

Submission
by
Brett Biddington

to

Space Inquiry
conducted by
Senate Economics Committee

April 2008

GLOSSARY

ADF	Australian Defence Force
ADIESA	Australian Defence Information and Electronic Systems Association
ARC	Australian Research Council
ASAT	Anti-Satellite – weapon, or test such as was conducted by China in Jan 2007
ASKAP	Australian Square Kilometre Array Pathfinder – radio telescope
DARPA	Defense Advanced Research Agency - US
ESA	European Space Agency
FEDSAT	Federation Satellite – small scientific satellite launched to celebrate the centenary of Australian Federation, ceased operations in early 2007
GPS	Global Positioning System (US owned and operated)
JORN	Jindalee Over-the-horizon Radar Network
LEO	Low Earth Orbit
NASA	National Aeronautical and Space Administration - US
NCRIS	National Collaborative Research Infrastructure Strategy
PILOT	Pathfinder International Large Optical Telescope – proposed for location at Dome C on Australian Antarctic Territory
SATCOM	Satellite Communications
SCRAMJet	Supersonic Combustion Ramjet
SKA	Square Kilometre Array – radio telescope
SSA	Space Situational Awareness

**Submission by Brett Biddington
To
Senate Economics Committee
Space Inquiry**

Thank you for inviting me to make this submission to the Senate Economics Committee inquiry into Australia's involvement in space. In preparing this submission I have drawn on quite diverse experience which is outlined below. The opinions expressed and recommendations made are mine alone and do not reflect those of any of the organisations or interests listed.

Relevant Background

- 2003 – present. **Member** of a global team in Cisco Systems Inc., responsible for introducing internetworking technologies into and between satellites
- 1980 – 2002 **Intelligence Officer** in the RAAF , including capability development responsibility for several classified space-related projects
- 2008 **Author** of a report for the Kokoda Foundation, *Skin in the Game: Australia's Space Engagement to 2025* (being prepared for publication and drawn on for this submission)
- Present **Chair**, Australia Telescope Steering Committee – senior governance board for radio astronomy in Australia
- Present **Chair**, Australian Antarctic Astronomy Advisory Committee – governance of an NCRIS funded design study to place a large optical telescope at Dome C on the Antarctic plateau in Australian Antarctic Territory
- Present **Chair**, Australian Defence Information and Electronic Systems Association (ADIESA) – an association which provides industry best practice advice to Defence about industry capabilities, emerging standards and new technologies
- Present **International contributor** to the Eisenhower Institute (Washington DC) Expert Panel on Space Security
- Present **Board member and Treasurer**, Australian Space Research Institute
- Present **Member**, Uni SA Institute of Telecommunications Research (ITR) Advisory Board. ITR operates a satellite ground station from which FEDSAT was controlled and data from other satellites is received
- Present **Executive Member**, Australian Space Industry Chamber of Commerce
- Present **Steering Group Member** for Australian Space Science Decadal Plan
- Previous **Board member**, CRC for Satellite Systems (2005-2006), the operator of FEDSAT
- Previous **Member** of the Space Policy Advisory Group, established by Senator Grant Chapman

Opening remarks

This submission draws on my wide exposure to many facets of Australia's involvement in space past, present and future. During my RAAF career, I had for a short time capability management responsibilities for Woomera and I was deeply involved for some years in sensitive activities close to the heart of Australia's alliance relationship with the US. More recently I have been involved with scientific, commercial, educational and amateur/enthusiast space activities in Australia. There are also international dimensions to my experience, embracing space security policy, advanced technologies and commercial developments as well.

Space: no longer an 'optional extra'

Until quite recently Australia has had an easy ride in space. There are three key space-based utilities on which Australia and Australians have come to depend and take for granted. These are:

- Timing and positioning (GPS) and the many applications which depend on assured access to these signals
- Satellite communications (SATCOM) which connects the most remote users to terrestrial networks
- Remote sensing data for intelligence, surveillance, mapping and charting, disaster monitoring, agricultural and land use applications, weather prediction, climate modeling, etc.

None of the satellites on which Australia depends for these services is owned or operated by the Australian Government or Australian companies and we have little or no say in the big questions about optimisation of these systems to meet Australian requirement; decisions about system design, technology selection, operational concepts, future investment plans and assured access are made by others.

In the past decade the Australian Defence Force (ADF) has started to move from being a 'platform-centric' force in which ships, tanks and planes dominated military cultures and decision-making to a 'network-centric' force. In the former, planners assumed that platforms would fight more or less one on one battles with similar platforms in state on state wars. In the latter, platforms are brought together in highly interdependent relationships to achieve the desired military and political effect against a range of state and non-state adversaries. In the platform-centric world, assured access to space was an optional extra. In a networked world, assured access to space is an essential enabling element of warfighting capability. If space utilities are not available, the security of Australian forces is reduced as is the likelihood that these forces will be able to fight and win.

Space utilities allow small forces, such as the ADF, to fight with great precision. Political and military will, information operations and firepower, when necessary, can be brought to bear quickly and with great agility and flexibility to achieve pressures and effects previously unobtainable except by massed armies – and they invariably caused massive 'collateral' damage in pursuit of particular objectives.

The key finding of a study I have prepared for the Kokoda Foundation is that there are critical missing pieces of national space capability which must be filled-in if

Australia's national security strategy and national security operations are not to be seriously and potentially fatally compromised.¹

The investments required to complete a national space capability are predominantly not in the military domain. Without them however, Australian soldiers, sailors and airmen will be placed at unnecessary and avoidable risk and their capacity to fight and win will also be diminished.

This situation has arisen through a complex set of forces including:

- lazy policy making by sometimes ill-informed policy-makers who have placed undue stock in Australia's geo-strategic circumstances;
- undue and uncritical reliance on the US;
- economic rationalist ideology pursued at the expense of the national interest;
- poor industry behaviour – a regrettable tendency to not understand the Australian market and to oversell products and services, notably in remote sensing and earth observation;
- timidity by potential investors;
- poorly developed business cases, emphasising technology push rather than user pull arguments; and
- absence of a national space strategy, consequential policies and a coherent executive voice.

Comments will be expanded under the appropriate term of reference in the remaining pages of this submission.

Recommendations

- A fast-tracked program to increase the number 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, possibly 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. One or both of these satellites might be launched as members of a constellation of similar satellites.
- Production of a national counter-surveillance intelligence estimate and establishment of a national counter-surveillance plan with associated policies and procedures.

¹ Biddington, B, *Skin in the Game: Australia's Space Engagement to 2025*, Kokoda Foundation, Canberra, 2008 (forthcoming)

- Investment in a Space Situational Awareness (SSA) 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.

The remainder of this submission is keyed to the specific terms of reference of the Senate Inquiry.

Term of Reference 1

Australia's capabilities in space science, industry and education, including existing Australian activity of world-class standard.

Space Science Other submissions are expected to provide detail about Australian capabilities and achievements in space science. They are considerable. Points that this writer would make are:

- Australia hides its space science lights under a bushel. Australian achievements in space science are not well-publicised or appreciated.
- The Australian space science community is fragmented. The inaugural space science decadal plan is a first step, intended to provide this community a common, coherent and effective voice.
- Astronomy is a national research strength which attracts considerable Government funding and public support – notably through current efforts being made to ensure the Square Kilometre Array (SKA) radio telescope is built in Australia. Proposed new investments in space science should be targeted to exploit, where possible, synergies with astronomy and to close capability gaps.
- One branch of space science, space weather, has direct and immediate impacts on the ionosphere and on earth weather. Given the continuing impacts of drought and the apparent and accelerating effects of climate change, investment in understanding space/earth weather inter-actions may warrant targeted investment. This may also serve to further enhance the effectiveness of the Jindalee Over-the-Horizon Network (JORN) which depends fundamentally on the ionosphere to work. JORN is Australia's principal wide area national security surveillance sensor.

Industry Australia has no space industry, defined as companies which design, build, launch and operate satellites. However, there are many people employed in companies, some world-class, and in areas of government whose jobs fundamentally depend on assured access to space utilities. No doubt other submissions will provide data to support this proposition. The points this writer would make are:

- There is poor appreciation of the numbers of people and associated demographics whose jobs are dependent on assured access to space-based utilities.
- An even larger group, have some, potentially increasing, dependence on these utilities, including all sectors of the transport sector banking and finance and farming and agriculture.
- A company in Sydney, Peregrine Technologies, produces special computer chips (using silicon on sapphire technology) which are used on most US satellites and spacecraft, including the Mars Rover. This is a great story waiting to be told².
- An Adelaide-based geo-spatial service company, Apogee Imaging International, has built a unique business model. Through normal business relationships Apogee has created a virtual constellation of remote sensing

² Advice to this writer by the CEO of Peregrine Inc, March 2008.

satellites. An innovative business model has been coupled with clever processing to provide a capability of national importance within industry.

- Australia continues to maintain world-class instrumentation capabilities including at the Australia Telescope National Facility in Sydney, at Mt Stromlo Observatory in Canberra and in a small Queanbeyan-based company, Electro-Optic Systems. These capabilities are fragile due to uncertain capitalisation, an aging workforce and modest and lumpy order books. Such capabilities represent important national self-reliance capabilities. Australia should think twice before letting market forces alone dictate their future.
- Regrettably many companies which have tried to sell launch services, satellites, data and engineering capabilities into Australia have behaved badly. This writer can cite examples of poorly developed business cases, uncertain financing, poor appreciation of the market (requirements and size), lack of understanding of Government processes, exaggeration of particular capabilities and unrealistic pricing models. Such ill-informed, often opportunistic, behaviour has tarnished the image of the space industry as a whole especially in the eyes of governments. One possible reason for such poor and ultimately self-defeating behaviour is the lack of a clearly identified executive agent for space which acts as an authoritative first point of contact, information and education for companies interested to invest in space activities or to sell applications and services in Australia.

Education Space is said to be one of the areas of human experience which inspires young children to study mathematics and science.

- The Victorian Space Science Education Centre is a stunning, world-class education facility which opened in 2006. Its experience is already indicating success in encouraging students to stay with or indeed transfer to maths. and science.
- The space – maths./science nexus deserves systematic study and if demonstrated might indicate an educational investment pathway with high pay-off potential.
- A detractor is said to be that secondary school students as well as others in tertiary studies are dissuaded from taking space courses because the career opportunities in space engineering and technology jobs in Australia are so limited. Certainly, those who seek to design and build satellites and launch vehicles and others who aim to be astronauts must travel overseas. The diversity of space-related jobs in Australia, using and supporting the space utilities, is not well-articulated. Better explanation of this situation may also provide rapid pay-off with limited investment.

Heritage Australia has notable space heritage.

- **Indigenous Heritage** Evidence available to this writer indicates that indigenous Australians had a deep understanding of the night sky which was intimately connected to their understanding of the land. Indeed there was considerable unity of appreciation which is represented in ‘The Dreamings’ of numerous indigenous communities. Some of this understanding is in the

public domain and research and collection is ongoing but somewhat ad hoc and erratic. A systematic effort to record such of this understanding as indigenous people are prepared to share could be a project of national significance.

- **The Cold War** Australia hosted significant facilities which were directly related to the 'space race of the Cold War. Woomera is the most obvious but there are numerous others. Some local efforts to interpret these sites has been made with varying degrees of success. As national efforts have been made to record and interpret sites relevant to World Wars 1 and 2, so a similar effort would be in order for Australia's Cold War sites which are invariably related to support of allied space activities.³

³ Dr Alice Gorman, a lecturer in archaeology at Flinders University, has published material on this subject.

Term of Reference 2

Australia's capabilities in space science, industry and education, including areas in which there is currently little or no activity but that are within the technical and intellectual capacity of the country.

If Australia chose, it could develop the capacity to design, build, launch and operate small satellites operating in Low Earth Orbit (LEO) reasonably quickly. There would be significant opportunity costs and the need to do all of these things in country is not apparent. The immediate capability gaps are elsewhere.

- There is no compelling requirement for Australia to have a national satellite launch capability. There is no 'one size fits all' launch solution. Different satellites, placed into different orbits need to be launched from different places in different directions on different launch vehicles. If the costs/benefits led to a compelling business case, no doubt investment would follow – not likely to happen any time soon in Australia.
- That said, the difficulty of gaining access to space, is arguably the most severe constraint to the use of this domain for the benefit of humanity. The research being undertaken at the University of Queensland into SCRAM jet technology holds promise in this context.
- The critical and most pressing gap in Australian space capability is the dearth of senior public officials who have knowledge and understanding of the physics, technologies, constraints, strategic and policy dimensions of space. There is expertise at middle-levels, however, it is dispersed thinly across governments. We tend to consider space policy as an adjunct to other policy domains such as non-proliferation, our alliance relationship with the US or air safety as aircraft become increasingly reliant on GPS for navigation. Simply put there are not enough clever people assigned by government to think about space in a coherent, organised fashion to allow for public policy to be determined and implemented.
- Woomera is an under-used resource of national and possibly international importance. It offers a secure area for the test and evaluation of new technologies, electromagnetic as well as kinetic, with application to all space activities – civil and commercial as well as military. Its governance is fragile and needs to be reviewed and strengthened.

Term of Reference 3

Arguments for and against expanded Australian activity in space science and industry including an assessment of the risks to Australia's national interest of Australia's dependence on foreign owned and operated satellites.

This is a vexed area. With regard to earth observation satellites, a common argument is that Australia is beholden to other countries for access to the data from their satellites. They may invoke 'shutter control' leaving Australia blind, potentially at critical moments. There is an evident paradox. Space is a truly international place where the traditional prerogatives and obligations of sovereignty do not apply. Soldiers cannot be sent to guard or protect the property of Australia and Australians which may be located in space. Yet the key players in space are nation states intent on maximizing their own interests, sometimes at the direct disadvantage of others.

The space environment is amazingly fragile and easily disturbed; witness the debris field created by the Chinese ASAT test in January 2007. A high energy pulse in space may well damage/destroy the electronics of all satellites in the vicinity – making no distinction between friend and foe. Yet, the US, at the level of policy and rhetoric asserts the right to take such steps as it deems necessary, including offensive actions to deny, deceive, degrade, damage or destroy space objects which are considered to represent a clear and present danger to US interests.

Australia needs to ask a series of hard questions some of which might be:

1. What are Australia's national interests in space and how are they best protected and promoted?
2. If Australia accepts that assured access to space is a national security priority, what policy and investment options are most likely to achieve the desired outcome over what timescale?
3. If Australia opposes space weaponisation, how active should this nation be in seeking to influence the policies of others, notably the US?
4. What position should Australia adopt if US facilities in Australia directly or indirectly support weapons which the US might deploy into space in the future?
5. What capabilities, if any, might Australia need to develop, in order to be regarded as a credible middle-power voice in these discussions?

For middle power diplomacy, to be in any way credible, it must be backed by some level of investment and capability. It is insufficient to host ground stations, there must be skin in the game, meaning Australian owned and operated satellites, which are integrated into the national information infrastructure. They do not need to be military satellites, indeed, this writer suggests that the first two should be low earth orbiting imaging satellites optimised for environmental monitoring. The in-principle point is that the end-to-end system, of which the satellites are but one element would

be optimised to meet Australia-specific requirements first and the requirements of others second. This is the reverse of the situation today.

Australia MUST develop a modest space program of its own, which includes satellites, to give substance to its diplomacy and to ensure that it has access to the best data possible on which evidence-based policies can be developed with respect to, for example, the national impacts of global warming and climate change.

In the next 15 years questions about space almost certainly will become increasingly prominent in international affairs. Australia's credentials as a candidate for a non-permanent seat on the Security Council will be substantially strengthened if the nation has a stake in space. Conversely, lack of real capability may become a serious weakness in Australia's bid.

A space program is a capability which needs trained people, sustaining industries, relevant ground support facilities as well as satellites and a clear view of how the system works and whom it exists to serve over time. Measured, phased development over the next five years of such a capability, focusing initially on strengthening our public policy capability and credentials is strongly advocated

There is no question that Australia has access to very high quality data in the classified and unclassified domains. The data supports myriad applications including national security, emergency management, climate modeling and weather prediction, environmental measurement and monitoring, and civil and commercial activities.

BUT

This country is never the first user of any of these system systems. Most of the world's satellite operators are located in the northern hemisphere and their systems, especially for remote sensing of all types, are optimised for northern hemispheric observation (this influences sensor selection and design, the orbit selected, satellite power management, location of ground stations, data release protocols, etc). This writer contends, that for operational purposes, Australia's dependence on foreign owned and operated satellites, especially for earth observation, represents a national vulnerability of increasingly serious magnitude.

'Shutter control' *per se* is not the real concern. The real issue is that none of the systems are optimised to meet Australian conditions and requirements. This writer contends that it is simply unacceptable for this nation to be a Cinderella or a Second-hand Rose when it comes to access to spatially-derived information. Australian governments owe their electorates evidence-based policies drawing on the best information available; data from space, in key areas, is presently sub-optimal.

Turning the argument around, Australia pays almost no attention to asking what others might be able to learn about this country through observing the Australian continent from space. Counter-surveillance is not a developed capability in Defence which has implications for the security of operations in all phases – planning, pre-deployment preparation, deployment, operations and redeployment. Counter surveillance has broader implications for example in crop growth monitoring. When going into any negotiation, it is very helpful to know in some detail what others

already know about you. Understanding how foreign-owned satellites might and do operate (separate points) when over Australia is an under-developed element of Australia's national security broadly defined.

In summary, there are compelling strategic and operational reasons for Australia to invest in satellites as elements within a coherent national space capability. The dependencies, vulnerabilities and risks which Australia has accepted in the past are no longer considered by this writer to be acceptable.

Term of Reference 4

Arguments for and against expanded Australian activity in space science and industry including the potential benefits that could accrue to Australia through further development of our space capability.

The basis of this submission is that space is no longer an optional extra for Australia. Defence must have assured access to space to conduct network centric operations and the economy, more broadly, is increasingly reliant on space-based utilities. The question is to determine the measures which might reasonably be taken to ensure with considerable confidence future access to these utilities. This is a question of national strategy well beyond the capacity of the commercial marketplace to solve.

Australia must provide leadership nationally and internationally. Investment in space activities and space infrastructure will be needed to reinforce our diplomacy strategically and to provide national components of capability operationally.

Australia is not coming off a zero base. There are numerous pockets of research and engineering excellence spread across the nation providing niche collaborations, products and services to a raft of demanding users including NASA, DARPA and ESA. There is no sense of an Australian space community. One of the major challenges faced by the principal author of the inaugural space science decadal plan was that many researchers who were asked to collaborate to produce the plan had never met each other and there was a sense of competition between some of those involved. This may be due, in part, to ARC and other grant processes which tend to pit researchers against each other. There is an aphorism that the smaller the prize the more intense the fight. Currently much energy is spent by researchers writing and defending grant applications for very small sums of money – time and effort that might be spent more productively on collaborative rather than competitive activities.

At the risk of generalisation, this writer has observed that a ‘culture of poverty’ is deeply entrenched in the world view of many members of the Australian science community. They have learnt to struggle along by bottom-feeding on ARC and similar grants which constrains imagination and the embrace of more ambitious and potentially productive initiatives. Grant processes are also incredibly cumbersome with high time and bureaucratic overheads. Grant applications should be means to an end, they have tended to assume the standing of ends in themselves. This is hardly consistent with policies intent on promoting innovation.

Specifically with regard to future investments in space science, engineering and industrial capability, the initial investments need to occur over a five – ten year period to ensure that sustainable national capability is being built.

Term of Reference 5

Arguments for and against expanded Australian activity in space science and industry including economic, social, environmental, national security and other needs that are not being met or are in danger of not being met by Australia's existing space resources or access to foreign resources.

In the world of commercial and civil space there are complex and multiple inter-dependencies which arguably work to ensure a stable political and operational space environment. The 'dual uses' (national security and civil/commercial) of many satellites notwithstanding, key systems remain firmly in the hands of governments.

Key drivers for Australia's space engagement in the past half century have included:

- **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 US and previously the UK 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.

Three further drivers are emerging:

- **Spectrum** – The radio spectrum is a finite resource, and trade-offs are looming between national security and commercial requirements. How these trades will be made, and the criteria on which they will be made are not at all self-evident. National and especially international regulatory mechanisms are cumbersome and slow – much slower than the rate of changes of technology. Although technology can allow more efficient use to be made of the spectrum by many users, technology alone may be insufficient to meet the seemingly insatiable demand for bandwidth in the so called 'beachfront' spectrum – those frequencies which are essential for next generation mobile phones, numerous military and first responder applications and space communications.
- **The Impact of Climate and Environmental Change** – on Australia directly as well as on other nations with whom Australia trades. Weather, soil moisture, stream flows, and vegetation cover/growth are but four examples of phenomena which can be readily measured from space. These measurements, with relevant analysis allow predictions to be made which influence behaviours across society – from decisions about what to wear or whether to take an umbrella, to decisions about when to plant, fertilise and harvest crops. Australia's ancient ecology is under huge stress through prolonged drought south of the Tropic, land clearing, over-stocking and over fertilising, etc. Data available from foreign designed and operated satellites is helpful but sub-optimal in total system terms. Stewardship of this continent has critical dependencies on data from space. If this country is serious about its obligations to generations to come, second-best solutions on

which to make evidence-based policies should no longer be considered acceptable by governments or the electorate.

- **New Technologies** – developments in materials science, miniaturisation and the advent of space-based internetworking. Together, these technologies may be expected to combine to reduce the cost of satellites and also to reduce single points of failure in the space segment of satellite systems. Clusters of small satellites, networked together in space, to operate as one virtual larger entity are likely to be flying within a decade. DARPA has recently let contracts for such a system.

As more satellites are fitted with inter-satellite links (ISL), they will form ad hoc networks as satellites rise and set relative to each other and become seamless extensions of the terrestrial internet. To declare my corporate interest, this is the field in which my employer, Cisco Systems, is taking a leading role. However, space-based internetworking, irrespective of which company or companies develop the technologies, has the potential to revolutionise space communications opening up new markets and creating demand for new services and for old services to be delivered in new ways.

Term of Reference 6

Arguments for and against expanded Australian activity in space science and industry including impediments to strengthening and expanding space science and industry in Australia, including limiting factors relating to spatial information and global positioning systems, including but not limited to ground infrastructures, intergovernmental arrangements, legislative arrangements and government/industry coordination.

Earlier this year, the information in the table below was released by the CEO and President of the US Air Force Association. It paints a concerning picture of the current run down state of key components of the US “Space Force”. Replacement programs are often behind schedule, over-budget and beset by technical problems. Looking beyond the technology, 27% of the entire US aerospace engineering workforce is eligible to retire this year. Australia would do well to consider the vulnerabilities which flow from uncritical dependence on some of these capabilities which are increasingly brittle.

The 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			
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 Jan 2008

Satellites are not a panacea. They offer unique advantages because of their location high above earth to provide the utilities mentioned earlier in the submission.

However, they also have vulnerabilities. Some of these are:

- communications and navigation signals can be readily jammed or degraded (intentionally or unintentionally);

- weather affects the performance of communications and earth observation satellites;
- orbits are predictable and relatively inflexible (useful from the counter-surveillance perspective but not when agility and responsiveness to a new situation may be needed);
- satellite launch remains a risky business and once launched, satellites, if they mal-function, are difficult to repair (mostly they are left as inoperable pieces of space junk).

In the context of surveillance, whether for environmental monitoring or national security purposes, the key word is ‘persistence’. Persistence is only achieved by a layered system of sensors the data from which is collected over time and fused to build coherent images of the targets being observed. Satellites, ground-based radars (including JORN) and sensors mounted on manned and unmanned aircraft are examples of the types of capabilities which provide information to decision-makers. The key point is that there is no ‘silver bullet’. The satellite data layer, in Australia’s case, as noted in previous sections, comes entirely from foreign systems which are not optimised for Australian requirements. The associated risks of this dependence do not need to be accepted and are readily and, in the broader scheme, relatively inexpensively mitigated.

The second and further order effects of reducing this dependence are entirely consistent with the aim of Government to reinvigorate the national industrial base and to base it on innovation and the development and application of new technologies to serve domestic and global markets.

Two beginning points could be:

- continued support for both radio and optical astronomy, and
- early adoption of key elements of the inaugural Space Science Decadal Plan.

Government support for Australia’s bid to host the SKA radio telescope has been outstanding. If this telescope is built in Australia, the underlying network can be expected to deliver incredible national benefit. It should allow the nation to think of alternative futures presently denied due to the limitations of the national information infrastructure. It represents to the 21st Century what the Snowy Mountains Scheme represented to the 20th Century.

The concept of Australia hosting a very large optical telescope on the Australian Antarctic Territory is another project of national and international significance.⁴

⁴ Australia’s sovereign claims would be strengthened considerably by locating such an instrument with the associated physical and networking infrastructure on the Antarctic plateau in the Australian Antarctic Territory. Australia’s current activities in Antarctica are confined almost entirely to the coasts and contiguous waters making our claims to huge wedges of the Antarctic continental landmass look somewhat hollow and disingenuous. Antarctica, almost certainly, is going to loom much larger in international affairs in the next 20 years in the context of climate change and as a potential source of food, energy and other raw materials. Stewardship and sovereignty need to be demonstrated through presence and tangible investments.

Australian governments are investing in pathfinder instruments - the Australian SKA Pathfinder (ASKAP) and the Pathfinder International Large Optical Telescope (PILOT) in Antarctica - in support of these very large instruments. They provide starting points through which Australia's scientific, engineering technical and industrial base might begin to expand to meet the challenges of operating, maintaining and improving these instruments through out their operational lives. The disciplines, skills and capabilities are similar to, if not the same as, those needed to support a space industry.

In days of global supply chains, the idea that a nation such as Australia can be totally or even substantially self-reliant is unsustainable. However there are areas where local capability is considered important to provide a regional capability edge in national security terms.

In 2004, the Defence Electronic Systems Sector Strategic Plan (DESSSP) identified five areas in which Australian industry capabilities were considered critical to the self-reliance of the Australian Defence Force⁵. The five areas were:

- military systems integration;
- mobile military communications (which, by definition, includes a satellite communications component);
- electronic warfare;
- niche capabilities in radar; and
- underwater acoustic technologies.

Nine enabling or emerging technology were identified which would warrant focused public sector and industry research and development to support the five capability areas. The emerging technologies identified were:

- photonics;
- monolithic microwave integrated circuits (MMICs);
- artificial intelligence;
- electro-optics;
- radio frequency (RF) engineering;
- radar technologies;
- data fusion;
- safety critical software systems; and
- space-based communications.

One task of the Defence White Paper, presently being written, will be to consider whether there remain areas of industry capability in which some level of national self-reliance is important if not essential. Without seeking to pre-empt the White Paper's findings, almost certainly it will advocate retention of a set of industry skills and capabilities within Australia in the national interest. That set, in the opinion of this writer, is not likely to vary greatly from the findings of the DESSSP.

The technology areas identified above are inter-related. They are core technologies for any innovative economy with applications well beyond Defence. Sensor networks of all types - from telescopes to water monitors in the Murray-Darling basin to

⁵ Department of Defence, *The Australian Defence Electronic Systems Sector Strategic Plan*, Canberra, 2004, p.xxi.

‘Smart’ homes to measurement of human performance- depend on fundamentally the same basic science and core technologies from which all manner of novel applications are derived.

Astronomy, space science, and Defence applied science can be expected to combine to provide foundation stones for a series of inter-dependent industry capabilities which will provide essential elements of self-reliance to critical future national security capabilities. They can also be expected to deliver enormous benefit to the broader economy and society.

Government/industry relationships

A general observation is that governments and industry in Australia continue to struggle to build trusting relationships especially in ventures which entail technical and development risk. As noted earlier, in the context of space, some companies have not acted in their own or their wider industry’s best interests which has not been helpful.

An innovative economy, of which space capabilities are likely to form an essential component, must have contracting mechanisms which promote, encourage and reward technological and entrepreneurial risk-taking. Risk acceptance must become the norm rather than risk avoidance. These words may be easy to write but, in government especially, are very hard to implement.

Contracting reform must occur if governments are to play their part in creating new industries which are based on innovation. This includes industries which would contribute to a national space capability. The preference of the Commonwealth for firm fixed price contracts, including for the delivery of products and services in which there are significant development risks, is a real impediment to innovation. Certainly the Financial Management Act and the Procurement Guidelines say all of the right things about sharing risk and liability but when push comes to shove, the Commonwealth routinely attempts to impose unreasonable commercial terms and conditions on suppliers. The effects include:

- some companies with technologies products and services of potential use to the Commonwealth simply do not bid;
- some companies accept the restrictive conditions and hope that nothing goes seriously wrong – which only serves to increase the exposure of both the Commonwealth and the supplier;
- contract negotiations, even for relatively small value contracts become unduly expensive and protracted, with three major implications:
 - the contract price is higher than it needs to be due to the costs of tendering and contract negotiation;
 - the technology being sought may have been superseded by the time the contract is signed; and
 - the team assembled to do the work may need to be broken up – companies cannot afford to pay staff, especially those who are highly skilled, to wait around whilst contracts are being sorted out.

There is no one size fits all contracting model but for so-called spiral development projects where components of a system(often the software components) are undergoing rapid evolution and change, cost plus or time and materials contracting

models may lead to improved outcomes. The processes and methods used to develop those components of a space industry in Australia which analysis determines are necessary can be expected to play a major role in the success or otherwise of the venture.

Term of Reference 7

Arguments for and against expanded Australian activity in space science and industry including the goals of any strengthening and expansion of Australia's space capability both in the private sector and across government

Comment against this term of reference will be confined to Space Situational Awareness (SSA).

There are millions of pieces of space junk, some the result of human activity and the rest the detritus of the solar system – small rocks and other particulates. Most of these objects are tiny or are in orbits around the earth which present no threat to currently operating satellites. However, there are other objects which do present concern.

The effect of an operational satellite colliding with even a small piece of space debris can be catastrophic for the satellite. Nations which operate satellites are concerned, therefore, to minimise the risk of such collisions taking place. They also seek to understand that any collision which may occur was not the result of a deliberate (therefore hostile) act.

The US Air Force maintains a catalogue of in the order of 15,000 such objects. Some are space junk – satellites which have ceased to operate, debris from experiments such as the ASAT test conducted by the Chinese in January 2007, launch vehicle upper stages, bolts, tools and other objects which have been 'dropped' by astronauts. Another class of objects is operational satellites. Changes in the behaviour of these satellites (orbits, especially), can provide insight into both the capabilities of the satellites themselves and the intent of their owners and operators.

Various nations have SSA capabilities most in a state of disrepair. The US capability is the most robust but it too has deficiencies. One of the most serious is that there are no sensors south of the Equator in the Asia Pacific region. This means that satellites launched south from China, for example, are not detected until they have crossed the Antarctic and are moving north on the far side of the earth. Much can happen between the time of launch (which can be detected) and the time the satellite (or satellites) is detected and its orbit determined.

Large parts of the US catalogue are in the public domain and one might infer that the material which is not may well pertain to US systems or provide, by inference details about the capabilities and limitations of the US SSA system which the US would prefer not to disclose widely.

More countries, including most of Australia's regional neighbours, already or soon will operate at least one satellite (usually for earth observation). Reducing launch costs and the advent of smaller, cheaper and more capable satellites is permitting more nations to own and operate satellites. Some orbits are becoming cluttered increasing the risks of collision and mutual radio interference substantially.

Some organisations which work in the space security domain of public policy are calling for new 'rules of the road' for space. The aims of these 'rules' include:

- to build confidence amongst nations which operate satellites;

- to minimise the likelihood of accidents;
- to minimise the likelihood of strategic miscalculation in the event of accident; and
- to deter nations from seeking to harm the satellites of others by disguising a deliberate (hostile) act as an accident..

SSA capabilities provide essential inputs to the transparency on which the proposed new ‘rules of the road’ would depend. Just what might be disclosed when, to whom and by what mechanism(s) would seem to be topics for fertile international debate. However, the discussions would not have much point if there was not data available to disclose.

Australia itself and the Australian Antarctic Territory are both well-placed to host ground-based SSA sensors.⁶ Such capabilities would not only assist allies but could underpin Australia’s broader space diplomacy which must aim to secure space in the national and global interest. SSA capability would seriously underpin the middle-power diplomacy to which the Commonwealth Government aspires.

⁶ Preliminary calculations indicate that a 2 metre class optical telescope located in Antarctica would be able to detect and characterise space debris in low earth orbit to the size of a small coin. The provisions of the Antarctic Treaty concerning peaceful activities for the benefit of humanity would need to be carefully observed, should such a system be installed.

Term of Reference 8

Arguments for and against expanded Australian activity in space science and industry including realistic policy options that facilitate effective solutions to cross-sector technological and organisational challenges, opportunity capture and development imperatives that align with national need and in consideration of existing world-class capability.

Comments against this criterion pull together some points already made directly and indirectly.

- Space is a multi-disciplinary enterprise.
- Space systems, to be considered as mature capabilities, require balanced investment across all elements of the system of which the space segment (the satellites) are but one part.
- Australia is a sophisticated user of the three space-based utilities (communications, precision navigation and timing and remote sensing).
- The Australian Defence Force has a critical and growing dependence on assured access to these space-based utilities. There are no easily obtained or affordable ground-based equivalents or substitutes.
- Australia's space capabilities lack coherence and direction and are incomplete. The missing pieces include:
 - A sufficient number of space literate policy makers at senior level of government (eg. officials who understand how a multi-spectral image of a wheat crop might be put to use and that it differs fundamentally from a GoogleEarth image of the same field) to properly represent space as an area demanding strategic and policy attention;
 - An executive agent for space at the national level – resourced to bring together, balance and suggest priorities for investments in space science, space education, operational space capability for national security and wider economic and social benefit, and supporting industrial capacity;
 - Space segment (satellites). To be taken seriously in the space counsels of the world, Australia MUST put 'skin in the game' and in this game that means satellites via a sustained program;
 - A satellite design and operations authority around which a space industry, in time, might develop – in concert with complementary capabilities in which Australia seeks a degree of self-reliance for national security reasons (eg. mobile communications and electronic warfare);
 - A Space Situational Awareness capability in support of allies and to underpin middle power diplomacy designed to strengthen space security and deliver the assured access to space now essential for the ADF and important, if not critical, for the national and global economy; and
 - Development of a national counter-surveillance estimate as the first step to developing and implementing a national counter surveillance plan.

Australia today builds world class astronomical instruments and is a leader in niche areas of radar, digital radios and sub-components, phased array detectors and digital signal processing. All of these capabilities are fragile. But, they exist and the skills

and knowledge embedded in them could, with appropriate care and feeding, form the core of a national industrial base capable of supporting and advancing Australia's vital interests in space.

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Canberra
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