ltd	1					1			
Soul Communications	1				1				
Southern Cross Media Group	1				1				
Southern Launch	1	1		1			1		
Space Ops / Space Ops Australia	1	1		1					
SpaceDaily.com	1				1				
SpaceInfo	1				1				
SpaceTech International	1					1			
SpaceX	1			1					
Spatial Vision	1							1	1
Spectrum Communications	1				1				
Spee3D	1	1		1					
SpeedCast Managed Services Pty Ltd (SpeedCast)	1	1	1	1			1	1	
Spiriti River	1								1
SSC Space Australia	1								1
SSL (Space Systems Loral/MDA)	1			1					

Starlab Education Pty Ltd	1	1								
Starmaster Technologies Pty Ltd	1	1								
Station Innovation Pty Ltd	1	1		1						
STEP Electronics, Hills Holdings	1	1								
Stephen Belfer	1	1								
Studio Kite	1						1			
Sundown Pastoral	1									1
Superair	1									1
Swagelok Eastern Australia	1						1			
Swift Networks Group Ltd	1	1								
Switchmode Power Supplies Pty Ltd	1	1								
Sydney Teleport Services	1					1				
Symbios Communications	1	1				1				
Syndetic	1						1			
SYPAQ Systems Pty Ltd	1	1						1		
Systemmic	1									1
TAE Pty Ltd (TAE Aerospace)	1	1		1						
Takor Group Pty Ltd / Takor Group	1	1								1
TC Communications	1					1				
TCL Communication Technology Holding Ltd	1	1								
TCN Channel Nine Pty Ltd	1					1				
Teakle Composites	1	1	1	1			1			
Techstars	1	1								
Techtel	1					1				
Teekay Shipping (Australia) Pty Ltd	1					1				
Teledynamics Pty Ltd	1					1				
Television Oceania Pty Ltd	1					1				
Telstra	1	1	1	1		1			1	
Temperature Controls	1						1			
Thales	1	1		1	1	1			1	1
The Weather Company Pty Ltd	1					1				
Think Bottom Up	1									1
ThinkSpatial	1									1
Thomson Playford Cutlers	1					1				

Thoughtworks	1									1
ThunderStruck Aerospace	1	1								
Tidetech Commercial Marine Pty Ltd	1	1	1	1						
Toolcraft Precision Engineering / Toolcraft Pty Ltd	1		1	1				1		
Top Con / Topcon Positioning Systems Inc	1		1	1						1
Topfield Australia	1					1				
Toppro Pty Ltd	1					1				
TR Pty Ltd	1	1								
TRS Engineered Solutions Pty Ltd	1					1				
Trellis Data	1				1					
Triggar VR Pty Ltd	1	1		1						
Trimble Navigation Australia Pty Ltd / Trimble	1	1	1	1						1
Truman Hoyle Lawyers	1					1				
TV Oceania	1					1				
TV Plus Pty Ltd	1	1								
TVB (Australia) Pty Ltd	1					1				
Twynam Agricultural Group	1									1
UGL Limited	1			1						
Ultra Electronics Avalon Systems Pty Ltd	1	1								
Umwelt	1									1
Unify	1									1
URSYS Pty Ltd / Cygnus Satellite	1	1	1	1						
V-Tec Pty Ltd	1	1								
Vantage WA	1									1
Verizon	1				1					
Viasat	1	1	1	1	1				1	
Vipac Engineers & Scientists Ltd	1	1							1	
Virgin Hyperloop One	1			1						
Visionstream Pty Ltd	1	1			1					
Visual Analysis	1				1					
Voestalpine High Performance Metals	1						1			
VPAC	1									1
VRT Systems	1	1								
VT iDirect	1			1						

Wesfarmers	1									1	
Western Digital (HGST)	1									1	
Whelans	1									1	
Woodside	1									1	
World Reach Ltd	1	1									
TOTALS	612	323	46	145	38	128	51	48	39	95	913

Key

Company mentioned in one database
Company mentioned in two databases
Company mentioned in three databases
Company mentioned in four or more databases

Summary	Companies	SIAA	APAC 2017	ERG	ACT	NSW	QLD	SA	VIC	WA	Records	
Number of companies listed	612											
Entries from SIAA, APAC and ERG											514	56%
Entries from States and ACT											399	44%
Total number of entries - all sources											913	100%
Company mentioned in one database	439	168	3	29	16	106	36	11	3	67	439	48%
% of unique records in each database		52%	7%	20%	42%	83%	71%	23%	8%	71%		
Company mentioned in two databases	103	90	6	51	4	11	5	15	14	10	206	23%
Company mentioned in three databases	39	35	13	35	3	2	4	12	6	7	117	13%
Company mentioned in four or more databases	31	30	24	30	15	9	6	10	16	11	151	17%
TOTALS	612	323	46	145	38	128	51	48	39	95	913	100%

Annex D

Companies with Three or More Records Across the Reference Databases

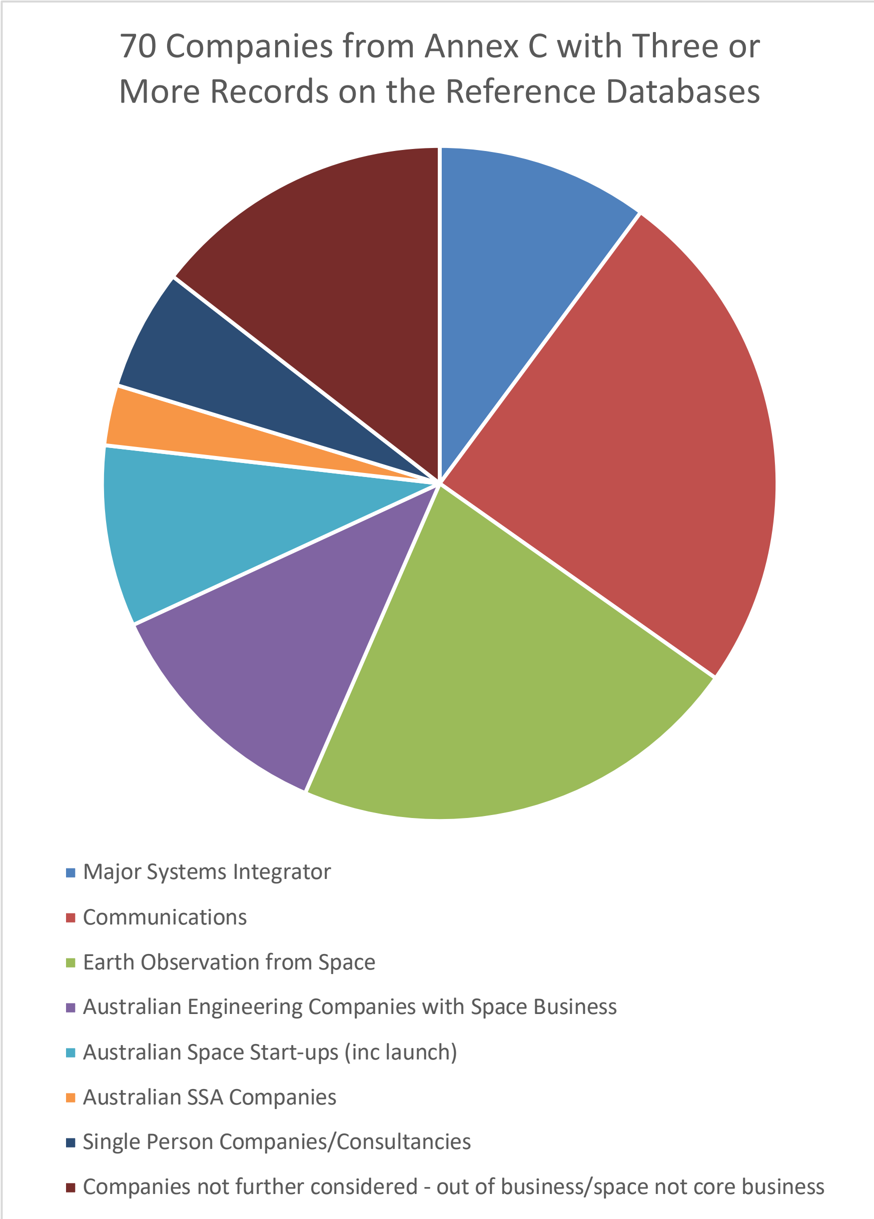
Company Name	Category	Totals
Airbus Defence and Space and GEO	Major Systems Integrator	
BAE Systems Australia Ltd / BAE Systems Australia	Major Systems Integrator	
Boeing Australia Holdings Pty Ltd / Boeing / Boeing Australia Ltd / Boeing Defence Australia	Major Systems Integrator	
Lockheed Martin Space Systems / Lockheed Martin Australia	Major Systems Integrator	
Northrop Grumman Australia Pty Ltd / Northrop Grumman	Major Systems Integrator	
Raytheon Australia Pty Ltd / Raytheon	Major Systems Integrator	
Thales Australia Holdings Pty Ltd / Thales / and Alenia space	Major Systems Integrator	7
Clearbox Systems Pty Ltd	Communications	
EM Solutions / EM Solutions Pty Ltd	Communications	
Foxtel Management/Foxtel / Foxtel Management Pty Ltd (and Austar)	Satellite TV	
NBN Co Ltd / NBN	Satellite Operator	
Singtel Optus Pty Ltd (Optus Satellite Services) / Optus Satellites / Optus Networks	Satellite Operator	
Skybridge Group Pty Ltd	Communications	
SpeedCast Managed Services Pty Ltd (SpeedCast)	Communications	
Telstra Corporation Ltd / Telstra Global / Telstra International	Communications	
Viasat Australia Pty Ltd	Communications	
Activ8te Me	Communications	
Intelsat Asia Pty Ltd / Intelsat	Satellite Operator	
ITC Global (Australia) Pty Ltd (Panasonic) / ITC Global	Communications	
M2M Connectivity	Communications	
Pivotel Group Pty Ltd / Pivotel	Communications	
Sky and Space Global Ltd (SAS)	Communications	
Small World Communications	Communications	

URSYS Pty Ltd / Cygnus Satellites	Communications	17
AAM Pty Ltd / AAM	Earth Observation/GNSS	
Geoplex Pty Ltd / Geoplex	Earth Observation/GNSS	
Geospatial Intelligence Pty Ltd	Earth Observation/GNSS	
GPSat Systems Australia Pty Ltd / GPSat	Earth Observation/GNSS	
Locata Corporation Pty Ltd	Earth Observation/GNSS	
Position Partners	Earth Observation/GNSS	
Trimble Navigation Australia Pty Ltd / Trimble	Earth Observation/GNSS	
ESS Weathertech	Earth Observation/GNSS	
Fugro Spatial Solutions Pty Ltd (FSS) / Fugro Satellite Positioning / Fugro	Earth Observation/GNSS	
Geoimage Pty Ltd / Geoimage Jensen Bowers	Earth Observation/GNSS	
NGIS Australia International (Aust) Pty Ltd	Earth Observation/GNSS	
Ozius Spatial	Earth Observation/GNSS	
Pod Trackers Pty Ltd / Pod Trackers ANZ Pty Ltd	Earth Observation/GNSS	
Tidetech Commercial Marine Pty Ltd/ Tidetech Pty Ltd	Earth Observation/GNSS	
Top Con / Topcon Positioning Systems Inc	Earth Observation/GNSS	15
Auspace Pty Ltd	Australian Engineering Company	
Nova Systems Australia Pty Ltd / Nova Systems / Nova Group	Australian Engineering Company	
Saber Astronautics Australia Pty Ltd	Australian Engineering Company	
Shoal Engineering Pty Ltd / Shoal Engineering / Shoal Group Pty Ltd	Australian Engineering Company	
Silanna Semiconductor Pty Ltd / Silanna Semiconductor	Australian Engineering Company	
Teakle Composites	Australian Engineering Company	
Neumann Space Pty Ltd	Australian Engineering Company	
Picosat Systems	Australian Engineering Company	
Toolcraft Precision Engineering / Toolcraft Pty Ltd	Australian Engineering Company	9
Delta-V Space Works Pty Ltd (Delta-V Space Alliance)	Australian Space Incubator	

Fleet Space Technologies	Australian Satellite start-up	
Inovor Technologies Pty Ltd	Australian Satellite start-up	
Gilmour Space Technologies	Australian launch company	
Hypersonix Pty Ltd	Australian launch company	
Southern Launch	Australian launch company	6
EOS Space Systems Pty Ltd / Electro Optical Space Systems Pty Ltd	Australian SSA company	
Silentium Defence Pty Ltd	Australian SSA Company	2
Coutts Communications Pty Ltd	Single person consultancy	
Moody Space Centre	Rockhampton-based enthusiast	
Myriota Pty Ltd	Australian applications company	
Nodesat	Single person consultancy	4
IBM Australia Ltd / IBM	Space not core business	
Cisco Systems Australia Pty Ltd / CISCO	Space not core business	
Cobham Aviation Services	Space not core business	
DefendTex Pty Ltd	Space not core business	
General Dynamics Mediaware	Space not core business	
Irriscan Australia Pty Ltd / Irriscan Australia	ASIC de-=registration filed 2018	
Jacobs / Jacobs Engineering	Space not core business in AS	
Liquid Instruments	Space not core business	
Opaque Space	Space not core business	
Orbit Australia Pty Ltd	Space not core business	
TOTAL		**70**

Summary of Annex D

Business Area/Category	Number
Major Systems Integrator	7
Communications	17
Earth Observation from Space	15
Australian Engineering Companies with Space Business	8
Australian Space Start-ups (inc launch)	6
Australian SSA Companies	2
Single Person Companies/Consultancies	4
Companies not further considered - out of business/space not core business	10


70 Companies from Annex C with Three or More Records on the Reference Databases
Major Systems Integrator
Communications
Earth Observation from Space
Australian Engineering Companies with Space Business
Australian Space Start-ups (inc launch)
Australian SSA Companies
Single Person Companies/Consultancies
Companies not further considered - out of business/space not core business

Annex E

Australian Space Companies: Three or More References in the Referenced Databases – Refined Data

Company	Brief Description of Main Space relevant activity	Upstream	Upstream Potential	Downstream
Fleet Space Technologies	Adelaide-based start-up aiming to launch a fleet of small satellites to support IoT applications	1		
Gilmour Space Technologies	Gold Coast-based space launch company	1		
Hypersonix Pty Ltd	Queensland-based start-up developing SCRAM-jet propulsion technologies	1		
Inovor Technologies Pty Ltd	Adelaide-based start-up that builds cubesats	1		
NBN Co Ltd / NBN	Satellite owner, Australian Government owned business enterprise, satellites flown by Optus	1		
Neumann Space Pty Ltd	Adelaide-based in space propulsion company, building a relationship with Airbus Defence and Space	1		
Picosat Systems	Perth-based satellite start-up	1		
Saber Astronautics Australia Pty Ltd	Sydney-based start-up, note that a US subsidiary exists to ease US export control issues	1		
Singtel Optus	The Optus satellites are operated by an Australian Company (wholly-owned subsidiary of Singtel)	1		
Southern Launch	South Australian space launch company	1		
Auspace Pty Ltd	space application training, wholly-owned subsidiary of Nova Systems		1	
Nova Systems Australia Pty Ltd / Nova Systems / Nova Group	Adelaide-based engineering services company, diverse portfolio, including a space line of business		1	
Shoal Engineering Pty Ltd / Shoal Engineering / Shoal Group Pty Ltd	Engineering services company with a space line of business in a diverse portfolio		1	
Silanna Semiconductor Pty Ltd / Silanna Semiconductor	Sydney- based chip manufacturing company – radiation hardened chips suitable for use in space		1	
Teakle Composites	Brisbane-based, fabricate carbon fibre structures		1	
Toolcraft Precision Engineering/ Toolcraft Pty Ltd	Precision engineering - aerospace focus		1	

AAM Pty Ltd / AAM	Australian geospatial and surveying company, some satellite, offices in and beyond Australia			1	
Delta-V Space Works Pty Ltd (Delta-V Space Alliance)	Sydney-based space incubator			1	
EOS Space Systems Pty Ltd / Electro Optical Space Systems Pty Ltd	Canberra-based company that uses lasers to track satellites for precise orbit determination			1	
Geoimage Pty Ltd / Geoimage Jensen Bowers	Brisbane-based geo-spatial company - surveying and 3D visualistion, now partnered with Geoimage			1	
Geoplex Pty Ltd / Geoplex	Australian owned geospatial company - subsidiary of Nova Group			1	
Geospatial Intelligence Pty Ltd	Australian owned geospatial company			1	
GPSat Systems Australia Pty Ltd / GPSat	Melbourne-based company - GNSS solutions, inc RFI location using propriety sesnor and gaming visualisation			1	
Locata Corporation Pty Ltd	Australian owned positioning technology company			1	
M2M Connectivity	Sim cards and data plans for M2M and IoT. Wireless IP -no mention of Satcom			1	
Myriota Pty Ltd	Adelaide-based start-up, developing satcom apps to support remote asset monitoring			1	
NGIS Australia International (Aust) Pty Ltd	Perth-based geospatial SME - mapping focus, offices and clients in and outside Australia			1	
Ozius Spatial	Sydney-based Geo-spatial start-up			1	
Pivotel Group Pty Ltd / Pivotel	Australian owned and operated, satcoms through Iridium, Inmarsat, Thuraya and Globalstar			1	
Position Partners	Melbourne HQ, GNSS product and services, presence in SE Asia			1	
Silentium Defence Pty Ltd	Adelaide-based start-up, seeking to commercialise bi-static radar technology for SSA			1	
Skybridge Group Pty Ltd	Melbourne-based satellite comunications provider			1	
Small World Communications	Adelaide-based, very small company (Steve Pietrebon)			1	
SpeedCast Managed Services Pty Ltd (SpeedCast)	Australian satcom company, trading globally			1	
Telstra Corporation Ltd / Telstra Global / Telstra International	Australian telecomms company - no satellites			1	
Tidetech Commercial Marine Pty Ltd/ Tidetech Pty Ltd	Hobart-based geospatial company - maritime focus			1	
URSYS Pty Ltd / Cygnus Satellite	Sydney-based, Australian owned, remote area and high reliability comms. Some satellite			1	
TOTALS		**10**	**6**	**21**	**37**

Annex F

Australian Space Agency Charter

1. Introduction

The Australian Space Agency (the Agency) was established by the Australian Government as an ongoing entity on 1 July 2018. It was established to put in place a long term structure to support the growth and transformation of Australia's space industry.

The Agency is a non-statutory, whole-of-government entity located within the Department of Industry, Innovation and Science (the Department). The statutory basis for the Agency will be considered after a review of its operations, which will commence within four years of its establishment. This review will be considered by the Prime Minister.

The Agency Charter (the Charter) provides a high-level, strategic overview of the Agency's purpose, responsibilities and governance structure. It is informed by the draft charter provided in the Review of Australia's Space Industry Capability (the Review) and the Government Response to the Review. The Charter supports, but is not intended to replace, other strategy and governance documents, including the Agency Advisory Board's (the Advisory Board) Terms of Reference.

The Charter is approved by the Minister responsible for civil space activities (the Minister). At the discretion of the Prime Minister, the Prime Minister may also approve the Charter. The Head of the Agency (the Agency Head), in consultation with the Agency Advisory Board, may make operational changes to the Agency's Charter. Where substantive changes to the Charter are proposed, the Minister must be consulted.

2. Purpose

The Agency's purpose is to transform and grow a globally respected Australian space industry that lifts the broader economy, inspires and improves the lives of Australians – underpinned by strong international and national engagement.

The Agency 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. The Agency ensures that Australia's civil space activities contribute to productivity and employment across the Australian economy, secure new knowledge and capability, and inspire all Australians.

3. Values

The Agency is committed to the Australian Public Service Values and Code of Conduct and the values of the Department. In every step of its work, the Agency will also be guided by its space industry values:

Responsible – Australia as a responsible global citizen committed to safe and secure operations in space and on earth.

- Shared ambition – Building strong partnerships to realise shared ambitions.
- Trust and integrity – Building trust and respect within the Agency and with our partners.
- Entrepreneurial spirit – Embracing risk and an entrepreneurial approach.
- Inclusive – Valuing our differences and drawing strength from diversity.
- Passion – Dedicated to our purpose, curious to push the boundaries of our knowledge and constantly strive to be at the forefront of space industry development.

4. Roles and Responsibilities

The Agency is responsible for whole-of-government coordination of civil space matters and is the primary source of advice to the Australian Government on civil space policy. Under this broad mandate, the Agency has six primary responsibilities:

1. Providing national policy and strategic advice on the civil space sector.

2. Coordinating Australia's domestic civil space sector activities.

3. Supporting the growth of Australia's space industry and the use of space across the broader economy.

4. Leading international civil space engagement.

5. Administering space activities legislation and delivering on our international obligations.

6. Inspiring the Australian community and the next generation of space entrepreneurs.

5. Governance

The Agency is located in the Department as a non-statutory, separately branded function. To remove ambiguity, the Secretary of the Department is the relevant Accountable Authority.

The Agency's governance structure is centered on the roles of the Agency Head, Deputy Head and the Advisory Board.

5.1 Agency Head

The Agency Head is appointed by, is accountable and reports to, the Minister. The Agency Head is prescribed as an official by the Secretary of the Department to enable the exercise of certain powers and functions under the *Public Governance, Performance and Accountability Act 2013 (PGPA Act 2013)*, where appropriate.

The Agency Head is responsible for overall governance and performance, management, policy leadership and strategic direction of the Agency.

5.2 Deputy Head

The Deputy Head of the Agency is a Senior Executive Service (SES) officer from the Australian Public Service and reports to the Agency Head. The Deputy Head has oversight of strategy, policy and day-to-day operations of the Agency, and supports the Agency Head in monitoring the performance of the Agency.

5.3 Advisory Board

The Advisory Board is a non-statutory, independent, skills-based board that provides advice to the Agency Head. The Advisory Board's purpose is to review and advise the strategic direction and performance of the Agency, and to support the Agency to achieve its purpose. It is not a decision-making body, and has no governing legislation.

The Advisory Board may have up to ten members. Members are appointed by the Minister, on recommendation by the Agency Head. At the discretion of the Prime Minister, the Prime Minister may also approve members. Ex-officio members may also

be appointed including the Secretary of the Department or a delegate, and a senior Department of Defence representative with responsibilities that include space.

Appointments will be for a period of up to three years. The Minister may extend the appointments of Advisory Board Members by up to two years. There is no limit to the number of times the Minister may extend appointments. The Chair is the only Advisory Board member to be remunerated at a daily rate consistent with similar advisory boards in the Industry, Innovation and Science portfolio and consistent with the Remuneration Tribunal.

The responsibilities of the Advisory Board will be outlined in the Advisory Board's Terms of Reference. The Terms of Reference will be formulated to be consistent with the Charter. At the discretion of the Prime Minister, the Prime Minister may also approve the Terms of Reference.

5.4 Consultation mechanisms

The Agency has close linkages and works in partnerships with government agencies involved in space activities to ensure a whole-of-government approach is taken in respect of civil space activities. To meet its responsibilities, the Agency also works with a wide range of stakeholders, including industry, state and territory governments, Australian Government departments, researchers and international organisations. Collectively, this engagement will ensure that the Agency is informed by industry relevant issues and able to provide one voice for the civil space sector.

Engagement mechanisms include the Australian Government Space Coordination Committee, the Space Industry Leaders Forum and the State and Territory Space Coordination Meeting. The Agency may also establish, from time to time, expert review groups to support the activities of the Agency. The Agency will also leverage existing consultation mechanisms as required, including the Council of Australian Governments (COAG) Industry and Skills Council and the Commonwealth Science Council.

5.4.1 Australian Government Space Coordination Committee (SCC)

The Agency will coordinate civil space activities with other Australian Government departments and agencies through the SCC.

The purpose of the SCC is to coordinate and discuss whole-of- government policy settings on civil space activities. It is open to all relevant Australian Government departments. The SCC is chaired by the Agency (generally the Deputy Head) and functions as an interdepartmental committee comprising senior official representation from across the Australian Government. The responsibilities of the SCC will be outlined in the SCC's Terms of Reference.

The SCC meets approximately once per quarter, although fewer or more meetings may occur as required. The SCC may also be supported by technical working groups including, but not limited to, earth observation, space law, position-navigation-timing, satellite communications and critical infrastructure.

5.4.2 Space Industry Leaders Forum (the Forum)

The Agency will establish and facilitate the Forum as the primary mechanism for engagement and coordination with the space industry within Australia. Members of the Forum will be invited by the Agency Head. The Chair of the Forum will be appointed by the Agency Head. Membership will include industry representatives, academia, relevant industry associations and other non-government space organisations.

The purpose of the Forum is to assist the Agency with the business and technological aspects of the space industry and to provide input into national civil space strategy and policy. The Forum is not a decision making body, nor lobby group, and does not replace the role of trade associations.

5.4.3 State and Territory Space Coordination Meeting (S&T Meeting)

The states and territories play a key role in the national space enterprise. The Agency will engage closely with states and territories to support national space policy and strategy, coordinate activities and provide one voice for Australia's civil space sector.

The Agency will establish a regular S&T Meeting to support active engagement with states and territories.

6. Performance and Reporting

The Agency will develop and report against key performance indicators consistent with the Agency's purpose and responsibilities, and report against these annually. These may be provided through specific Agency documents or reported to government through the Department.

6.1 Reporting through the Department

The Agency will contribute to the Department's reporting arrangements under the *PGPA Act 2013* and other Departmental processes as required. The Agency will not duplicate any performance reporting carried out by the Department.

6.2 Reporting to Government

The Agency will provide an update on the Agency's activities at least once a year to government. The update will focus on key achievements against the Agency's purpose, key performance indicators, and include its forward strategy. The Agency will also produce the State of Space Report, documenting the Australian Government's activities in civil space for each calendar year.

Australian Space Agency Charter

October 2018 18-COM12765

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Biddington B 1998. BB was a member of the team that negotiated the terms and conditions under which RAAF personnel would be employed within the SBIRS control centre at Buckley Air Force Base in Colorado.

Biddington B 2004. Discussions with Mr Shuber Ali, Astrovision, Sydney, 2004.

Biddington B 2006a. BB assisted Professor Andrew Parfitt, the CEO of the CRCSS, to prepare the re-bid documentation for the CRCSS.

Biddington B 2006b. BB attended the SASI meeting and, at DIAB's request, reviewed the report of the meeting prepared by Metafilm.

Biddington B. 2006c. Discussions with Professor Iver Cairns, lead author of the 2010 Space Science Decadal Plan.

Biddington B 2007. Roy Gibson/Brett Biddington meeting in Paris, 29 January 2007.

Biddington B 2008a. Record of Conversation with Dr Hubert Reile and others, DLR, Cologne, Germany, 1 December 2008.

Biddington B 2008b. Discussions and correspondence with staff member of Senator Stott-Despoja, December 2007, January 2008.

Biddington B 2009a. BB attended the 1 April meeting, invited as Chair of the Australian Space Industry Chamber of Commerce (ASICC).

Biddington B 2009b. Discussions in early 2009 with DIISR officials.

Biddington B 2009c. Chair of ASICC letter to the Prime Minister, dated 3 March 2009.

Biddington B 2009d. BB was a member of the Space Industry Advisory Council, invited as Chair of ASICC.

Biddington B 2010a. From personal notes taken at a workshop, *Improving our Vision IV*, sponsored by the Eisenhower Center for Space and Defence Studies, held in the offices of Inmarsat Global, London, 21-22 June 2010.

Biddington B 2010b. Discussions with parties involved in the proposed summer trial of the Cosmo-Skymed mobile ground station in Canberra. Parties included Auspace, ANU, Commonwealth and NSW Governments and the Embassy of Italy.

Biddington B 2010c. Discussions with DIISR officials.

Biddington B 2010d. Discussions with Mr Anthony Wicht.

Biddington B 2011. Discussions with Defence and Industry Department officials and the main author of the Plan in the weeks immediately before its release.

Biddington B 2012. BB was a member of the team that bid to host the IAC in Adelaide in 2014.

Biddington B 2013a. Discussion with the Hon Jack Snelling, former Treasurer of South Australia.

Biddington B 2013. BB led the team that bid to host the IAC in Adelaide in 2017.

Biddington B 2015. Discussion with DFAT officials, November 2015.

Biddington B 2016a. Discussions with ITU Officials at Spectrum Workshop in Auckland New Zealand, 2 August 2016.

Biddington B 2016b. Discussion with former Senator Kate Lundy (Labor, ACT). She launched the *Satellite Utilisation Policy* in her role as Parliamentary Secretary to Minister Carr in 2013.

Biddington B 2016c. Correspondence with Professor Russell Boyce, 8 December 2016.

Biddington 2017a. Discussion with Director, Canberra Deep Space Communications Centre (CDSCC) whilst inspecting newly installed antenna.

Biddington 2017b. Discussions with Professors Bland and Tingay from Curtin University.

Biddington B 2017c. Briefing provided at the AGI booth at the Space Symposium, Colorado Springs, March 2017.

Biddington B 2017d. Discussions and correspondence with Mexican Ambassador to Australia.

Biddington B 2017e. Discussions with ACT Government and industry association representatives before and after the meeting.

Biddington B 2017f. BB attended the Parliamentary Breakfast.

Biddington B 2017g. Remarks by Minister Cash to BB, Tuesday 26 September 2017.

Biddington B 2017h. Bell T 2017. Email correspondence, 12-15 June 2017.

Biddington B 2017i. Discussions with Mr Rob Debelle, the lead for exhibition and sponsorship sales for IAC2017, especially in the period October 2016 to September 2017.

Biddington B 2018. Discussion with senior CSIRO official, 23 August 2018.

Biddington B 2019a. Personal Correspondence with Professor Steven Freeland, June 2019.

Biddington B 2019b. Personal Correspondence with Professor Walter Peeters, June 2019.

Biddington B 2019c. Discussion with Mr Michael Walkington, CEO Jacobs Australia Pty Ltd, January 2019.

Biddington B 2019d. Meeting with the Executive Committee of ADIESA, 21 February 2019.

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