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SKIN IN THE GAME: REALISING AUSTRALIA’S NATIONAL INTERESTS IN SPACE TO 2025

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PREFACE

This research project began in the latter part of 2006 and has been in train for about 15 months. In this time several national and international events intervened which significantly influenced the course of the study and its outcomes. Notably the Chinese anti-satellite test, on 11 January 2007, caused a series of waves and ripples internationally, with domestic implications for Australia which, only now, are being appreciated. The shooting down by the United States of a 'dead' spy satellite in February 2008 has served to further magnify the pace at which the space security environment is changing.

This report is the product of extensive consultation in Australia and overseas.

First, numerous members of the Australian Defence Force and senior Defence officials gave readily of their time to discuss aspects of the project as it progressed.

Second, numerous officials from space agencies, universities, think tanks and companies located outside Australia provided valuable and generous advice.

Third, a series of closed workshops were conducted, six in Australia and three overseas. Altogether nearly 100 people participated in these events from which many different perspectives emerged. There was clear consensus, however, that Australia, in it own interests and as a respected member of the community of nations, must become considerably more active in shaping and influencing the space environment of the future. An almost unanimous view was that the Australian voice will only be credible if Australia operates one or more satellites, on a continuous basis, in its own sovereign interests.

The main purpose of the international workshops was to gather expert views on global drivers for human activity in space in 2025, from strategic, organisational and technological perspectives. These form some of the major boundaries and assumptions of this paper. For example, there was unanimity that in 2025 access to space will be by conventional, chemically powered multi-staged rockets. No attention, therefore, is given to discussing emerging launch technologies and their possible implications for Australian space policy development.

I would like to acknowledge the help of those who provided support and critique throughout the project, notably Roy Sach, Roger Franzen, Mike Banham and Ross Babbage.

As always, this report is not intended to be the last word on the subject. Readers who wish to discuss and debate aspects are encouraged to do so by preparing either a short commentary or a longer article for the Kokoda Foundation's professional journal, *Security Challenges.* For details on how this can be done, please visit:

http://www.kokodafoundation.org/journal/New%20Site/author.html

EXECUTIVE SUMMARY

Australia has a vital and strengthening national interest to ensure that satellites which provide a range of utilities (communications, navigation and timing and remote sensing data) may operate in a safe and secure environment. The policy drivers which have influenced Australia's involvement in space include:

- *Australia's Strategic Geography*. The continent is ideally located to host ground stations.
- *Alliance Relationships*. Facilities and activities vital to the national interests of the United States (US) and previously the United Kingdom have been hosted to Australia's strategic and operational benefit.
- *Good International Citizen*. Australia is committed to the concept that space should be a domain used for peaceful purposes to benefit all of humankind.
- *Cost*. Australia has gained access to space-based utilities without having to bear the costs of technology development and the many risks associated with space operations.
- *Spectrum*. Spectrum is an emerging driver. The radio spectrum is a finite resource, and trade-offs are looming between national security and commercial requirements.

Australia is a sophisticated user of space utilities but none of the satellites currently accessed have been designed or are operated to meet Australian requirements first and foremost. Certainly they provide useful services but in the remote sensing domain especially, they are sub-optimal. Against the backdrop of global warming and climate change Australia's primary interests are less likely to be met by these arrangements and dedicated operational assets are proposed for the future.

The space environment is changing rapidly. Although the US remains the dominant space power there is evidence that its influence may be declining and that its dependence on space utilities for national security and commercial purposes may be a significant risk. Accordingly, Australia may also be vulnerable given its current and increasing reliance on US space-based systems notably to enable highly networked military capabilities and operations by 2020. Space debris, new entrants into space and new technologies are further complicating factors.

The concept of sovereignty does not apply especially well in space because few nations have the capacity to protect or defend property or assets which have been launched into that domain. The question becomes how to create transparent regulatory and operational regimes which build confidence and prevent competitive behaviours from becoming aggressive.

In the next decade, Australia faces major decisions about its future role in space. Of particular importance will be whether and how to invest in Operationally Responsive Space capabilities, Missile Defence and Space Situational Awareness (SSA). Australia is especially well located to host new SSA capabilities, which, providing the data is openly shared, may contribute to space security by improving global understanding of the space activities of nations.

This report argues that Australia must become an active participant in the coming debates and discussions about the future of space. Too much is at stake for the nation to watch from the sidelines.

In order for the Australian voice to be credible and legitimate it will need to be backed by a more explicit policy commitment.

The following initiatives are proposed:

- A fast-tracked program to increase the cadre of space literate policy makers across the Commonwealth Government.

- Development of a Cabinet endorsed national space strategy.
- Establishment of a small space policy coordination unit in the Department of the Prime Minister and Cabinet (to bring together Commonwealth, State and Territory interests).
- Establishment of a satellite design, construction and operations organisation, possibly responsible to the Minister for the Environment.
- Determination to purchase two remote sensing satellites, in a phased program, which would be optimised in systems terms to meet Australian requirements first and the requirements of any others second.
- Establishment of a national counter-surveillance capability with the aim of determining what others can discover about the Australian environment, events and activities which may be disadvantageous to the nation.
- Investment in a space situational awareness capability – initially as an adjunct to the US system but with a view to developing a national capability, data from which could be made available, at Australian discretion, to any nation or user.

In summary, this report argues that Australia should acquire space competencies and capabilities which will add national benefit in their own right whilst adding weight and credence to an independent national space strategy. Whilst this strategy could be expected to acknowledge and promote a continuing close affinity on space matters with the US, it would also provide room for Australia to exercise, where appropriate, independence of thought and action in pursuit of longer term national interests.

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Australian Government

Department of Defence

JE JACOBS

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Brett Biddington was a member of the Royal Australian Air Force (RAAF) for 23 years serving in a series of intelligence, security and capability development positions. Before joining the RAAF he was a member of the Australian Diplomatic Service and later taught at the Canberra College of Advanced Education (now the University of Canberra). He retired from the RAAF as a Group Captain in 2002 and joined the Space Team of Cisco Systems. He is actively involved in Australian astronomy governance and in several space and defence industry associations.

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SKIN IN THE GAME: REALISING AUSTRALIA'S NATIONAL INTERESTS IN SPACE TO 2025

INTRODUCTION

Australia has a vital national interest in a secure, stable and predictable space environment looking to 2025 and beyond. This report:

- explains why space matters to Australia,
- describes Australia's space activities since the end of World War II,
- discusses the emerging 'big issues' in space, and
- proposes a set of initiatives which might be adopted and led by the Commonwealth Government to ensure that Australia's legitimate sovereign interests with regard to space are both protected and advanced beyond 2025.

Space is a vital, although understated, component of Australia's national security strategy. Space-based utilities and services provide communications, timing, navigation, and remote sensing data on which the nation increasingly relies. None of the satellites which provide these services are operated with Australia's national interests as their first priority. Indeed, Australia has had to make do with systems which have been designed primarily to meet the interests of others first.

This situation may have been acceptable during the Cold War but it no longer serves Australia's national interests and, indeed, may be harmful to them. Australia's current and predicted future dependence on space together with the associated vulnerabilities and risks must be identified and quantified to permit an evidence-based approach to development of both strategy and policy. There is some urgency required due to the rapidly changing, increasingly contested and less secure space environment.

The variables to which Australia needs to pay particular attention as it defines its future engagement with space are as follows:

- There is evidence that, although the United States (US) is likely to remain the dominant space power for the next decade, its lead is slipping and its assertion of space dominance is coming under challenge.
- The reliance on space, especially by the US, to support networked military operations and other national security activities is a vulnerability recognized both in the US and by potential competitors, notably China.
- The number of nations seeking to develop space capabilities is growing and non-state actors are now extending their access for commercial purposes beyond satellite communications services to remote sensing and space tourism.
- Developments in miniaturisation and software assurance are allowing satellites to become smaller, more capable, more reliable and more readily replaced; they are also becoming networked allowing new possibilities for redundancy, the creation of new markets and the redefinition of old ones..
- Costs of entry to space are falling, encouraging numerous smaller nations to own and operate satellites to further their own interests.
- The global economy is increasingly reliant on Global Navigation Satellite Systems[1] for precision timing and location information in support of myriad applications and utilities on Earth. This trend is likely to accelerate

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[1] Global Navigation Satellite Systems is the generic name for Global Positioning Systems, Galileo, and similar systems.

leading to increasing dependence on space-based utilities.

- The electro-magnetic spectrum, especially in the bands that must be used for communicating between the earth and satellites, is increasingly crowded; the spectrum is finite; and its allocation is becoming increasingly complex and contested.
- In a related development, the positions or slots available for satellites in Geo-Stationary Orbits (GEO) around the earth are running out and the possibility of mutual radio interference between satellites which are relatively close to one another is of increasing concern to satellite operators.
- The space and cyber domains of modern and future warfare are necessarily linked, presenting vulnerabilities which may be relatively easily exploited by an adversary, yet difficult to protect.
- Space debris, including parts of old satellites and of launch vehicles, is becoming a potential hazard to satellite operations in some orbits.
- Space is a ‘global commons’, offering a unique vantage point from which to monitor and better understand the linked phenomena of global warming and climate change and their observed and potential impacts on life on Earth.
- Dual use technologies are becoming more prevalent placing increased pressure on restrictive export control regimes, notably the International Traffic in Arms Regulations (ITAR) of the US.

In the next 20 years, as the interplay between these factors unfolds, both competitive and cooperative behaviours between the main space-faring nations of the world are likely.

There are two key questions for Australia.

- To what extent should Australia seek to influence the themes, directions and timing of the discussions and decisions which are likely to have profound impacts on the use and regulation of space in the future?
- If Australia does become an active participant, what, if any, new capabilities may be needed to lend credibility and legitimacy to the Australian voice?

This report addresses these questions by:

- describing Australia's involvement in space,
- identifying the drivers for Australia's space engagement,
- examining the capabilities of the US in space,
- assessing the emerging issues of space security, and
- proposing those things that Australia might do in order to protect and promote its interests in space.

The report concludes with an Action Plan that proposes a way forward, together with the indicative costs.

Annex A offers some explanatory notes about space and satellites for readers who are unfamiliar with space and satellite concepts. This Annex includes the basic terminology and the important technical challenges associated with the successful design, construction, launch and operation of satellites. Annex B provides a brief overview of astronomy and space science.

Australian policy, academic, scientific and industry circles all agree that insufficient attention has been paid to space. There is also frustration in some parts of industry that Australia is not investing sufficiently in national space capabilities. The main concern is that Australia lacks the expertise and institutional mechanisms to identify and realise its national interests in space. Even worse, these interests may be compromised unless a more systematic, comprehensive and involved space engagement strategy is developed, resourced and implemented.

Satellites must be considered as components within a complex system, most of which are on Earth. To be fully effective the system needs to be understood from end-to-end and investments made across all elements in a balanced way.

This report does not propose that Australia should aspire to become a space-faring nation with a national space program and a large supporting bureaucracy. Something far more modest is suggested that can still deliver a national and global benefit.

AUSTRALIA'S SPACE ENGAGEMENT: SOME BACKGROUND AND THE SITUATION TODAY

In the 50 years since Sputnik 1 was launched, in October 1957, developments in technology and political, social and environmental change have combined to create global dependencies on satellite systems. They provide communications, navigation and timing and information about the earth and the space environment itself on which many nations and economies increasingly depend. Australia is a sophisticated user of these utilities, nearly all or which are foreign owned and operated[2]. The risks that come with such dependence are emerging as public policy issues which deserve debate and remedial action.

Australia's direct investment in space activities since the late 1940s has been stop/start. To those who define involvement in space as building, launching and operating satellites for national and commercial purposes, this has been a disappointment. Others argue, and this has been the position of numerous governments, that Australia's interests, notably in terms of national security, have been exceptionally well-served for very little cost. Australia has gained great benefit from the capabilities of foreign-owned satellites without incurring substantial infrastructure and industry overheads.

[2] Optus operates a number of commercial communications satellites which have been licensed by the Commonwealth Government. One of these, the C1D satellite has a unique hybrid payload meaning that the Australian Department of Defence and commercial interests operate separate 'receive and transmit' systems yet make common use of the satellite's core, known as the 'bus'.

The Legislative and Regulatory Framework

Australia's International Obligations in Space

Australia is a signatory to the five treaties and agreements which set out the principles governing the uses of space. These are:[3]

- 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, entered into force on 10 October 1967, 98 ratifications and 27 signatures (as of 1 January 2007);
- 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, entered into force on 3 December 1968, 89 ratifications, 24 signatures, and 1 acceptance of rights and obligations (as of 1 January 2007);
- 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, entered into force on 1 September 1972, 84 ratifications, 24 signatures, and 3 acceptances of rights and obligations (as of 1 January 2007);
- 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, entered into force on 15 September 1976, 47

[3] These documents are available online from the *United Nations Office of Outer Space Affairs* at: <http://www.unoosa.org/oosa/index.html>.

ratifications, 4 signatures, and 2 acceptances of rights and obligations (as of 1 January 2007);

- 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, entered into force on 11 July 1984, 13 ratifications and 4 signatures (as of 1 January 2007).

This is a slender body of law to which can be added other instruments which seek to limit nuclear and missile proliferation. Australia is a signatory to a number of these instruments including:

- *The Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water* (1963); and
- *The Treaty on the Non-Proliferation of Nuclear Weapons* (1973).

Finally, Australia is one of 34 countries to have joined the Missile Technology Control Regime (MTCR) which was established in 1987. This is an informal and voluntary association of countries which share the goals of non-proliferation of unmanned delivery systems capable of delivering weapons of mass destruction, and which seek to coordinate national export licensing efforts aimed at preventing their proliferation.

Australia, formerly quite active in the United Nations Committee on the Peaceful Uses of Outer Space and its various sub-committees, now takes a more passive role.

Domestic Law and Regulations

The body of domestic law relating to space activities is slender. Two Commonwealth Acts have the word 'space' in their title.

- The Australian Space Council Act, No. 27 1994, provided for the establishment of a Space Council which was tasked to develop a national space policy and program with an emphasis on space science. The Council achieved little and was replaced by an inter-departmental forum now chaired by the Department of Innovation, Industry, Science and Research (DIISR).[4] The Forum meets twice a year, provides a venue for an exchange of views on space matters and has no executive authority.
- The Space Activities Act, No. 123 1998, provides the legislative framework to permit commercial space launches from Australian territory and to permit the launch of Australian-registered satellites from other countries. This is the only law of any nation which defines the lower boundary of space as beginning 100km above the surface of the earth. The Act and associated regulations essentially address licensing, safety regulation and liability matters.

A third Act, the *Defence (Special Undertakings) Act, No. 121 1952* was initially enacted to protect the UK nuclear program in Australia but now applies to the Joint Defence Facility Pine Gap (JDFPG) and allows the Commonwealth enormous discretion in the means it takes to protect the site from unauthorised access and establishes harsh penalties for any person convicted of breaching its provisions.[5]

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4 DIISR is responsible for civil and commercial space and science policy.

5 In February 2008, an appeals court in the Northern Territory quashed convictions against four protesters who trespassed at Pine Gap in 2007 and had been charged under this legislation and found guilty. They are the first people ever to have been charged under the Defence (Special Undertakings) Act. They were convicted of lesser offences, including damaging Commonwealth property. This outcome casts some doubt on the continued

The Woomera Prohibited Area (WPA) was declared under Defence Force Regulation 35 in 1947 for the purposes of "the testing of war material". At the time, the interests of the indigenous inhabitants were simply ignored sparking protests which had no impact.[6] Today, the integrity of the WPA is increasingly under challenge. Busy east/west and north/south highways and railways run through or close to the WPA and indigenous communities, miners, pastoralists and tourists are seeking increased access. At the same time, missiles and other weapons systems under test have a longer range and more stringent safety requirements. Also, the radio spectrum needed to support range activities is increasingly sought by commercial interests including mobile phone operators. Where these competing interests come into conflict they are dealt with on a case by case basis without the benefit of strategic context or direction.

In recent years the Royal Australian Air Force, which has stewardship of Woomera on behalf of Defence, has begun to re-invest in new range tracking and instrumentation facilities with a view to better utilise the capabilities of the range for Defence uses. Woomera is, by far, the largest land test range in the Western world and, providing the integrity of the WPA is adequately preserved, is a national asset of strategic importance.

Government Policy

Since the end of the Second World War, Australia's engagement in space activities has been bifurcated. The national security component has been highly classified and has been an important, but implicit, input to national strategy. The economic and commercial components have been opportunistic providing only limited rewards to investors, potential customers and the nation. The unifying theme of

relevance of the Act and its application to facilities such as JDFPG. *The West Australian, 22 February 2008.*

6 Gorman A, 'The cultural landscape of interplanetary space', *Journal of Social Archaeology*, vol. 5, no. 1, pp. 95-6.

Australia's space engagement has been the provision of 'suitable real estate' to support space activities for national security, civil and commercial purposes.

- From the 1940s to the '60s, Woomera was developed to facilitate the UK missile and nuclear programs.
- In the 1960s, "joint" facilities, deemed critical to the security of the US, were established at Nurrungar near Woomera and at Pine Gape near Alice Springs.[7]
- Since the earliest days of the US manned space program, Australia has hosted mission-critical ground stations and supported considerable associated atmospheric and other research. More recently, Australia has hosted research infrastructure and activities in support of European and Japanese space exploration and research.
- There are numerous ground stations in Australia which support commercial communications and remote sensing satellites. Also, considerable effort has been devoted by various governments, State and Commonwealth, since the 1970s, to establish commercial satellite launch ventures on Australian territory. Not one has succeeded.

Australia does not have an explicit Cabinet-endorsed national space policy. The classified components of the nation's approach to space are implicit in the discussions and understandings which underpin Australia's alliance relationship with the US. Simply stated, in return for permitting the US to locate ground stations, which are vital to US interests on Australian soil, Australia receives the strategic benefit of having a powerful ally and an operational benefit in terms of access to valuable intelligence which might not otherwise be available to Australian policy makers. Hosting JDFPG has also allowed successive governments to argue

[7] The phrase 'a suitable piece of real estate' was popularised by Des Ball in his book with that title: Desmond Ball, *A Suitable Piece of Real Estate: American Installations in Australia*, Hale and Iremonger, Sydney, Australia, 1980.

that they have contributed to nuclear non-proliferation by allowing monitoring operations to occur on Australian soil which increase transparency and reduce the likelihood of miscalculation and error leading to nuclear war.

Commercial and industry aspects (essentially those matters to do with utilities provided from space for other than classified purposes) are covered by a document called *Australia's Space Engagement*, with is sponsored by DIISR. The starting proposition is that Australia views space as a means to an end and not an end in itself and the document basically states that market forces should determine the type of space industry that Australia needs.

Failed Commercial Space Initiatives in Australia

Australia does not have a space industry, if such an industry is defined as a group of companies with supporting infrastructure (markets, finance, factories, tooling, qualified staff, and know-how) to design, build, launch and operate satellites or to conduct niche activities in selected parts of this supply chain. Pieces of such an industry have existed but critical mass has never been attained.

In the 1970s, 80s, and 90s, numerous attempts were made to establish commercial launch facilities in Australia. Most sought to take advantage of the relative proximity of northern Australia to the Equator from where satellites intended for GEO are best launched. Unrealistic business cases, uncertain finance, environmental concerns and technology release issues, in various combinations, led to all of these initiatives failing.

Commercial operators of remote sensing satellites in particular have made the repeated error of trying to sell their products in Australia, to government agencies and others, on the basis of the satellite alone without adequate reference to, or appreciation of, the wider system requirements, the needs of potential customers and their small budgets. Poor appreciation of the Australian market, lack of business expertise and grossly exaggerated claims in marketing materials typify many of these approaches. One hopeful vendor for example claimed that a particular satellite would ‘virtually eliminate wildfires’. Invariably the business development vector has been ‘technology push’ rather than ‘market pull’.

Such efforts have led governments and public officials to view the space industry as being populated by opportunists, dreamers and technocrats. This is a substantial handicap for which there is no ready or immediate remedy and helps to explain the reluctance of successive governments to invest in national space capabilities.

The Chapman Report

In 2005, Senator Grant Chapman (Liberal, South Australia), formed a Space Policy Advisory Group which helped him produce a paper called *Space: A Priority for Australia*. This was forwarded to the Prime Minister in November 2005. The document emphasised Australia’s dependence on space from the utility perspective and highlighted the associated vulnerabilities and risks. The paper called for a whole-of-government approach to the development and execution of national space policy.

The Chapman Report recommended that responsibility for coordinating the Australian strategic space policy framework be assigned to the Department of Prime Minister and Cabinet to address the following priority requirements to:

- periodically review our critical national space interests;
- reduce our vulnerability to disruption or denial of space data and services;
- improve our capacity to validate data and products derived from space sensors;
- optimise our assured access to space data and products in the future;

- increase Australian contributions to reducing international tensions stemming from space-related competition;
- make it more difficult to collect intelligence on our activities;
- periodically review our self sufficiency needs; and
- increase involvement in the international dialogue on space issues.

In April 2007, the Minister for Industry provided the Government's response to the Chapman Report. The response restated the Department's position outlined in *Australia's Space Engagement* without addressing in any substantial way the points made by Chapman. The Minister for Industry saw no need to change the current arrangements regarding policy responsibility or policy content for space matters.

This outcome, although not unexpected, was disappointing. It suggests that those who prepared the Minister's response may not have been aware of, or sought to ignore, the growing international pressures for changes to the regulation of global space activities to account for technological change, new entrants into space and the potential implications of weaponisation. The basic norm that access to space is open to all nations for peaceful purposes on the basis of the principle of mutual non-interference is under challenge.

Australia's economic and security dependencies on space identified in the Chapman Report have not changed, but have deepened, since that report was published.

Applications

Remote Sensing

Australia has significant experience and competence in remote sensing in national security. Agencies including the Bureau of Meteorology, Geoscience Australia and the land management agencies of the State and Territory Governments; all have a heritage of using data derived from satellites to support their core activities. Some have particular strengths in creating algorithms to support complex climate, weather, geological and vegetation modelling. Some sectors of the economy, notably mining and energy, also make routine use of remote sensing data to support investment and other business decisions.

In 2006, an Interdepartmental Committee for Commercial Satellite Capabilities was formed. This committee is co-chaired by the Defence Imagery and Geospatial Organisation and Geoscience Australia. It aims to 'improve the efficiency and effectiveness of commercial remote sensing across Australian Government Agencies'.[8] Although a modest step, this committee might begin to address in a systematic fashion a series of issues concerning the stewardship and use of geospatial data. These include:

- data ownership;
- data standards, including interoperability and sharing arrangements;
- accuracy and currency of data and data products, including maps and charts; and
- liability and insurance issues which may result from the publication of incorrect, incomplete or superseded data.

The State and Territory governments also have substantial holdings of geo-spatial data and opportunities exist, including

[8] Department of Industry Tourism and Resources, *Annual Report*, 2006/7, p. 109.

through Council of Australian Governments mechanisms, to establish a set of national arrangements which make best use of current and future holdings of data derived from remote sensing satellites.

Data from the satellites of others, provided at little or no cost, is now assumed as an (unstated) component of the national information infrastructure.

Communications

Australia relies heavily on satellite communications, especially to service remote communities across the continent. Several commercial operators, including Optus and Intelsat, provide a range of services through a number of satellites in GEO. Increasing numbers of Australian homes are investing in Satellite TV and other services, provided ‘direct to the home’ by satellites.

Defence makes considerable use of commercial satellites, especially to support deployed forces.

Position Navigation and Timing

The Global Positioning System (GPS) of the US and similar systems operated by Russia and China have become vital global utilities. Designed initially to assist military forces to know where they were, to fix the positions of targets and to guide weapons to targets, these systems were quickly adopted for civil, commercial and personal uses. Basically, small receivers on the ground (they may be handheld, fitted to vehicles or embedded in weapons and other systems) receive signals providing time and positional information from several satellites (ideally five) simultaneously. These signals are correlated in such a way that the position of the receiver can be determined. The signals are weak and readily jammed which has led the US to introduce a range of enhancements to more recent GPS satellites and receivers. These are designed to assist friendly forces whilst denying adversaries access to the same information at the same level of fidelity.

Although the GPS system of the US is the most comprehensive and robust of these systems, it is fragile. There are 30 operational satellites in the GPS constellation of which 14 are operating beyond their intended design life and 19 are one component from failure.[9] The European Union is planning to build an alternative system to GPS, called Galileo, to mitigate the civil and national security impacts in the event that GPS is unavailable – possibly turned off by the US or in some other way downgraded so as not to be useful. That the European Union is seeking to duplicate, in essence, the space segment of the GPS system, is an indication of the importance of Position Navigation and Timing (PNT) to the countries and economies of Europe. The Galileo system had proposed to transmit on frequencies already used by GPS, which would have caused radio frequency interference to the potential disadvantage of both systems. This problem has been solved and both systems should be accessible to appropriately designed receivers adding to the overall robustness of space-based precision navigation and timing.

From an Australian perspective, GPS is almost a free good. Users need only invest in inexpensive and readily available receivers and link them to other devices which need a precision time standard. Beyond defence, GPS plays a vital role in many sectors of the economy – including aviation, road and rail transport, logistics, open cut mining, minerals and gas exploration, banking and financial services, precision agriculture and forestry. In-car navigation systems and emergency beacons used by bushwalkers and yachtsmen are two examples of the personal application of GPS.

There are reported gaps in GPS coverage of Australia and contiguous areas, although the extent, frequency and potential impact of deficiencies in national security and economic terms remains to be quantified. This would seem to be an important

[9] Source: Notes to US Air Force Association (AFA) members from the President and CEO, LTGEN (Rtd) M.M. Dunn, sent as email, dated 24 January 2008 (see also Table 1 on p. 27).

task which should be undertaken in order to inform vulnerability assessments and remediation strategies.

Understanding the Near Space Environment in the National Interest

The interactions between space weather and global climate are not well-understood. Space weather, notably solar storms can affect terrestrial communications and, more seriously, the intense radiation released by the storms can damage satellites, especially those in GEO.

Continued Australian investment would seem prudent in atmospheric and ionospheric physics to support international efforts in space weather research and to meet national requirements as well. Jindalee Over-the-horizon Radar Network (JORN), which is likely to be Australia's principal nationally owned and operated broad area surveillance system at least until 2025, depends entirely on the ionosphere to work. To the extent that the structure of the ionosphere and how and why it changes is understood, Australia's ability to extract more information from JORN will increase.

The relationship between space weather and global climate also needs to be far better understood as the world comes to terms with the potential impacts of global climate change and as mitigation strategies are devised and implemented. If, as some evidence suggests, an element of global warming is a consequence of the sun heating up, this information alone could influence the solutions which are implemented to counter the impact.

Australia needs to have the institutional capacity to think about the consequences for the nation and the region if a very large near earth object (NEO), such as a rogue asteroid, were to impact the earth. Although the likelihood is presently remote the potential consequences are catastrophic. Several international agencies are monitoring a number of NEOs one of which, Astreroid 99942 – Apophis, could potentially impact the earth in 2036 or 2037. Sometime before 2025, international decisions will need to be taken about how to deal with this particular threat. One option will be to do nothing, but even that decision is best made consciously rather than by default.

Astronomy and Space Science

Since World War II, Australia has made substantial and repeated investments in selected areas of radio physics with the result that Australia is amongst the world's leading nations in radio astronomy. Both the radio telescope at Parkes and the Australia Telescope Compact Array at Narrabri are amongst the most productive radio telescopes in the world in terms of citations in learned journals. Also, Australia operates the world's most sophisticated and capable high frequency long range radar – the JORN. If a broader definition of space activity is allowed, Australia has been an active participant, not merely as a user of data, but as a contributor of important enabling capability (Australian territory and technology) and science (notably in astronomy, ionospheric and upper atmospheric physics and space weather).

Currently, under the auspices of the Australian Academy of Sciences, a decadal plan for space science is being prepared. The intent is for this plan to serve as a blueprint for large investments in space science infrastructure. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is reviewing its commitment to space research under the theme 'Understanding the Universe'. Similarly, the Defence Science and Technology Organisation (DSTO) is also reviewing its commitment to space research.

Individual Australian researchers in various fields of space science have gained world recognition in their fields and many have strong ties to foreign space agencies and institutes including the US National Aeronautical and Space Administration (NASA), the European Space Agency (ESA), the Japanese Space Exploration Agency (JAXA), and, increasingly, with the Chinese. These activities point to a growing awareness among scientists of the importance of space as a domain which needs to be better understood in its own right and also as the vantage point from which to gain increased insight and understanding about Earth. Some further detail is provided at Annex B.

DRIVERS OF AUSTRALIAN SPACE POLICY

There are five drivers that have shaped Australian space policy.

Driver 1 – Strategic Geography

Australia's strategic geography offers five fundamental advantages for users of space.

- Australia's land mass is large, geologically stable and relatively flat. It offers a unique vantage point in the southern hemisphere from which to observe the space activities of established and emerging space-faring nations including Russia, China, Japan and India.
- Australia, in terms of longitude, is approximately equidistant between Europe and the Americas. A minimum of three satellites in geo-synchronous orbit is needed to provide complete coverage of the earth (discounting the poles). Additionally, Australia hosts several ground stations which have sister facilities in Europe and the US.[10]
- Central Australia is far from either coast. Remoteness provided a considerable measure of security during the Cold War for classified activities which were conducted at Woomera, and continues to provide a useful layer of protection for JDFPG.
- Except for the eastern and south western coastal fringes, the continent is mostly uninhabited, meaning that radio frequency interference, which is largely a function of human activity, is generally very low.
- Australia is stable politically, allied to the US, historically well-disposed to the UK and to Europe and increasingly involved in collaborative space activities with Japan. Small steps towards space cooperation with India have also been taken. Geosciences

[10] A good example of this is the deep space network operated by NASA which has facilities in the US, in Spain and at Tidbinbilla, near Canberra.

> Australia recently announced that it would be acquiring data from an Indian earth resources satellite, Resourcesat-1 from early in 2008, to ensure continuity of data supplied by LANDSATs 5 and 7 both of which are failing.[11]

Successive Australian governments have been well aware of the benefits which accrue from Australia's location and this driver has been the most important in shaping Australia's space engagement.

Driver 2 – Alliance Relationships

A constant in Australia's political history has been close alliance with a great power – initially the UK and, since World War II, the US. In allowing the UK and the US to conduct space related activities on Australian sovereign territory, Australia could represent itself as a trusted ally, keen to contribute to Western interests during the Cold War. There is no reason to think that the fundamentals of Australia's alliance with the US are likely to change within the timeframe of this report although there are compelling reasons for Australia to reassess the strategic and operational costs and benefits which accrue from its current alliance relationships with regard to space activity.

Ground Stations

Hosted facilities and shared capabilities are a key component of Australia's alliance relationship with the US and an important element of national strategy.

The Joint facilities have also provided intelligence, that otherwise would not have been available, to Ministers, officials and, increasingly, to the Australian Defence Force (ADF) and the broader national security community. Australia has invested substantially, in dollar and people terms, to take advantage of these capabilities. This investment, which is not readily apparent, has led others to conclude that Australia is a

[11] Geoscience Australia, Media Release, 12 February 2008.

bit player in space because the only visible activity is that which occurs in the civil and commercial spheres.

Not surprisingly, the activities which are most visible to the wider public are ground stations which support civil space activities, such as NASA's Deep Space Tracking Station at Tidbinbilla near Canberra. Famously, the television images of Neil Armstrong stepping onto the moon in July 1969 were captured by antennas at the now dismantled Honeysuckle Creek tracking station (near Canberra) and at Parkes (the radio telescope) in New South Wales.

Full Knowledge and Concurrence

'Full knowledge and concurrence' is a key operating principle which describes the insight and influence that Australia insists on having into the activities conducted at all US/Australian joint facilities as well as at all other satellite ground stations hosted by Australia. The phrase is a powerful assertion of Australian sovereignty and its clarity and strength derive from the unique attributes of Australia's strategic geography already described. Australia insists on being:

- able to understand all that occurs within any ground station located on Australian soil; and
- consulted if retaliatory or hostile activity is proposed as a result of information received by a ground station.

An implication of the advent of networking technologies which allows once standalone systems, such as JDFPG, to be linked to other similar facilities around the world means that new approaches to 'full knowledge and concurrence' are being developed and implemented, including the integration of Australian military personnel and Defence officials into key positions in US headquarters and Australian participation in high-level US war games. Beyond helping to meet the formal requirements of 'full knowledge and concurrence', participation in these activities allows Australia to better understand US intent and to evaluate emerging capabilities at the strategic and operational levels.

Some other countries which have sought to place sensitive facilities or technologies on Australian soil for commercial purposes have baulked at the “full knowledge and concurrence” principle and have not proceeded with their plans.

‘Full knowledge and concurrence’ is an element of, but not a substitute for, a comprehensive national space strategy or policy.

Recent Developments

Early in 2007 the Australian Government announced approval for the US Navy to construct an earth station for its next generation satellite communications system, known as the Multi-User Objective System near Geraldton in Western Australia. In October 2007, the Australian Government announced that Defence would gain access to the US Wideband Global SATCOM (WGS) system by paying for the construction of one of the six satellites in the constellation. These satellites, the first of which has been launched, will be in GEO and by meeting the cost of one satellite Australia will be able to access the entire constellation; essentially this is an investment in access to bandwidth. As the US re-invests in its space-based defence communications and surveillance and intelligence systems over the next 20 years, Australia should anticipate being asked to host more ground stations associated with these systems and also anticipate being invited to invest in the space segment as well.

Operationally, this type of investment makes considerable sense because access to a constellation provides a degree of on-orbit redundancy in the event that one or more of the satellites in the constellation is in some way disabled or becomes inoperable.

Strategic considerations are less clear-cut:

- The assumption remains that the US will continue to be a close ally of Australia for the foreseeable future, disposed to facilitating and in no way interfering with Australian national communications which are carried on the WGS system.
- In the event of tension or competition in space between the US and China, Australia's capacity to manoeuvre diplomatically and to steer a somewhat independent course may be considerably restricted.
- Australia's capacity to act as a diplomatic bridge between rich and poor, East and West, North and South, in space matters may be compromised.
- Such investments do nothing to strengthen Australia's industrial base. Some transfer of knowledge will be essential for Australians, mainly ADF personnel, to understand and operate the system effectively and efficiently; however, broader economic and social benefit will be limited.

Driver 3 – Good International Citizen

In signing and ratifying the treaties and other instruments relating to space, Australia has applied with rigour the principle that space is part of the common heritage of mankind. Best evidence for this is that Australia is one of only a handful of nations, none of them space-faring, to have signed and ratified the Moon Treaty.

There are numerous parallels between the regulation of Antarctica and the regulation of space, and Australian experience in the former domain may become applicable to the latter. Australia may be able to make a practical contribution to the location and characterisation of space debris through sensors located on the Australian continent and possibly in Antarctica as well. These possibilities are discussed below under the heading 'Space Situational Awareness' (SSA).

Driver 4 – Cost

There is a persistent view that space is expensive – essentially beyond the means of a country of 20 million people. The question is not so much about cost as it is about choices, priorities and risk. Countries with smaller populations and less wealth, Israel for example, have flourishing space programs with the capacity to design, build and launch satellites. Successive governments have asked, quite reasonably, why Australia should go to this sort of expense and trouble when its basic needs are met for little or no cost and minimal risk.

Whether it is wise for Australia not to have some space industry capability is a different point. In February 2004, the Defence Electronic Systems Sector Strategic Plan listed mobile military communications as one of five industry capabilities which were 'critical to the self-reliance of the Australian Defence Force'. Space-based communications was identified as one of nine enabling or emerging technologies which would underpin self-reliance and warrant particular focus of public sector and industry research and development.[12]

In 2007, the Commonwealth passed legislation to invest $10 billion to restore the essential health of the catchments and waterways of the Murray-Darling Basin. Remote sensing data will be essential to this project and it should be the best available. Tasking priority, relevance, resolution, accuracy and

[12] Department of Defence, *Defence Electronic Systems Sector Strategic Plan*, Canberra, February, 2004, p. xxi. In 2007 the then Government withdrew support for the Sector Plans in favour of a revised Defence Industry Policy that included a process to determine industry capabilities in which Australia must achieve some measure of self-reliance. Whether the newly elected Rudd Government will continue to emphasise the importance of space-based communications remains to be seen. The Government does remain committed to achieving a highly networked force by 2020, a corollary of which is assured and secure access to communications and other satellites.

timeliness should be optimised to support this national initiative. Certainly data will and should be obtained from current, non-Australian satellites but this should be an adjunct to the national capabilities, which would be designed to provide optimal coverage to meet national requirements first and any other requirements on an opportunity basis only.

The Cost of Not Investing

The costs to Australia of not investing systematically in national space capabilities are significant.

- Australia will be increasingly reliant on others for the provision of critical space infrastructure on which national defence and security increasingly depends and at a time when careful characterisation of the continent would seem essential in order to better measure and manage the effects of global warming and climate change;
- Australia's diplomatic voice in the approaching and inevitable international discussions about space security and weaponisation will be muted and not afforded due weight or legitimacy; and
- Australia's overall influence as a nation which bridges many international divides will be diminished.

Space Finance

An important missing element of national capability lies in the financial services sector. The unwillingness of governments to invest in space capabilities outside the Defence domain is mirrored by venture capital and the mainstream lenders. They have no substantial experience in assessing the risks associated with supporting companies seeking to make businesses in the space sector, so they decline to invest.

Driver 5 – Spectrum

Communications between satellites and the ground, and increasingly between satellites, presents enormous challenges to satellite operators and the International Telecommunication Union (ITU), the international spectrum regulator. The frequencies sought by satellite operators are the same as those sought by governments for military and national security uses and also by the mobile phone/radio telephony market. The Australian Communications and Media Authority (ACMA) is the national spectrum regulator. It is responsible for preserving those parts of the spectrum which are necessary and sufficient to meet national requirements, such as those for Defence. It also has the task of releasing spectrum for commercial and broader community use – a classic fox in the hen house situation.

Defence is at risk of losing access to numerous frequencies of direct interest unless it can articulate its longer term requirements in a compelling and cohesive way – a very difficult task. Without adequate protection of the requisite spectrum the ADF will simply not be able to implement its intention to create a highly mobile and flexible force based on the principles of Network-centric Warfare (NCW).

Particular problems occur with spectrum allocations that cross national boundaries – as occurs, by definition, with satellites, aircraft and global marine systems. The ITU may be a venerable institution but its mechanisms are slow – typically four to eight years for decisions on matters relevant to space communications. The technology cycle is much faster than this and a point can be anticipated where companies and governments may begin to ignore the ITU.

Looking towards 2025, the key policy challenges regarding spectrum are likely to be:

- How will Australia resolve which parts of the spectrum to sell to commercial interests and which to reserve for national purposes, notably for military and other national security communications?

- How will Australia preserve and possibly extend access to selected parts of the spectrum in international negotiations and will Australia continue to support current international arrangements or seek a more flexible and responsive system better attuned to technological developments?

Sovereignty and Access to Space Utilities

The concept of sovereignty implies that a nation, having identified those elements of its national interest on which survival depends, has the wherewithal (capability and intent) to mount a credible defence of those interests against others. Most of the 200 or so nations on Earth are incapable of meeting this test. In space, the idea of the defence of essential national interests is complicated by the difficulty of gaining access to and operating within the harsh environment more than 100km above the surface of the Earth.

Investment in satellites to meet national needs is far simpler than protecting or defending those assets against attack. In current circumstances, satellites are more likely to suffer damage from environmental influences than from human directed, deliberate attack. Cosmic radiation generated by solar storms can damage sensitive electronic components and collisions with even small objects can be catastrophic.

This leads to the question that if it is not practically possible to protect satellites by conventional means, including the use of force *in extremis*, how can their operations and utility be reasonably guaranteed? There is no single solution; however, a range of measures that focus on improving the transparency of space activities may be a useful starting point. Such an approach would serve to build confidence in the overall system.

Regardless of which country or company pays for, builds, launches and operates the satellites on which Australia is increasingly reliant, this country has a vested interest in ensuring that the international agreements, understandings and practices are in place which guarantee, to the extent possible, necessary access to these services. A prerequisite is for other nations with vital interests in space to regard Australia as a credible, informed and interested player with strong interests of its own. Australia's current credentials in this regard fall well short of the required level of national commitment is needed.

A frequent criticism of Australia's total dependence on foreign owned and operated remote sensing satellites has been that 'shutter control' could be applied by the owners and operators against Australian interests. Access could be denied by others to information considered by Australia to be of national importance. Whilst this is true it is not the greatest concern. A broader risk is that almost all of the satellites on which Australia depends for information about the Australian continent and contiguous areas are optimised to observe other parts of the earth, mainly targets in the northern hemisphere. Australia takes second best in terms of where and when information is obtained, by whom it is obtained, with whom it is shared and when it is released to Australia for analysis and use.

The ADF's Use of Space

The ADF is a routine user of space services which provide both classified and unclassified data to support intelligence and operations. Defence is a part owner of the Singtel/Optus C1D communications satellite which shares a commercial payload with a dedicated military payload. The military payload is fully controlled by Defence. Defence also leases LEASAT V, from the US Navy; this satellite provides UHF satellite communications services to Australian Navy ships. Finally, Defence purchases considerable bandwidth from commercial satellite providers such as INMARSAT. There are single points of failure in the current system which are recognised and accepted as risks.

Several thousand ADF members and Defence civilians are directly employed in the processing and analysis of data derived from earth observation satellites and in operating and maintaining satellite communications facilities in both fixed and deployed locations.

Looking to the future, Defence reliance on satellites will increase significantly during the next decade. A key driver is the ADF's plans to develop a highly networked and interoperable force by 2020, in accordance with the principles of NCW.

Not only do the capabilities of existing systems, notably the Singtel/Optus C1D satellite and LEASAT V, need to be replicated as these satellites reach the end of their operational lives but these capabilities need to expand to meet the bandwidth, assurance and security demands on which future network-centric operations will depend.

The current Defence Capability Plan (DCP) lists nine major projects valued between $1.75 billion and $2.57 billion which relate directly to investment in space capabilities (including a new communications satellite and ground and processing segments). These are listed at Annex D. Perhaps more telling, the *Defence Information Infrastructure Plan, FY 2007/08*, lists 32 major projects which have important dependencies on the Defence Information Infrastructure (DII).[13] Of those projects, 25 explicitly state a requirement for SATCOM and a further four state a need for beyond line-of-sight communication.

As the ADF moves increasingly to become a networked force, its dependence on space-based capabilities for navigation and timing, situational awareness and command and control will become profound. By making space capabilities an essential component of warfighting capability, instead of regarding them as an adjunct as has been the case in the past, Defence has changed the national space calculus with implications and impacts only now being perceived. Next generation systems, including new fighter aircraft, destroyers and future soldiers will simply not function very well without access to space communications and space-derived data. The

[13] Australian Department of Defence, CIO Group, *Defence Information Infrastructure Plan, FY 2007/08*, p. 46 (diagram and following notes).

ADF will not be able to defend Australia and its interests with any confidence unless it is supported by a tightly coordinated whole-of-government approach to space security. A secure space environment providing assured access to space utilities is an essential enabling capability of the ADF.

China has carefully studied how the US has conducted operations in the Middle East since the first Gulf war in 1991 and has concluded that the extent of US reliance on space-based utilities represents an Achilles heel in American capability which can be exploited. The ADF is developing similar capabilities and dependencies to those of the US without the benefit of strategy, policy or means which aim to preserve the operational integrity of space assets. This is a substantial vulnerability that must be addressed.

Hypothetical

Date: September 2012

The Australian Department of Defence is very pleased with the substantially improved communications between headquarters and deployed units as a result of Australian investment in and access to the WGS system. Although several of the satellites in the constellation had experienced some problems, the US had been assiduous in meeting its obligations to Australia under the Implementing Arrangements which define Australian access.

Highly credible intelligence is received that a series of coordinated suicide attacks by Jihadist elements is imminent on US military installations and embassies throughout, Europe, Africa, South East Asia and the Middle East. The aim is to disrupt the 2012 US presidential election and to potentially influence the result.

In response, US forces world-wide are brought to a higher state of readiness. The State Department calls in the Australian Ambassador to Washington and advises him that, in view of the increased communications needs to US forces around the world, Australian access to the WGS constellation will cease completely in 24 hours. Australia will need to find alternative means of communicating with its deployed forces. This is a matter for deep regret and represents an 'unforeseen and non-negotiable modification' of US intent with regard to Australian access to WGS in understandably difficult times.

What are the implications for Australia:

- Strategically – does this represent a major or a minor issue within the context of the alliance relationship?
- Operationally – Does the American decision increase the risk to deployed Australian forces?
- Noting that Australian forces are deployed around the world, requiring access to several satellites across the Indian Ocean and north of Papua New Guinea, what alternative communications arrangements can be made very quickly?
- Could more carefully constructed and negotiated Implementing Arrangements, which govern Australian access to the WGS constellation, have prevented or mitigated the restrictions now faced by Australia?

Comment

Today, Australian policy makers would be hard-pressed to answer these questions quickly and decisively and they would be substantially reliant on the advice of foreign nationals. Is this militarily and politically tenable?

The Impact of 'Dual Use' Technologies

In the past decade, technologies with dual uses have become more prevalent in the space domain; this trend continues and is accelerating. 'Dual use' technologies are products and services which have been developed primarily for one market or customer but which have application to others. Five examples of 'dual use' space-related or space-dependent technologies follow.

- Several governments, including the US, French, Russians, Chinese and Indians, through various trading mechanisms, sell satellite launch services to all comers, some by using vehicles which were developed originally as Intercontinental Ballistic Missiles (ICBM).
- Although many governments operate their own satellites, primarily for military communications and intelligence gathering, invariably these systems are not able to meet all of the demands placed on them by the military necessitating commercial bandwidth to be leased and imagery to be purchased from commercial providers. This especially occurs during operational deployments, often to places not covered by the government-owned satellites and where there are usually significantly increased demands for services and therefore satellite capacity.
- The US Government developed the GPS system primarily as a navigation and timing service for its armed forces. Today, GPS is an important component of the global information infrastructure which contributes to the livelihood, safety and security of many ordinary citizens across the world. In-car navigation systems, precision farming devices, automated teller machines and the boats of fishermen around the world are but a few examples of the reliance people place on GPS for routine, daily activities.

- Data services, for example, weather services, are of great interest to all people and organisations involved in outdoor activities, be they military, emergency response, mining, farming, or recreational in nature. National governments, acting within a framework of international agreements, provide weather services. Some nations seek to provide an augmented weather service to their armed forces, especially to those deployed on operations.
- Increasing numbers of remote sensing satellites are being launched and operated by a growing list of countries. Many of these satellites serve commercial and government interests through a variety of contracting and operational arrangements. The US, for example, reserves the right to delay or deny the on-passage of imagery from US registered commercial satellites if a risk is foreseen that such imagery could fall into hostile hands. This does not prevent non-US satellite operators from imaging the same area(s) and making the imagery readily available. The product of some of these satellites is now freely available to all comers through Google Earth and similar web-based applications.

In each of these examples, governments are working hard to gain and maintain a capability edge over competitors and adversaries who rely fundamentally on commercial sources and the internet. The differential is increasingly hard to establish and may be losing relevance as commercial products and standards often provide the necessary fidelity, resolution, timeliness and reliability to support the planning and conduct of operations.

Unbridled with the inertia of established programs and capabilities, some adversaries have coupled commercial equipment and the internet with exceptional operational security and sound counter-intelligence to obtain agility and flexibility which regular forces have struggled to emulate.

Summary

Space activities in Australia have a chequered past which may act as a brake on future development. Some civil activities have been successful although constrained by lack of funds and ongoing programmatic support. The substantial successes and investments have been confined to the Defence arena and almost all have occurred in the context of Australia's alliance relationship with the US which, to date, has provided an adequate, if *de facto*, national space policy construct. Civil and commercial initiatives have been hampered by lack of coherence, over-strident advocacy, bad behaviour by companies, an over-emphasis on technology and an under-emphasis on the business needs to which space-based utilities can contribute value.

THE SPACE CAPABILITY OF THE UNITED STATES: A HEALTH CHECK

US national strategy is predicated on free and unfettered access to space and today the US is the dominant world power in space. To this end, the US resists vigorously any attempts by others to restrict its ability to act in space as it sees fit. It simply refuses to countenance any potential restriction on its right to use space in its own interests and to take such measures as it deems necessary to defend those interests. It is determined to develop such systems and take such steps as it deems necessary to avoid, to use Donald Rumsfeld's phrase, 'a space Pearl Harbor'.[14]

Of the 800 operational satellites currently in orbit, 130 are owned and operated by the US Government for national security purposes and to support military operations.[15] Although the US remains the world's dominant space power, the look of invincibility is somewhat deceptive and, certainly taking a 20-year perspective, there are concerning fragilities which Australia would do well to consider when deciding how much money and sovereignty to invest in reliance on US systems.

The table below provides a current snapshot of the state of several major US Defence satellite programs and ground infrastructure.

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[14] Report of the Commission to Assess United States National Security Space Management and Organization, 2001, Washington DC (The Rumsfeld Commission), p. viii.

[15] 'spacesecurity.org', *Space Security 2007*, Project Ploughshares, Canada, 2007, p. 8.

Table 1: State of the US Space Force

Satellite Program	Number of Sats	Design Life (yrs)	Average Age (yrs)
Defense Support Program	classified	5	classified
Milstar	5	10	8.7
DSCS (communications)	9	10	10.1
Interim Polar	2	classified	classified
Space-base Visible	1	5	11
GPS	30	8.6	8.2
Note: 14 Sats past design life 19 Sats one component from failure			
Defense Met. Sat Program	5	4	7.4
Other Infrastructure	**Years in operation**		
Minuteman III ICBM	35+ extended ops beyond 2020		
USAF Satellite Control Network	40+		
Haystack Radar	44		
Eglin Radar	39		
Ballistic Missile Early Warning System (BMEWS)	15.9		
Phased Array Warning System	27.9		
Perimeter Acquisition Radar Attack Characterization System (PARCS)	32.3		
Launch pads and other ground infrastructure	Very old		

Source: Notes to US Air Force Association (AFA) members from the President and CEO, LTGEN (Rtd) M.M. Dunn, sent as email, dated 24 January 2008.

In Iraq and Afghanistan, planned reconnaissance missions by Uninhabited Aerial Vehicles (UAVs) have not been able to proceed because communications satellites have not been available to support the planned missions.

Programs to build new or replacement satellites for those outlined in the table above are also in difficulty. Three high profile examples are:

- The Future Intelligence Architecture program which was meant to deliver a next generation of high resolution reconnaissance satellites has been cancelled.

- The Transformational Satellite program, which is meant to provide high bandwidth networked next generation communications services to the US military is experiencing funding cuts through Congress and delays.
- The Space Based Radar program has been cancelled due to its cost.

The civil space program is also struggling. The Space Shuttle, which has been used to deploy classified as well as civilian payloads and is critical to the construction of the International Space Station (ISS), is scheduled to be retired in 2010. Its replacement, the Constellation, is not due to fly until 2015 at the earliest. This leaves a gap of at least five years during which the US will be reliant on Russian launch vehicles and spacecraft to move people to and from the ISS. Equipment and supplies will be moved by a combination of Russian and European vehicles. At the very least this represents a loss of prestige and may well be a lead indicator of deeper problems within the US space community.[16]

At a recent space forum in Washington DC, a senior US official noted that the median age of engineers in the aerospace workforce was 60 and that 27% were eligible to retire in 2008.[17] A glance around the conference venue told a grim story. The participants, uniformed and civilian, were overwhelmingly white, and many were in the twilight of their careers. There were few women, few Afro-Americans and Hispanics and, most concerning, few young people. The space sector in the US is not replacing itself and an industry which was once innovative and ingenious has become increasingly conservative, risk averse and resistant to change. Pressure to test and adopt new design, manufacturing and

[16] Kaufman, M., washingtonpost.com, 7 March, 2008.

[17] National Space Forum 2008, attended by the author. The Forum was arranged by the Eisenhower Centre for Space and Defense Studies, USAF Colorado Springs and held at the Center for Strategic and International Studies, Washington DC, 7-8 February 2008. Speakers included Members of Congress, and very senior commanders, policy makers and industry representatives.

operational processes which could help to offset the impacts of the reducing workforce whilst reaping the benefits of technological change, is coming from new and non-traditional space companies. Their resources, influence and impact are limited and change is slow.

The ITAR are designed to prevent products, equipment, devices and know-how of national security value being exported to potential adversaries. These regulations have been applied so restrictively to space technologies that numerous nations, including in Europe, have been forced to conduct their own fundamental and enabling research to duplicate the US developed ITAR protected equivalents. Some countries now advertise ITAR-free satellites. US reluctance to share technologies has been counterproductive in two ways – US manufacturers have been denied orders and several countries now have more advanced space system design and manufacturing capabilities than might have been the case had the ITAR been applied more wisely.

Although the rhetoric of the US speaks of cooperation and collaboration in space (and Australia's investment in the WGS constellation is being used as an example of this approach), the reality is somewhat different. Intent, policies and laws reflect a determination by the US to maintain supremacy and dominance. There is, however, a growing disconnect between rhetoric and reality. The space capabilities of the US are aging and becoming increasingly brittle and fragile.

CASE STUDY: BLENDING FACT AND FICTION

In 2007, a book called *Space Wars: The First Six Hours of World War III* was published.[18] Set in 2010, and in similar vein to a Tom Clancy novel, fiction but seemingly very well-informed, it describes a concerted and sustained attack on the government and commercial space systems of the US and the response. The villains are a plausible combination of the usual suspects – a ‘rogue state’ with nuclear and space ambitions, organised crime and a brilliant scientist seeking a better life. The story highlights the dependency of the US and its allies, on space and the vulnerabilities which arise and which affect many human activities - ranging from covert military operations to everyday social and economic activity. As the threat is analysed and understood, the US recognises it has no current capabilities on which to draw to counter the challenges presented. It draws instead on technologies developed in, and mothballed since, the 1980s and by retirees whose experience is needed to make these systems work. It also presses into service several technologies which are still under development to partially fill critical gaps in the operational systems.

Perhaps the most important point from the book is that the challenges presented to the US were only capable of being understood through cooperative and collaborative decision-making processes. Complexity, ambiguity and uncertainty, was dealt with through gaming and simulation which forced planners to consider the second and third order consequences of proposed courses of action. A useful task would

[18] Coumatis, M J., Scott, W B., Birnes, W J., *Space Wars: The First Six Hours of World War III*, Forge, New York, 2007.

be for Australia to take the scenario as presented in Space *Wars: The First Six Hours of World War III* and to ask how planners in this country might have responded. There are two questions:

- What, if any, useful role might the Australian Government have played in helping to resolve the crisis?
- Was this contribution sufficient and, if not, what additional capabilities would Australia have needed in order to play a more relevant and appropriate part?

THE BIG ISSUES: SPACE SECURITY AND WEAPONS IN SPACE

From the 1950s to the 1980s space activities were cast substantially in terms of the Cold War. The Union of Soviet Socialist Republics and the US invested enormous sums in developing missiles capable of delivering nuclear weapons which would assure their mutual destruction in the event of war and both nations 'raced' to the moon – a race won by the US when Neil Armstrong set foot on the lunar surface on 20 July 1969.

The Treaty regime established in the 1960s and 1970s to regulate human access to and use of space asserts the principle that space is part of mankind's 'common heritage' which should be used for peaceful purposes' for the benefit of all. Both the 'common heritage' and 'peaceful purposes' assumptions are now in question and the way in which the world community responds to a series of current challenges can be expected to have a major impact on global security in the broadest sense in the next 20 years. Today, satellites support and enable military and other national security operations in the sea, land and air environments but space itself is not a battleground. Whether this position can be maintained is an open question.

The US is presently engaged in a vigorous internal debate about whether to place weapons in space. This discussion has been running for some years and has considerable current impetus due to a successful anti-satellite test conducted by China in January 2007. The outcome of this debate is not certain; but the implications for Australia and, indeed, the world, irrespective of the result, are profound. A global arms race in space may well have the reverse of its intended effect and the level of security sought by space-faring nations may diminish to the detriment of all nations and peoples with dependencies on space utilities.

Although Australia has no plans to acquire or deploy space weapons, this country may be called on to support or host ground based elements of systems which support or enable offensive and defensive space operations. Emerging concepts including SSA, operationally responsive space (ORS) and Missile Defence are likely to demand the increasing attention of Australian policy makers if Australia's national interests in space are to be defined, protected and advanced over the next 20 years.

Weaponisation of space has implications for:

- National strategy; central to which is Australia's alliance with the US, as well as for Australia's relationships with Russia, China and other nations in Asia, notably Japan and India.
- National security operations; notably how the ADF conducts future operations and how future capabilities are defined and developed. Fundamentally, this is a question of the extent to which Australia is willing to be dependent on satellites which it cannot protect in an environment to which it has no independent access, dealing with governments over which it has limited influence.
- The Australian economy and industry in the extent to which space-based technologies are designed, developed, manufactured and used and how they influence broader social and educational activities and outcomes.

The Chinese ASAT Test

On 11 January 2007, China launched a missile which intercepted and destroyed an obsolete and non-operational Chinese weather satellite. From a technical perspective, the Chinese did nothing that Russia or the US had not done years earlier. From a legal perspective, the Chinese broke no laws or conventions. Yet the event provoked significant media and analyst comment. The test created a cloud of space debris which drew international criticism because of the risks the debris presents to satellites of other countries and the more general harm caused to the space environment.[19]

Political fall-out from the test has been mixed. Some analysts insist that the test is of no great strategic or international importance. According to this view, the Chinese were simply ticking off another milestone on the road to becoming a space power, as did Russia and the US in the 1970s and 80s. An alternative view is that the test was a show of China's emerging strength, intent and capability in space, aimed squarely at political and military decision-makers in Western capitals, principally Washington. In particular, it was a 'shot across the bows' of the US and a challenge to any ambitions the US might harbour to achieve hegemony in space.

Certainly the test gained attention in Canberra. The Chinese Ambassador was called in to the Department of Foreign Affairs and asked to provide assurances regarding future tests. The test has also encouraged Defence to consider what Australia might do to ensure that US primacy in space, so beneficial to Australia in the past, is preserved.

US Destruction of a Crippled Spy Satellite

In February 2008, the US, ostensibly for safety reasons, destroyed one of its own satellites, a modern spy satellite as big as a small bus.[20] The satellite, launched in 2006, never achieved its intended orbit and was gradually being pulled back to Earth by gravity. Although the satellite was expected to break up and mostly burn up as it re-entered the earth's atmosphere, some of the larger pieces were expected to reach Earth, including possibly a fuel tank containing highly toxic hydrozine propellant. The US declared its intent to destroy the satellite shortly before it was due to enter the earth's

19 O'Malley, S., 'Aust joins chorus asking China to explain missile test', Australian Associated Press General News, 19 January 2007.
20 'Navy says missile smashed wayward satellite: Military tracking debris over Atlantic, Pacific; China expresses concern', MSNBC News Services, February. 21, 2008 <http://www.msnbc.msn.com/id/23265613/>.

atmosphere, to ensure that the propellant could not harm people or other life.

A US Navy cruiser fired a modified SM-3 missile which hit and destroyed the satellite. The US announced its intention to conduct this operation some weeks ahead of the actual event which has led some commentators to conclude that the US was fielding a mature capability in which it had considerable confidence – a message intended for China and other space-faring nations about US determination to protect and preserve its freedom of action in space. This contrasted to the Chinese event which was announced after the event and only after it had been publicised by amateur satellite watchers. The impact on the space environment of the debris fields created by these events differs markedly. The Chinese test created a huge debris field with some of the larger objects not expected to re-enter the earth's atmosphere for some hundreds of years. Most of the debris from the US operation is expected to have re-entered the atmosphere by mid-2008.

Militarisation and Weaponisation of Space

At the same time as there was intense rivalry between the US and the USSR in the 1960s and 1970s, those two nations worked assiduously to devise the framework for space regulation which sought to place potential competitors into a permanent third place. This framework remains extant although with diminished relevance and legitimacy.

The 'rules of the road' of space which were thrashed out in the 1960s and 70s have much reduced application in the first decade of the 21st Century as more nations, including several in the Asia Pacific region, seek to become credible actors in the space domain. China, Japan, India and Brazil have manned space programs – all with the stated aim of putting a 'man on the moon'. Australia does not need and should not seek to emulate these ambitions but numerous practical questions arise from these developments.

What level of assistance and support, if any, should Australia be prepared to provide to these nations to achieve their ambitions? Is Australia prepared, for example, to host ground stations for command, control and communications, or to provide alternative or emergency recovery locations and Australian know-how? Should Australia take the initiative and offer assistance, or should it wait to be asked? If the former, when should such approaches be made, how should they be made and to whom? What level of consultation should first occur with the main space-faring nations?

Almost certainly, nations will continue to cooperate and compete in space. Australia needs to develop a sound strategic basis, however, from which to make decisions about when and when not to support the space ambitions of particular nations and how to represent that support both to the nations directly involved and to the wider international community.

US space policy has been widely criticised for being unduly bellicose in tone and unilateral in approach. Australia, however, may take much comfort from the US position which seeks to protect allied as well as US interests. Uncritical or unqualified alignment with this policy, could limit or constrain Australia's capacity for diplomatic action and influence in future. Australia has an opportunity, and possibly even a responsibility, to take a more sophisticated approach that may also help to steer the world away from space weaponisation.

Australia has a stake in discussions about the weaponisation of space because of national capabilities and hosted facilities which contribute routinely to the global ballistic missile early warning surveillance network and to the monitoring of arms control agreements. Australia has developed and now operates the world's most capable high frequency over-the-horizon radar, the JORN system, which has some capacity to detect missiles on launch which may contribute to the layered surveillance necessary for missile defence. Australia has announced that it proposes to buy three and possibly four air warfare destroyers over the next decade. These ships will be fitted with the Aegis radar system and may eventually be fitted with weapons capable of intercepting ballistic missiles. Important questions arise about the extent to which the Australian systems should be interoperable with similar US systems and possibly also with the systems of other nations.

In the event that the US, China, Russia, or any other nation, determines that their national interests are best served by placing weapons in space, Australia may prefer that it not happen. However, Australia is presently not well-placed to influence the situation. Such developments pose serious questions. Should Australia agree to a US request to place ground-based elements of such a system on Australian soil? If other nations make similar requests should Australia accede to them? Should Australia wait until asked or take the initiative and offer to host such facilities? Should Australia actively seek to be part of any US-led space weaponisation initiative? Presently there is no strong policy or experience basis in Government, academia or elsewhere capable of framing appropriate responses in the national interest. Certainly pockets of expertise exist; however, these are neither robust nor sustainable.

Operationally Responsive Space

Events in the 1990s (notably the first Gulf War, the Balkans conflicts, Somalia and the second Gulf War) led to senior US military commanders demanding more timely, flexible and assured access to space-based systems for communications, surveillance and reconnaissance purposes. The concept of ORS was developed to meet this need. The USAF, together with other elements of the US military, conducted studies and a series of scenario-driven exercises to determine the efficacy or otherwise of this concept.

Fundamental questions addressed include:

- What level of responsiveness is sought – minutes, hours, days or weeks? The answer to this question has fundamental implications for the system design, the operating concept and the cost.

- What might satellites, launched in direct support of a theatre commander, actually do the job, and do it better than alternative systems (both space-based and earth-based)?
- What should be the relationship between ORS systems and the national systems operated by the intelligence agencies? Who should task ORS systems, who should release the data and to whom?
- What should the mission duration be for ORS systems – days, weeks or months? The answer to this question also has basic design and cost implications such as whether to include solar panels or whether to rely solely on a battery.

Political, institutional, and practical difficulties abound. US Congressmen have feared that new systems might only be fielded at the expense of funded programs leading, therefore to job losses in particular Congressional districts and States. The US national intelligence community has expressed concerns that it may lose control of key capabilities and, perhaps worse, that sources and methods developed painstakingly over many years, could be unwittingly compromised by commanders not fully appreciating the value and the sensitivity of some of the information which might be delivered to them by ORS systems.

Readiness and responsiveness are possibly the biggest challenges faced by proponents of ORS. Launch vehicles are expensive to build and expensive to maintain, especially at high states of readiness. Similarly, satellites are difficult to maintain in a ‘powered-up’ state and there is inherent delay in integrating any satellite into its launch vehicle.

ORS programs continue to be funded at a low rate in the US with emphasis on the integration of commercial-off-the-shelf (COTS) technologies and processes into small electro-optical (EO) satellites. Australia has visibility into some of these activities and also some limited, direct experience in tasking a small satellite in support of operations (TACSAT-3 which was commissioned under ORS funding).

In 2002/3, Australian Defence commissioned modest studies of its own into the costs, benefits and practicalities of operating small satellites, especially in an operationally responsive mode.[21] Broadly the studies concluded that, although offering potential benefit, Australia could not afford to invest in a genuinely responsive system due to the costs of maintaining even a small inventory of satellites. The question of where and by whom an operationally responsive Australian satellite might be launched was not addressed. Typically twelve months' notice needs to be given to launch service providers – hardly an operationally responsive timeframe.

Space Situational Awareness

SSA involves monitoring and characterising naturally occurring and man-made space objects which are orbiting the earth. Once an object has been detected, its orbit determined and this data catalogued, its future location in space and time can be readily predicted. Variations and anomalies in the orbits of live satellites may indicate that their purpose or tasking has changed leading to questions concerning both their intent and capability.

Debris is of particular concern to users of space because of the damage that can be done to satellites from collisions with discarded objects. This has occurred in the past and there have been cases where satellites have ceased operations as a result of such collisions. Knowledge of the location of debris has caused Space Shuttle launches to be delayed and has also caused satellites to be moved into new orbits.

Providing there is shared access to SSA data, the process is collaborative and helps to build confidence and transparency between actors in the space environment.

[21] Department of Defence, *Tactical Satellites Study: Final Report Issue 2*, prepared by AUSPACE Ltd, August 2003.

Nations which maintain catalogues do not share all that they know for fear of revealing the strengths and limitations in their own systems which a competitor or adversary may seek to exploit. All of the world's SSA systems are incomplete and aging.

The US is seeking to strengthen its current system (sensors, processes and catalogue) with a view to achieving substantial global SSA within the next decade. One of the most important current weaknesses is that, except for one sensor on Ascension Island in the mid-Atlantic, the US has no dedicated space surveillance sensors located in the southern hemisphere. Overtures to Australia to host SSA sensors as joint facilities have been made. Australia is well-located for SSA, especially to track satellites which are launched to the south from locations in western China. Presently, satellites launched south from China are not detected by the US space surveillance network until they have crossed the south pole and are moving northwards across Europe or North America. Meanwhile orbital manoeuvres may have occurred or micro-satellites deployed, leading to classification and characterisation difficulties at a later stage.

In principle, SSA systems provide the possibility of creating a transparent space environment in which ambiguity and uncertainty are minimised. The location of space objects is known to all, prospects for surprise are reduced and a basis for confidence is created. If an SSA system detects a change to the orbit of an operational satellite the question is, why the change? Was it ordered to avoid debris or for some purpose related to the satellite's mission or capability or in response to an event on earth? If the change was not ordered by the operator is there any evidence to suggest an attempt has been made to degrade, damage or even destroy the satellite or that there has been any attempt to disguise or represent the change as an accidental event? From an operational perspective, if a deliberate attack can be demonstrated to have occurred, how should the satellite operator, whether commercial entity or government, respond?

There are, at present, no internationally agreed policies, rules or processes to guide behaviour in these circumstances. As more nations launch more spacecraft to support their national goals and aspirations, contention over radio frequency allocations and access to scarce GEO orbital slots and sought after orbit planes in Low Earth Orbit (LEO) can be anticipated. Whilst there is no evidence to suggest that these potential conflicts will lead to military responses either on the ground or in space, they introduce a new dynamic to space activities not anticipated by the current regulatory regime.

Returning to the issue of Australia hosting or developing SSA capabilities, the key point to be resolved is whether the data from such a system should be available only to Australia and its allies or whether it should be more generally accessible and if so, to whom and under what terms.

Options could include:

- To permit US detection and tracking facilities to be located in Australia with minimal involvement beyond the usual sovereign protections sought through 'full knowledge and concurrence'.
- To co-invest in these capabilities with a view to developing, in time, a national SSA capability – including sensors, processors and a catalogue.
- To invest in a processing and cataloguing capability as the first step to creating counter-surveillance awareness, doctrine, processes and responses.
- To invest in indigenous sensors, such as PILOT[22] and JORN, data from which can be fed into US and other SSA systems as dictated by policy.

SSA capability is possible and useful in its own right and does not lead necessarily to committing either to capabilities to

[22] A team led by the University of New South Wales is studying the feasibility of building a 2m class telescope, called the Pathfinder for an International Large Optical Telescope (PILOT) at Dome C, on Australian Antarctic Territory. See Annex C for more detail.

conduct space operations or missile defence. The entry costs into SSA are modest and would seem justified in view of Australia's dependence on space-based utilities, especially those needed to give effect to an increasingly networked ADF.

Missile Defence

For the past decade, Australia has maintained a low key dialogue with the US and other allies on missile defence matters – mainly through science and technology links and participation in various experiments, exercises and war games.

These links are anticipated to strengthen as the ADF acquires new platforms and capabilities, notably the Air Warfare Destroyer (AWD), in the next decade.[23] Australian policy is supportive of Theatre Missile Defence (TMD) – the capability to detect, track and destroy missiles and warheads which may be fired at deployed ADF units conducting operations. Development of a National Missile Defence (NMD) capability, or participation in a broader allied missile defence capability, is not under consideration.

A difficulty with this position is that the same platforms and weapons will be used no matter what is being defended. In both TMD and NMD command and control links and processes are likely to be complex, to ensure Australian national interests are adequately factored into coalition decision-making.

Arguably more important than physical capabilities are a strategy and policies which can guide Australian thinking and investments, if judged necessary, in Missile Defence over the coming years. There are three linked questions.

- Will anything that Australia does with regard to missile defence be likely to have any impact, positive or

[23] This report assumes that the AWD project will proceed and the ships will have a missile warning capability in the first instance, provided by the Aegis system. Under a later project phase, the ships may be equipped with a missile intercept weapon, such as the SM-3 missile.

negative, on the state of space security in the next 20 years?

- Must Australia protect deployed elements of the ADF from enemy missiles with organic Missile Defence assets or is it reasonable to assume and expect the US to provide such protection as a condition of Australian entry into coalition operations where a theatre missile threat might reasonably be anticipated?
- What advantages accrue to Australia by being able to offer TMD capabilities to future coalition operations and what are the opportunity costs associated with such an investment?

Questions such as these presumably informed the AWD decision-making process but do not seem to have been tested with any rigour in the public domain.

Although the US has deployed an initial Missile Defence capability, its commitment to new capabilities is muted and cautious. For every Missile Defence advocate in the US, there seems to be at least one detractor. The essential issue is whether fielded, capable Missile Defence capabilities would so alter the global politics of space as to lead to an enormously expensive arms race and the weaponisation of space.

Diplomacy and International Influence

From its earliest days as a sovereign state Australia has played a useful role in multi-lateral diplomacy appropriate to its standing as a middle power and its place in the world. Standing as it does at the intersection of the interests of large and small powers, rich and poor, north and south, Asian and non-Asian, Australia is well-placed, and often used, as a conduit by which the positions of otherwise opposing nations are represented to the other.

It will be essential to recast the ‘rules of the road’ for space in order to create the confidence that all nations will need to ensure that space remains an environment genuinely open to the benefit of all. To this point, Australia has played no significant role in the politics and the diplomacy of space. This situation is no longer tenable and the time has come for Australia to step in and exercise its skills in multi-lateral diplomacy in order to build consensus and confidence.

Successful diplomacy depends on those involved having a tangible stake that all can see and accept. The 'skin in the game' afforded by Australia's investment in the US WGS Defence communications system is a good start, however, it remains a dependent rather than an independent position. A practical next step might be to invest modestly in space situational awareness capabilities in two ways – through agreeing to host a US ground-based SSA sensor and by investing in indigenous SSA capabilities such as the PILOT telescope in Antarctica.

These ground-based investments are likely to be welcomed but may not be seen as sufficient. At some point, investment in space beyond membership of a US constellation is likely to become an imperative. This would be achieved easily, usefully and cheaply by investing in a national remote sensing satellite program. Such a system would not need to be tightly bound to a US system.

An international regime dedicated to averting the development and deployment of destructive space-based weapons and preventing nations from testing any permanently destructive ASATs is a necessary first step in enhancing the security of space assets. Several US 'think tanks' are considering how to gain traction for this view in the policy domain. The Eisenhower Institute, for example, has argued that the deployment of weapons in space by any nation would increase the vulnerability of its own space assets while almost certainly initiating an arms race, increasing the number of nations with space-based weapons, damaging prospects for international cooperation for space exploration, and increasing the prevalence of high-speed space debris. Their proposal is for a multi-layered strategy to bring together both existing and threshold space powers into a mutually beneficial and security-enhancing framework.

The Institute argues for maintaining the status quo, allowing space to be freely used for commercial, scientific, and military uses, but refraining from the space testing of destructive anti-satellite weapons and the deployment of any space-based anti-satellite system. Something akin to the MTCR is recommended, which might be known as the Space Security Framework (SSF) - a voluntary agreement to commit to certain principles in order to enhance mutual security in space.

Space-faring nations would be free to use a range of measures to help protect their assets without threatening other space powers. These might include hardening against radiation, physical hardening, redundant lines of communication, passive measures, dispersal of space systems, mobility of space assets, system configuration changes, and networking to reduce single-point dependencies and failures. The Eisenhower Institute proposal is included at Annex E.

Australia does have an opportunity to shape and influence the decisions which seem likely to be made about space security and weaponisation within the next decade. There are compelling strategic and operational reasons to be involved in a credible and respected way.

‘SKIN IN THE GAME’: A CREDIBLE AUSTRALIAN VOICE IN SPACE

This final chapter is broadly structured around the Fundamental Inputs to Capability (FIC) used by Defence in the capability development process. A series of investments is proposed which, if made, would permit Australia to realise its legitimate sovereign interests in space.

Enabler 1

Organisation

Since the mid-90s, the Commonwealth has pursued a highly decentralised approach to space amongst its departments and agencies. This is not considered a tenable option for the future. Two new organisations are proposed.

Central Policy Coordination Body

During the workshops which supported the preparation of this report, a recurrent question was, “For whom is the paper being written?” “Who is the champion for space in Australia?” Presently there is no single champion for space at any level of government, nor within the research community and industry. The lack of such a body, itself, detracts from any claim Australia may have to be taken seriously in the world’s space councils.

A central policy coordination body is proposed, similar to that recommended in the Chapman Report. A space agency is not suggested or warranted; however, a small office located in the National Security Branch of the Department of Prime Minister and Cabinet is considered a foundation component of capability. The first task of such a group would be to draft a national space strategy for Cabinet consideration and endorsement.

An Australian Satellite Design and Operations Authority

The second organisation proposed might be called the Australian Satellite Organisation. Its role, under ministerial direction, would be to initiate and manage satellite projects and to oversee their operation in the national interest.

None of the agencies and organisations which use data derived from space has any interest managing satellite projects or operating satellites. They simply want the data. If Bureau of Meteorology or Geoscience Australia were to be charged with the task of building and operating satellites this would be regarded, correctly, as a distraction from their core missions. They may also consider themselves at risk in the sense that some of their funds might be diverted from core activities to a non-core mission of building and operating satellites.

Three organisational models are offered for consideration.

- **A Statutory Authority**. A small organisation might be created with the task of devising a national satellite program and then proceeding to project manage the design, construction, launch and operation of, in the first instance, a series of earth observation satellites. Noting the $10bn national water initiative, a logical location for the ASO could be under the Minister for the Environment.

- **A Company**. Similar in concept to Australian Astronomy Limited (AAL), a company might be established. Recently, several universities and CSIRO agreed to form a company, known as AAL, with the initial task of ensuring appropriate governance for the $45m allocated to astronomy under the National Collaborative Research Infrastructure Strategy (NCRIS). AAL foreshadows the possibility of industry partners. AAL might serve as a useful model to attract and encourage private investment in the satellite component of the national infrastructure.

- **Satellites Managed as National Research Facilities**. Australia has a small number of designated national research facilities. These include the Australia Telescope National Facility (ATNF), which manages Australia's radio telescopes, and the recently commissioned Synchrotron in Melbourne, managed by Australian Nuclear Science and Technology Organisation. Although the satellites proposed for acquisition by Australia are to meet operational needs, they would be expected to support research as well.

Enabler 2

People (and individual education and training)

The most serious and most immediate deficiency to overcome if Australia is to build a credible space capability is to create an adequate pool of public officials who are space literate. Some expertise does exist, in the Department of Foreign Affairs and Trade (DFAT), the Department of Industry, Innovation, Science and Research, the Australian Communications and Media Authority, the Attorney General's Department and the Department of Defence; but it is limited, and so has little influence. In 2007, CSIRO elevated its space policy office to the headquarters level to ensure coherence and prominence. DSTO is also seeking to map more systematically its commitments and research on space-related matters.

Australians staff ground stations and earth terminals of all shapes and sizes to support numerous space missions, operations and activities. This technically qualified segment of the workforce is healthy, although aging. Suitably qualified new entrants are hard to recruit and retain.

Training

Several companies offer introductory courses about space with Defence being the principal customer. Some Australian universities offer courses in elements of space science and space engineering. These courses, although of considerable intrinsic interest, struggle for numbers due to the assessment made by students that employment in a space-related field will be almost impossible to obtain in Australia or overseas.[24] As Defence becomes increasingly dependent on satellites to deliver the advantages of a networked force, the need to train more Defence personnel, military and civilian, in all aspects of space operations is expected to gain prominence.

Enabler 3

Collective Training

Immersive wargaming using advanced modelling and simulation capabilities is suggested as an essential element of the space capability being developed within Defence. In the past, it has generally been assumed that communications bandwidth and situational awareness will be available. This has allowed the gamers to test the relative advantages and disadvantages of particular platforms and the weapon mixes in given scenarios. Different force mixes generate different communications and information requirements which should be explicitly stated and tested.

Increasingly network access, speed, security and redundancy should be expected to impact on the response options available to military commanders and government. Cyberwarfare options need also to be factored in and tested in relevant scenarios.

An increasing number of Defence civilian and military personnel are being invited by the US to participate in US wargames which involve space assets. Experience with a variety of US space-based surveillance systems is being gained and assimilated into the Australian command and control environment. This also enhances joint and allied interoperability.

[24] Australian students may find that obtaining training overseas is limited by nationality and other restrictions.

Enabler 4

Major Systems: Capability development implications

Defence, as noted earlier, is planning to make a substantial investment in space utilities in the forthcoming decade as part of the program to transform the ADF into a highly networked and effects-based force by 2020. Until equipment is on the ground and in service it is difficult to comprehend how doctrine and the conduct of operations might change to make best use of the new capabilities.

Looking beyond Defence, remote sensing systems which are optimised end-to-end to monitor the effects on Australia and its environs of global warming and climate change would seem to be politically defensible and responsible. The key is to develop a modest, enduring program which focuses on system requirements and not just the satellite(s) to meet defined user needs.

Enabler 5

Sustainment

Australia has no space industry to speak of. One Sydney-based company, Peregrine Semi-Conductors Australia (PSA) manufactures computer chips, using a globally unique silicon-on-sapphire technology, which is used in every satellite manufactured in the US. Negotiations are presently underway to transfer ownership of PSA from its US parent to an Australian company, thus ensuring that this manufacturing capability, which is optimised for low rate production and enabling research, moves into exclusively Australian hands. This would seem to meet a useful self-reliance objective.

This report does not support the view that Australia needs to be able to build sensors and satellites, at least not in the first instance. Nor does Australia need an independent launch capability. If Australian companies can build these systems competitively, they will succeed but this is not the imperative. The imperative is for Australia to be able to state its national space communications and earth observation requirements and for those requirements to be turned into real capabilities through design control, project management and skilled satellite operators. In time, a small but sustainable workforce could be expected to coalesce around these specialist capabilities and more might then be achieved.

Enabler 6

Command and Management

An Australian earth observation satellite program, funded, designed and operated specifically to meet Australian requirements ahead of any others would:

- provide agencies including Bureau of Meteorology, Geoscience Australia, primary industry, resources, Coastwatch and Defence, with, more timely and more relevant data than has previously been available;
- permit Australia to extend its environmental credentials into the space domain;
- allow Australia to learn about and apply counter-surveillance techniques when appropriate; and
- allow Australia to take a more active and credible position in global negotiations concerning the regulation of space activity, notably with respect to militarisation and weaponisation and to the allocation of finite radio spectrum through the ITU.

With respect to communications satellites, the requirement for national ownership may become less important as next generation commercial and government satellites are likely to be networked in space, providing redundancy, removing single points of failure and offering numerous communications pathways between the senders and recipients of information.

Conclusion

Australia is a sophisticated user of space applications and has been for a long time. Geo-strategic circumstances have created a situation where many domestic needs for data from satellites have been satisfied by non-Australian operators without Australia having to accept any of the risks associated with their construction, launch and operation. This comfortable situation is becoming less tenable as international pressures build on the questions of space security and the weaponisation of space. Australia has a strong and growing interest in participating in these conversations and subsequent development to ensure that its national interests are preserved and where possible advanced. In particular, as access to space becomes a necessary condition for the successful conduct of operations by the ADF, there is a national obligation to do what is necessary to ensure that this requirement is not compromised or placed in jeopardy.

To be heard and taken seriously, Australia will need to develop a balanced national space capability over the next decade which will include investments in people, organisations, training, doctrine (strategy and policy) and equipment. Recently announced investment in the US WGS system indicates a major national commitment to satellite communications which should be augmented by a nationally owned and directed earth observation program.

Action Plan

A seven step plan is proposed by which Australia could put 'skin in the game' in the national interest in a way that is affordable and sustainable.

Step 1

Embark, as a matter of priority, on a deliberate program to increase the number of policy makers, notably at the national level, who are conversant with space law, policy, science, engineering, and business.

Indicative Cost

- Less than $5m per annum for 5 years, then review.

Step 2

Establish a small policy Secretariat in the Department of the Prime Minister and Cabinet to be a single point of contact and coordination for space activities within the Commonwealth and also between the States and Territories.

Indicative Cost

- Less than $2m per annum for 5 years, then review.

Step 3

Establish a satellite design and operations organisation, possibly within the Environment portfolio, tasked to design, project manage and operate a series of earth observation satellites on behalf of established organisations including Bureau of Meteorology and Geoscience Australia. These satellites would be optimised in a total system sense (sensors, orbits, tasking; satellite control; data policies; and information storage, processing and use) to provide information of national significance to Australian governments and the public about the state of the continent, the surrounding seas and the atmosphere above. Data collected might include water flows, soil moisture content, CO_2 levels in the atmosphere and the oceans, and would be fused with existing records and with data from non-sovereign sources. The operational aim would be to provide additional data points in the southern hemisphere to increase the fidelity of predictive climate, weather, stream flow and other models essential for the development of evidence-based policies. Also, effort would be taken to make the information readily available and comprehensible to the wider public.

Indicative Cost

- $30-50m per satellite including the ground segment.

Step 4

Take a more active stance, consistent with Australia's experience and standing as a middle power, in current and emerging international debates about space security and the international regulatory framework governing human activities in space.

Indicative Cost

- Enhanced capabilities in key departments, notably DFAT, Defence and Treasury: approximately $2m per annum for 5 years, then review.

Step 5

Make a series of modest and cautious investments in an Australian Space Situational Awareness system which indicates a willingness to work closely with the US whilst also developing indigenous sensor capabilities.

Indicative Cost

- Cooperative programs with US: <$10m per annum for 3 years then review (note: this amount would increase if a radar is refurbished and relocated from the US to Australia).
- PILOT telescope in Antarctica: $20-30m to construct between 2009-2012, $2-3m per annum to operate.

Step 6

Dovetail the civil initiatives advocated in Step 3, to the extent possible with already announced and funded Defence space initiatives The reason for dovetailing is to develop, over the next decade, a sustainable satellite design and operations capability in Australia as an element of national capability.

Indicative Cost

- Minimal – the additional capability results from changes to business processes.

Step 7

Invest deliberately in space education, acknowledging the inspirational value of space, drawing, in particular, on the experience being gained by the Victorian Space Science Education Centre (VSSEC) at Strathmore College in Melbourne.

Indicative Cost

- Unquantified – VSSEC represents a cash and in-kind investment in the order of $16m.

Table 2. Action Plan Summary

Step No.	Description	Cost
Step 1	Increase knowledge of policy makers.	<$5m per annum for 5 years, then review
Step 2	Establish small policy Secretariat in PM&C.	<$2m per annum for 5 years, then review
Step 3	Establish satellite design & operations organisation (say within Environment portfolio).	$30-50m per satellite, includes ground segment
Step 4	Take a more active stance internationally in space security and regulatory frameworks.	Approx $2m p.a. for 5 years, then review
Step 5	Invest in an Australian Space Situational Awareness system.	<$10m p.a. for 3 years then review. PILOT costs: $20-30m to construct $2-3m p.a. to operate
Step 6	Dovetail Step 3 initiatives with funded Defence space initiatives.	Minimal – new capability through changes to business processes
Step 7	Invest in space education.	Unquantified. VSSEC cost $16m in cash and in kind to establish

Implementation

Some of these steps can be done in parallel, others sequentially. The overall aim must be for Australia to have a foundation space capability by 2015 which permits other choices which do not and should not be made now concerning missile defence, further networking of the ADF and the need for other national response agencies. This capability should also provide information which helps to guide decisions about the disposition of the Australian population and future infrastructure investment (cities and towns, roads, water supply, etc) in the face of changing weather patterns and their effect on the habitability of the entire continent.

ANNEX A

How Space Works: Some Explanatory Notes

The intent of this section is to provide a new comer to space operations with an introduction to the factors which influence the design and operation of satellites. The section can be comfortably skipped by readers who are familiar with this material.

Space is difficult to access and, once there presents an array of operational challenges. There are numerous single points of failure, all of which represent significant investment, technical and operational risks. Redundancy can be expensive and technically difficult to achieve however, the pay-offs for successful implementation of space-based utilities can be enormous as is evident by the ready take-up of GPS and global growth in the satellite communications market.

Some key points, more indicative than exhaustive, follow.

Satellites, which are placed into orbit around the Earth are, for practical purposes, artificial moons of the earth. They function according to the laws of gravity and planetary motion.

The Space Environment

Environment

Earth is continuously bombarded by streams of highly charged particles from the sun and other more distant sources. These can damage and even kill living organisms and they can also disrupt, disable and even destroy the sensitive electronics systems which are integral components of all satellites. For this reason, satellite operators pay great attention to solar disturbances such as solar flares. The magnetic field around the earth and the Van Allen radiation belts protect Earth from the adverse effects of these charged particle streams however many satellites operate outside the Van Allen belts. This means that much effort is taken in the design and construction of satellites to harden them against the effects of harmful radiation. Even satellites in LEO, receive doses of radiation which can lead to the failure of components, sub-systems and eventually the satellites themselves.

In addition to the natural hazards, nuclear detonations either in the atmosphere or in space can deliver doses of radiation which are harmful to satellites, to the point that they can be disabled. Such detonations are indiscriminate in that the radiation they produce can be expected to affect all satellites, irrespective of ownership and mission. Some satellites are hardened against the possibility of such attacks.

Material

Space is unable to sustain life as known on Earth without the creation of artificial habitats such as the International Space Station or the suits used by astronauts when they conduct 'space walks'. Near-earth space contains many objects including meteorites as well as space debris created by human activity in space, including upper stages of launch vehicles, old satellites, bolts and tools and fragments of old satellites and other objects which have been deliberately destroyed in the context of developing future space capabilities. Operational satellites which are hit by or which run into any of these objects may be damaged, disabled and even destroyed.

Launch and Escape Velocity

To escape the earth's gravity, satellites must achieve a velocity in the order of 11 kilometres per second. The only reliable means of doing this for satellites of any size is with large, multi-stage rockets. Few nations have sustainable and reliable launch programs, however the number is increasing. The costs, risks and inherent difficulties of launch remain the major impediment to the commercial development of space. Launch vehicle design has remained largely static since the 1950s and re-usable vehicles, similar in concept to aircraft, which can land, be cleaned, refuelled and re-used, all within a short timeframe, have not been achieved.

Launch site choice or availability influences satellite design and available orbit options. In particular, satellites intended for geo-stationary (GEO) orbits are optimally launched from as close to the Equator as possible; this allows launch vehicles to operate optimally and to place into GEO very heavy satellites.

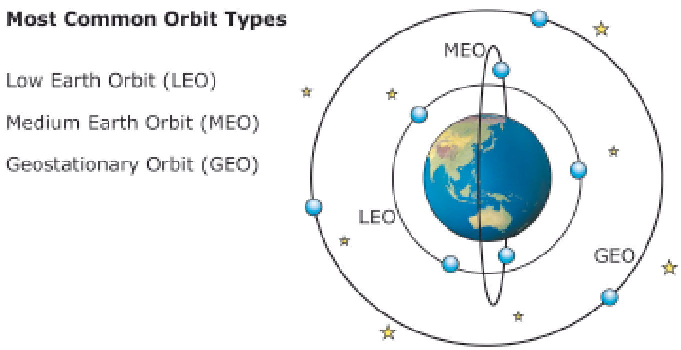

Figure 1. Most Common Orbit Types

Orbits

The mission requirements dictate the orbits selected for particular satellites. A balance is struck between the user need, the sensor(s), the size of the satellite and its projected life (influenced by the available budget), and the communications requirements. Typically, earth observation satellites (for intelligence gathering, surveillance, crop monitoring and other remote sensing purposes, operate in LEO. Navigation systems, such at GPS, operate in Medium Earth Orbits (MEO). Most communications satellites operate in geo-synchronous orbits GEO. Highly Elliptical Orbits, including the Molnya orbits used by some Russia satellites are designed to permit the satellite to 'hang' or dwell over particular parts of the earth for extended periods which is useful for broadcasting and intelligence gathering.

There are numerous variations to LEO orbits depending on the inclination of the orbital plane chosen for a particular mission – from polar or high inclinations to equatorial inclination (ie. from going across or nearly across the poles on each orbit to continuously circling the Equator). Polar orbits can be synchronised with the position of the sun relative to the earth – to achieve sun-synchronous orbits. This is useful for electro-optical satellites because it allows place of interest to be imaged at the same time of the day, allowing for change in shadow length to add a dimension to analysis.

Communications

Satellites communications with the earth, and in the future between satellites, is a key factor in the design of a satellite system. Many of the current generation of remote sensing satellites, for example, use 'store and forward' techniques. An image is captured of a target of interest and the data is stored on the satellite until it comes into view of a ground station to which it downloads the image for on-forwarding to end-users via conventional communications paths.

Spectrum

Operating frequencies and bandwidth are further considerations in satellite operations and design. The radio spectrum is a finite resource which is managed internationally by the ITU. The optimum frequencies for many satellite communications application are the same as those used, or sought, by mobile phone operators as well as specialist users with safety critical needs, such as test and evaluation frequencies on missile test ranges. Frequency selection is a critical design consideration for all satellites. Attention must be paid to solar storms which can temporarily interfere with communications and even permanently damage equipment. Atmospheric moisture can severely attenuate the quality of some satellite communications links through a phenomenon known as rain fade. This is an important factor in the case of Australia; almost half of the continental landmass is in the tropics and the area of primary strategic interest is to the north. Satellites serving these areas must operate in frequencies which can cope with such conditions.

Sensors

For remote sensing satellites, sensor selection is driven primarily by the objects and phenomena to be observed. However, decisions must be made about resolution, coverage and observation bands such as electro-optical/infra-red (EO/IR), multi-spectral, and hyper-spectral sensors. A more general decision is whether to opt for passive sensors or for active sensors (radars of various sorts). Weather, notably cloud cover, degrades the performance of EO/IR sensors but has no appreciable effect on the performance of radar satellites. Sensor performance and characteristics need to be matched to satellite performance as well

Tasking

Tasking satellites is an art form. To gain the optimum performance for the principal users numerous variables need to be identified and taken into account. These factors include competing user demands and priorities, space weather, earth weather, satellite performance (notably power management) and the management and mitigation of satellite faults or degraded performance over time.

Satellites as Systems

Only when the system is laid out, from end-to-end, can the costs, benefits, potential limitations and opportunities be fully appreciated. Such analysis provides the context for satellite operations and permits judgements about whether or not the system is likely to meet the user requirement.

ANNEX B

A Note about Astronomy and Space Science

Astronomy

The southern hemisphere offers the most interesting view of the universe from the perspective of astronomers. The reason for this is that astronomers in southern latitudes look towards and through the centre of the earth's galaxy, the Milky Way.

Australia has invested systematically in astronomy since the 19th century. Since World War II, radio astronomy in particular, for which Australia is uniquely well-suited, has been well-funded by Government. This support continues and strenuous efforts, backed with significant investments of money, people and other resources, are being made to ensure that the Square Kilometre Array (SKA) radio telescope, which will be the largest scientific instrument ever built on Earth is located in Australia. If the Australian bid is successful, the core of the array will be located at Boolardy in Western Australia with a series of remote stations located across the continent and possibly in New Zealand as well. South Africa is also seeking to host the core array with remote stations located in nine other nations in southern and Equatorial Africa and the southern Indian Ocean. Funding agencies are expected to make the site decision in 2012.

A one per cent demonstrator telescope, known as the Australian Square Kilometre Array Pathfinder (ASKAP), will be built at Boolardy over the next four to five years with funds provided mainly by the Commonwealth and Western Australian Governments – in the order of $100 million and $5 million respectively. ASKAP holds the promise of revolutionising radio astronomy in Australia and globally. Further information about this project may be found at: www.skatelescope.org.

Optical astronomy has also fared well, although environmental conditions for optical telescope operations are not as conducive in Australia as elsewhere. Absence of high mountains, atmospheric water vapour and particulate matter are all impediments. The most capable optical telescopes in Australia are located at Siding Spring in Central NSW. These are now being impacted by light pollution from Sydney. This contrasts to the situation in the Andes in Chile, for example, where the telescopes are located at much higher elevations and further away from large population centres with significantly better 'seeing' conditions.

The Australian Astronomy Decadal Plan, released in 2005, identified three areas for investment in astronomy over the next decade – radio astronomy, optical astronomy and Antarctic astronomy (in effect a subset of optical/infra-red astronomy). In summary, the plan proposes major investment in radio astronomy in Australia and major investment in foreign telescopes for optical astronomy. Initially modest investment in Antarctica may become more substantial in time.

Space Science

Presently, through an initiative sponsored by the Australian Academy of Science, an inaugural Space Science Decadal Plan (SSDP) is being prepared. This plan seeks to bring together the disparate space science disciplines in order to develop a collective view around an investment plan which can be put to government. The intent of the plan is to identify the instruments, missions and other capabilities needed over the next decade to meet desired science outcomes. The SSDP process is a challenging exercise. A necessary first step has been to forge a sense of community between space scientists, who, until now, have acted essentially independently and in isolation from each other.

Civil engagements, basically cooperative space science with agencies including NASA, ESA and JAXA, are managed bilaterally between collaborating institutions and lack any form of coherence or oversight. One aim of the SSDP is to provide a framework or context for these activities in future.

In the first 50 or so years of humanity's involvement in space, Australia has invested considerably in some branches of space science and has left others to struggle. Advocates for a stronger Australian involvement in unclassified space activities argue the need for a space agency, perhaps along the Canadian model, and others argue for investment in manned programs such as the International Space Station (ISS). Australia has been invited several times to join ESA, and was also invited to be a partner in the ISS consortium. These invitations have been declined largely on the grounds that the claimed and perceived benefits were outweighed by the not insubstantial costs.

Individual researchers, however, have established numerous international links and have strong credentials in many branches of the space sciences. These include, for the record, space weather (sun/earth interactions), planetary science (geology), astrobiology (origins of life), humans in space (life sciences, medicine), and space engineering (materials and structures, systems and propulsion).

ANNEX C

Antarctica, Astronomy and Space: Converging Interests

There are numerous parallels between the regulation of Antarctica and the regulation of space. The sovereign claims in Antarctica are 'frozen', and the continent is essentially given over to fundamental science which is meant to benefit all of humankind. On the ice, there is enormous practical cooperation between those who live and work at the various bases – especially in matters of safety, life and death. This is not dissimilar to the cooperative activities that Russia and the US pursued in space during the Cold War, more or less in parallel with their competitive activities.

As the world grapples with questions about increased military uses of space and the prospect of weaponisation, governments might do well to reflect on the sorts of arrangements and understandings that exist and through which Antarctica has been managed for the past 50 years. Essentially a balance has been struck between sovereign interests and the broader interests of humankind.

Australia sits at the heart of the Antarctic Treaty. Australia claims about two thirds of the Antarctic continent as sovereign territory and is the pivot around which the large and medium powers and the smaller countries with interests in Antarctica revolve. It is fair to say that Australia is seen as an honest broker between the various interested parties. Might this be a role that Australia could extend into the domain of space?

PILOT

Potentially the very best place for conducting optical astronomy in the world, in terms of the 'seeing' conditions for the telescopes is on the high plateau of Antarctica. This area is exceptionally dry, devoid of particulate matter and is a long way from the blizzards which frequently lash the Antarctic coastline. Most of the plateau, including the points of greatest potential to host observatories is within the Australian Antarctic Territory. Not well appreciated is that the area claimed by Australia in Antarctica is almost the same size as the area of continental Australia – such is the distortion of most common map projections. Presently, a team led by the University of NSW is studying the feasibility of building a 2m class telescope, called the Pathfinder for an International Large Optical Telescope (PILOT) at Dome C, on Australian Antarctic Territory.

The French and Italian Governments operate a permanently staffed station at Dome C, called Concordia Base. PILOT is expected to produce new science in the infra-red band and also, at relatively low cost and risk, to serve as an engineering pathfinder. It will allow astronomers and engineers to face and solve the challenges associated with operating a large optical telescope at a site that is remote, cold and generally inhospitable. PILOT is expected to cost in the order of $20-30 million (Australian) to design, construct and bring into operation and cost in the order of AUD2-3m annually to operate.

PILOT will be able to locate and characterise space debris down to the size of a 10 cent coin in the increasingly congested low earth orbits. Such an operational task offers numerous operational and other benefits to Australia.

- Australia's sovereign claims in Antarctica would be strengthened by such an investment on Australian territory away from the coast. Presently, Australia's three permanent bases (Mawson, Casey, and Davis) are all on the coast and Australia's current research efforts in Antarctica are focused on the life sciences, notably the biomass in the surrounding oceans.

- Australia could quickly, contribute to global space situational awareness from a unique location. This would add fidelity and a source of independent verification to data already available. As more nations launch more satellites potentially creating more debris in the process, finding, characterising and tracking this material will be essential to reduce the hazard that debris presents to operational satellites. To the extent that space surveillance data is synoptic and shared, it should also help to reduce the scope for intentionally aggressive acts in space to be misrepresented as accidents, thereby building the trust that will be necessary for users of space to continue to reap national and global benefits with confidence and high levels of assurance.

- Looking further ahead, the engineering and operational lessons that astronomers stand to learn from PILOT should help them to design, build, construct and operate within the next 20 years a very large optical/infra-red telescope on the Antarctic Plateau in Australian territory. Potentially, by 2025, Australia could be host to the world's largest radio telescope, the SKA, and the world's most capable optical telescope. These projects, both international in scope, could be expected to become cornerstones of Australia's science and high technology infrastructure for the remainder of the 21st. Century. They should serve as incubators for innovative research and for spin-off companies that will be of strategic importance to the economy and society in the long term.

In 2007, the Australian Strategic Policy Institute (ASPI) released a report which urged Australia to take a more active interest in Antarctica from a Defence and national security perspective.[25] Defence support for PILOT may provide a low risk, low cost method of fulfilling the objectives outlined by ASPI whilst simultaneously meeting space-related objectives as well.

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[25] Bergin, A and Haward, M., *Frozen Assets: Securing Australia Antarctic Future*, Australian Strategic Policy Institute, Canberra, 2007.

ANNEX D

Defence Capability Plan (DCP) 2006/2015 Projects Directly Related to Space Investment[26]

Project Number	Project Name	Dollars $m		Description	DCP Page
		Lower	*Higher*		
JP2008 Ph 3F	MILSATCOM	50	75	terrestrial infrastructure - terminals, etc	59
JP2008 Ph 4	MILSATCOM	1000	1500	next generation space segment	59
JP2044 Ph 3A	EAGLE EYE	50	75	space-based surveillance - grnd infrastructure	64
JP2044 Ph 3B	EAGLE EYE	50	75	space-based surveillance – ground infrastructure	64
JP2064 Ph3	Geospatial Information and Services	250	350	geospatial databases and applications	72
JP2056 Ph2	Integrated Broadcast System	30	50	tactical level intelligence from national systems	74
JP2056 Ph3	Integrated Broadcast System	20	20	tactical level intelligence from national systems	74
JP2078 Ph2	Hyper-Spectral Imaging	50	75	early learning phase	85
JP2096 Ph1	Surveillance Enhancement	250	350	long range sensor fusion, space surveillance	93
TOTAL ($ millions)		**1750**	**2570**		

[26] This list does not account for: other projects which will contribute funds to enable space segment as a component of the capability being acquired; the ongoing investment in intelligence, timing and navigation for platforms and weapons with space dependencies; the ongoing purchase of space services - data and access; or minor capital equipment projects (i.e. a project cost of less than $20m), that will acquire elements of space capability over the next decade.

ANNEX E

FRAMEWORK FOR SPACE SECURITY AN ALTERNATIVE TO WEAPONIZING SPACE

The Eisenhower Institute[27]

THE CHALLENGE

The medium of space has been transformed dramatically over the past half century. From Sputnik to the International Space Station to GPS and Galileo, the unique character of space has enabled nations and individuals to learn, see, and connect in ways never before imagined. However, as this environment offers opportunities, it brings with it certain limitations. Satellite orbits are controlled by the laws of orbital mechanics and, as a result, there are a limited number of orbital slots and frequencies. At the same time, though space assets orbit the earth as a whole, they do not recognize national borders and are, by nature, more vulnerable to attack than ground-based systems and much more difficult to defend. They follow a predetermined and predictable course, and they are left exposed and unprotected by either personnel or material. This is why it becomes vitally important for nations and commercial entities to cooperate on space security while inhabiting ever closer quarters in space.

The current international space security framework, which can trace its birth to the Eisenhower administration, acknowledges the importance of non-aggressive military applications in space, a recognition which has served to enhance national and international security for many years. Few, after all, can deny that reconnaissance from space and early warning satellites strengthened the stability of deterrence

[27] This framework has been reproduced with the permission of the Eisenhower Institute. The original document is available from the Eisenhower Institute online at: <http://www.eisenhowerinstitute.org/themes/international/fos/framework.dot>.

during the Cold War. Over the past decade, many nations have invested in creating military space systems that have greatly augmented their reconnaissance, communications, and targeting capabilities. These assets' increasing value have made them integral to military planning by most space-faring nations, both to defend and to target. These nations are now at a crossroads. They must decide if security will be increased by weaponizing space or by maintaining the status quo, where space is utilized for military purposes, but not yet as a base for destructive weapons.

For a medium that is inherently international in nature, space is predominantly unregulated. The International Telecommunication Union is responsible for the allocation of communication frequencies and orbital slots, but it has no authority over what is deployed on orbit. The Outer Space Treaty forbids only the presence of nuclear weapons, or other weapons of mass destruction, in orbit or on heavenly bodies and military installations on heavenly bodies. The former ABM Treaty, by prohibiting a space-based missile defense system, had simultaneously banned the testing of space-based ASATs in an anti-missile capacity. However, despite some effort to create a new treaty at the Conference on Disarmament, the US' withdrawal from the ABM Treaty has lifted any limitations on the deployment of non-nuclear weapons in orbit. In addition, the recently released US National Space Policy specifically states that the US will "oppose the development of new legal regimes or other restrictions that seek to prohibit or limit U.S. access to or use of space."[28] The new directive pledges the US to preserve the unregulated nature of space. These developments have led to a potentially unstable situation.

The first nation to deploy weapons in space, even if only out of concern for the security of its own assets, will likely trigger a chain reaction of reciprocal moves, opening a space arms race. Major space powers such as Russia and China have made clear that that they oppose the weaponization of

[28] United States National Space Policy. *White House*, August 31, 2006.

space, yet are prepared to respond in kind to any U.S. attempt to deploy weapons there.[29] Consequently, unregulated and unilateral action by any nation to weaponize space may be quickly transformed into a new area of confrontation. At the same time, the space security that all nations and commercial entities are seeking for their space assets could be irrevocably lost.

A space arms race always brings with it the possibility of the purposeful, or even accidental, use of destructive space weapons. Aside from the grave military damage an attack on space assets could cause, including the possible debilitation of critical national defense infrastructure, offensive weapons in space could be extremely disruptive to every day life in the public sphere. Satellites in orbit around the Earth are now used for communications, banking operations, television broadcasting, airplane navigation, the internet, weather and climate research, remote medicine and education, and numerous other important services. All of these assets, and in many respects our quality of life, would be at risk either from direct attack or by the resulting barrage of high speed space debris created from the destruction of other co-orbital assets. A war in space would clearly have global repercussions.

This is why a joint effort on behalf of all major and emerging space-faring nations to eliminate the threat of space-based warfare, such as The Eisenhower Institute's proposal below, would be a significant and worthy first step toward a comprehensive response to space security threats.

[29] While senior Russian foreign affairs and defense officials have promoted an agreement preventing weaponization of space in the UN's Conference on Disarmament, they also have promised a response should another nation (the United States) deploy weapons in space. Sergei Ivanov, Russia's Minister of Defense, stated in June 2005, "Russia's position on this question has not changed for decades: We are categorically against the militarization of space. … If some state begins to realize such plans, then we doubtless will take adequate retaliatory measures." China's recent ASAT test in January 2007 proves their country's willingness to use destructive weapons in space. The successful test has been interpreted by some as a response to "years of sword-rattling by the United States [in space]" (Philip Coyle, *Center for Defense Information*, February 12, 2007).

In summary, it is our belief that the deployment of weapons in space by any nation would increase the vulnerability of its own space assets and almost certainly produce a number of other negative consequences, including:

1. The possible initiation of an expensive arms race by the major space powers;
2. A resultant increase in the number of nations with space-based weapons;
3. Damaged prospects for international cooperation on a new vision for space exploration;
4. Disintegration of space objects, which would create dangerous, high-speed space debris fields in heavily used orbits.

THE PROPOSAL

We believe that this fragile situation calls for a multi-layered strategy which would bring together both existing and threshold space powers into a mutually beneficial and security-enhancing framework. There are three distinct categories of countries with different levels of space capabilities: established space powers that are capable of designing, developing, and launching space assets independently; emerging space powers that are on the threshold of achieving a space launch capability or are capable of designing and developing space assets independently; and "countries of concern" that possess basic rocket/satellite technology but do not have the technical means or geographic capacity to launch satellites. Each of these categories of nations are capable of posing, in their own way, a threat to the security of space objects.

The challenge in dealing with the first group – established space powers – is to maintain the security of their space assets while avoiding the creation of a hostile and unsafe space environment. An arms race, once sparked, would be extraordinarily expensive and counterproductive to global security interests.

The second group – threshold space powers – may possess rocket technology capable of sending an object to Low Earth Orbit or have the capability to become significant "players" in the future. The international community must find ways to encourage these nations' developing access to space to the extent that the MTCR allows, while ensuring that security in space for all nations is not decreased.

The third group – "countries of concern" – are important to engage, but the complexity involved in drawing nations such as North Korea into the regime could very well put its creation at risk. Should the regime's members believe it useful, they may engage these countries at a later date.

The most pragmatic approach for achieving a consensus among space-faring nations is to maintain and "lock-in" the status quo, thus preventing the full weaponization of space, but not attempting to scale back on systems which have already being deployed. Our strategy, applicable to both established and emerging space powers, would reward responsible countries that choose to join the framework voluntarily while isolating those who do not abide by its principles. At the same time the plan would not prohibit complementary measures undertaken by the signatories in order to make their space assets more secure and redundant.

Key to this proposal is the establishment of a multilateral regime based on an international agreement banning on-orbit offensive weapons and the testing of any destructive anti-satellite weapon based on land, sea, air, or space. We recommend a regime similar in structure to the MTCR.

STRUCTURE

Create a Multilateral Regime Similar to the MTCR.

The Space Security Framework (SSF) would be a voluntary agreement rather than a treaty and would create an organization of like-minded nations that commit themselves to abiding by certain principles in order to enhance their mutual security in space. The creation of this new regime would have the advantage of providing a forum outside the United Nations and the Conference on Disarmament for discussing and acting on civil, commercial, and military space issues with only existing or threshold space powers. It would eliminate the need to negotiate with nations who may have opinions, but no power or potential role to play in space.

Aside from those nations that are currently in space or likely to be soon, the regime could also include countries with a favorable geographic location, which is critical for launch purposes; satellite manufacturing capability; ground stations; or any other critical function. Observer status could be accorded to those nations that are consumers of space technology and want to be associated with the pact.

Each member of the regime would commit itself to the principles discussed below. Each would also undertake to pass domestic legislation that demonstrates a minimal commitment to these principles as confidence-building measures. Because membership in the regime is voluntary, collective punitive measures could not be taken against those members that violate the regime's principles. However, each member nation should, as part of its domestic legislation, enact policies for dealing with both members and non-members that violate the framework's principles.

The creation of this forum would be a critical first step toward ensuring that space remains a secure environment for the assets of all space-faring nations. The group would then be in a strong position to engage new emerging space powers and to address other important space security issues such as minimizing space debris and fairly allocating communication frequencies and orbital slots.

PRINCIPLES

The establishment of an international agreement creating a regime of member nations who agree to work purposefully to prevent the deployment of destructive space-based weapons and the testing of any destructive anti-satellite weapon based on land, sea, air or space.

1. Definitions

    1.1. A destructive space-based weapon: Any object deployed on orbit designed to permanently damage or destroy another space-based or earth-based object by directed-energy, explosives, or intentional impact.

    1.2. A destructive ASAT test: The space test of a system based on land, sea, air, or space that is designed to permanently damage or destroy a space-based object by directed-energy, explosives, or intentional impact.

    1.3. Coordinated Space Awareness Center: A center jointly supported and managed by members of the regime that is capable of detecting, tracking, and identifying man-made objects orbiting the Earth.

2. Basic Tenets

    2.1. The regime would be an agreement by all members, as current or threshold space-faring nations, to maintain the status quo in space, allowing it to be freely used for commercial, scientific, and military uses, but to refrain from the space testing of destructive anti-satellite weapons and the deployment of any space-based anti-satellite system.

    2.2. It would not require any reversal of the already adopted segments of the US National Missile Defense program, nor would it ban potential equivalent programs of other nations. The regime would ban the deployment and testing of the weapons component of a space-based missile defense system, because it would be indistinguishable from a destructive space-based weapon.

    2.3. There would be no prohibition on temporary and reversible interference with satellite functions or transmissions.

3. Individual Requirements of Membership

    3.1. Members would be a part of a new forum in which to engage in confidence-building measures and discuss issues of mutual interest and concern with other major space players, eliminating the need to address these issues in other fora that may include nations who wield no power in space. An initial activity might be a joint effort to address the issue of space debris and engage in "orbit-cleaning" activities.

    3.2. Members would pledge to enact domestic legislation as a confidence-building measure that commits each nation to the basic principles of this regime and sanction those members or non-members that violate them. An outline of this legislation is attached as an Appendix.

4. Joint Activities

    4.1. A powerful and constructive initial trust-building activity by this regime would be to establish a jointly-sponsored Coordinated Space Awareness Center (see definitions) with access for all regime members. It would also serve to increase transparency among nations, so each could ensure that no destructive ASAT testing has taken place. Enhanced space situational awareness, much like early warning systems in the nuclear weapons field, is critical to a nation's knowledge of the security of its space-based assets. Lack of full knowledge about an event can lead to hasty and reckless actions.

In addition to all these collective rules and measures, the individual member countries or groups of them are free to undertake additional steps, such as redundancy and space situational awareness, to enhance survivability of their space assets. Redundant systems capable of rapid deployment might serve both as a deterrent to those interested in attacking space assets and insurance against any such attack.

Responsive space, consisting of flexible systems, infrastructure and launch capabilities, seeks to assure that if a country has the capability to replace any lost space asset within a very short window of time it would become economically and tactically difficult for an adversary to eliminate that capability. Even though responsive space techniques and technologies provide a range of diverse measures that can quickly meet a threat in space, the systems reside on the earth, thus eliminating weaponization while providing a deterrent.

Space-faring nations would be free to use a range of measures to help protect their assets without threatening other space powers. Among these options are:

- hardening of satellites to radiation;
- investing in the physical hardening of space structures;
- investing in more redundant lines of communication between the ground and satellites to counter any attempts at jamming;
- adopting passive measures, such as a robust defense for ground-based systems;
- assuring dispersal of space systems. In space, dispersal would involve deploying satellites in a multi-satellite system such as GPS into various orbital altitudes and planes. On the Earth, dispersal would involve deploying mobile ground stations to multiple locations; [30]
- providing for mobility of space assets to defend themselves and their connection with terrestrial nodes. The limitations of space maneuverability as a means of deflecting attack are on-board fuel capacity, orbital mechanics and advance warning. Limitations of

[30] Counterspace Operations: Air Force Doctrine Document 2-2.1, pg. 26, August 2, 2004.

terrestrial nodes include maintaining "line of sight" positioning with its space partner;

- establishing system configuration changes – RF amplitude changing and frequency hopping techniques to prevent jamming, encryption, orbit altering physical shape changing;
- and networking satellites to reduce single-point dependencies and to minimize the impact of single-point failures.

CONCLUSION

The cost of weaponizing space would not only be extraordinarily high, it would probably result in a net reduction of security for all space-faring nations and for the rest of the world. We believe the strategy we have put forward would significantly enhance space security by offering greater transparency to the international community, while making it possible to isolate countries that have illegitimate or hostile objectives with regard to space. Furthermore, such a plan would also include measures that should be acceptable for all space-faring nations to employ without reducing the security of the others. By creating a regime dedicated to averting the necessity of developing and deploying destructive space-based weapons and preventing nations from testing any permanently destructive ASATs, all current and future space-faring nations would be taking the necessary first steps to enhance the security of their assets, while avoiding the great cost of developing a new field of weapons.

APPENDIX

SUGGESTED OUTLINE OF DOMESTIC LEGISLATION FOR THE US (OTHER NATIONS WILL VARY)

Each nation will undertake to pass domestic legislation with this minimum set of requirements:

1. Testing Ban
   1.1. Authorizing legislation to be enacted by Congress to limit/deny the appropriation of money to the Department of Defense for the testing or deployment of destructive ASATs.
2. Sanctions Legislation
   2.1. Legislation banning US individuals and corporations from doing business with entities of any nation, whether members of the regime or not, that are proven to have undertaken actions counter to the principles of the agreement and have been acknowledged so by Congress.

This information/intelligence is to be shared with other member nations so that each nation may undertake similar action toward the nation or entity.

ABOUT THE KOKODA FOUNDATION

Purpose

The Kokoda Foundation has been established as an independent, not-for-profit think tank to research, and foster innovative thinking on, Australia's future security challenges. The foundation's priorities are:

- To conduct quality research on security issues commissioned by public and private sector organisations.
- To foster innovative thinking on Australia's future security challenges.
- To publish quality papers (The Kokoda Papers) on issues relevant to Australia's security challenges.
- To develop Security Challenges as the leading refereed journal in the field.
- To encourage and, where appropriate, mentor a new generation of advanced strategic thinkers.
- Encourage research contributions by current and retired senior officials, business people and others with relevant expertise.

Membership

The Kokoda Foundation offers corporate, full and student memberships to those with an interest in Australia's future security challenges. Membership provides first-release access to the *Kokoda Papers* and the refereed journal, *Security Challenges*, and invitations to Foundation events. Membership applications can be obtained by calling +61 2 6161 9000, and downloaded from:

http://www.kokodafoundation.org/Joinindivdual.html