Kokoda Foundation

DISCUSSION PAPER SERIES

Looking Upwards to Look Downwards: Contemporary Developments in Australia's Access to Space

Dr Gary Waters and AVM John Blackburn AO (Retd)

May 2014

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EXECUTIVE SUMMARY

This Report summarises the findings of a Kokoda Foundation workshop in March 2014 that sought to develop an understanding of the progress made on Australia's Satellite Utilisation Policy, released in April 2013. The workshop was the first time for some years where the Department of Defence, civilian government agencies (including the Department of Industry, the Department of Foreign Affairs and Trade, Bureau of Meteorology and Geosciences Australia), commercial organisations and Academia have come together to discuss the major Space policy issues facing Australia. Outcomes from the workshop were to:

- Build networks and trust for furthering national Space policy.
- Ensure better-informed advocates for national Space policy in and out of Government.
- Provide an updated environmental scan of national Space policy developments.
- Identify emerging industry opportunities not saddled by industrial-age legacies, which allows companies to take advantage of miniaturisation, new materials, and new operating concepts.
- Ensure consistency of message in approaches to the current Government of what is needed to further Australia's interests in Space.

These future discussions should be shaped and driven by a number of critical policy guidelines and mindsets.

The Kokoda Foundation makes just the single recommendation and that is for the Space community to maintain the momentum from the March 2014 Workshop and to continue their dialogue through regular Workshops or Colloquiums that bring the community together. As evinced from the Workshop, these future discussions should be shaped and driven by a number of critical policy guidelines and mindsets as described in the 'Recommendation and Observations' section at the conclusion of this Report.

INTRODUCTION

In 2013, the Australian Government released Australia's Satellite Utilisation Policy, which states that Australia's national goal in Space is to 'achieve on-going, cost-effective access to the Space capabilities on which we rely'. On 31 March 2014, the Kokoda Foundation held a workshop to develop an understanding of the progress made on Australia's Satellite Utilisation Policy since its release. The workshop was sponsored by Jacobs, a global engineering services company.

This workshop was the first time for some years where the Department of Defence, civilian government agencies (including the Department of Industry, Department of Foreign Affairs and Trade (DFAT), Bureau of Meteorology (BoM) and Geosciences Australia (GA)), commercial organisations and Academia have come together to discuss the major Space policy issues facing Australia. Outcomes from the workshop were to:

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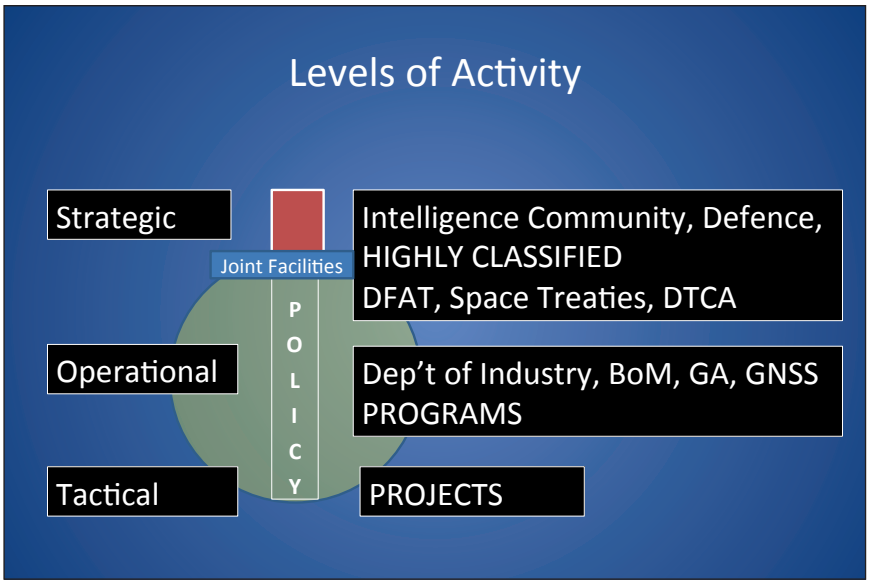
- Provide an updated environmental scan of national Space policy developments.
- Identify emerging industry opportunities not saddled by industrial-age legacies, which allows companies to take advantage of miniaturisation, new materials, and new operating concepts.
- Ensure consistency of message in approaches to the current Government of what is needed to further Australia's interests in Space.

While this Report summarises the discussions from the workshop, it also brings in other important aspects to help provide context and improve broader public understanding. In doing so, the Report examines the importance of Space and the inherent vulnerabilities before addressing national Space policy issues in the broad. It then addresses specific issues involving Space security in terms of Defence policy and capabilities, and international policy and regulatory aspects. From here, the challenges for Earth Observation and Global Navigation Satellite Systems (GNSS) are examined, the role of commercial Situational Awareness (SSA) is discussed, the need to strengthen GNSS with a terrestrial component is explored, and challenges for Australian research are canvassed. Some more general thoughts are offered in 'The Concluding Comments and Way Forward' section, and a comprehensive set of Summary Observations is offered, together with the single recommendation that the Space community should maintain the current momentum by continuing their dialogue through regular Workshops or Colloquiums that bring the community together. These future discussions should be shaped and driven by a number of critical policy guidelines and mindsets outlined in this Report.

BACKGROUND AND CONTEXT

Whilst Australia's reliance on Space and the potential vulnerabilities that accrue are reasonably well known and solid objectives were expressed in Australia's Satellite Utilisation Policy, there has been little public discussion on achievements over the past 12 months, and on Australia's increasing Space dependency and how it intends to ensure continuing access to Space. Small to medium powers such as Australia are dependent on Space but they have no significant influence on developments in Space, so in a sense, they are Space disadvantaged.

The various activities in Space can be seen through the lens of strategic, operational and tactical levels as depicted below.



Legend:

DTCA - Defence Trade Controls Act.
DFAT - Department of Foreign Affairs and Trade.
BoM - Bureau of Meteorology.
GA - Geosciences Australia.
GNSS - Global Navigation Satellite Systems.

The Department of Industry had principal carriage for developing Australia's Satellite Utilisation Policy and has enduring responsibilities for civilian Space policy development and coordination. Defence and DFAT are heavily involved in Space security policy and related activities. Ground-based SSA capabilities are being developed at North West Cape under Defence auspices and DFAT has carriage of the regulatory aspects of Space security, including the treaty regime and the emerging International Code of Conduct for Outer Space. There are Canberra-based companies that are world leaders in specific areas. For example, Electro-Optic Systems (EOS)[1] that uses ground-based lasers to track Space objects and Locata that has developed a locally-based terrestrial positioning capability. There is no question that issues involving investment in satellite communications, earth observation and Global Navigation Satellite Systems (GNSS)[2] are vitally important economic considerations for Australia in future.

There is no question that issues involving investment in satellite communications, earth observation and Global Navigation Satellite Systems (GNSS) are vitally important economic considerations for Australia in future.

1 Note that the acronym EOS is used throughout this Paper, where it refers to Earth Observations from Space, not the company Electro-Optic Systems.
2 GNSS refers to current and future satellite navigation systems deployed by the United States (GPS), Russia (GLONASS), European Union (Galileo), China (Beidou), Japan (QZSS) and India (IRNSS). These systems currently, or will soon, provide reliable Position, Navigation and Timing (PNT) information in real-time, which can be used for a wide range of applications.

There has been a lot of activity in SSA over the past four years; for example:

- The Australian/United States Ministerial (AUSMIN) Communique of February 2011.
- The Australian/United States agreement to cooperate on SSA.
- The Australian/United Kingdom Ministerial (AUKMIN) Communique of February 2011.
- Identification of the unique geographical advantages offered by Australia.
- The C-Band Space surveillance radar at North West Cape.
- The Space Surveillance Telescope at North West Cape.
- Australia's strong contribution to the Code of Conduct in Outer Space.
- The launch of the Cooperative Research Centre (CRC) for Space Environment Management in March 2014.

It is also important to note that the Space Industry Association of Australia is developing a bid to host the International Astronautical Congress (IAC) in September 2017 in Adelaide. The IAC is the world's largest annual Space gathering, attracting in the order of 3,000 delegates. Adelaide's bid is highly regarded and the decision will be made later this year. If the bid succeeds, the Congress will provide an aiming point for companies, research organisations and Government to work towards substantive policy announcements and investments.

The Australian Space sector is small. There are approximately 8,400 people employed in the sector, almost all in data processing and satellite communications. Only one company (Silanna) makes Space-qualified components. There are about 30 companies that provide Earth Observations from Space (EOS) data as re-sellers. Optus has five satellites and a sixth in build. The National Broadband Network Company (NBN Co) is to have two satellites, and NEWSAT at least one satellite (possibly more); although recent reporting about NBN Co suggests that the two satellites might be sold to Optus and Intelsat to reduce the capital-intensive nature of NBN Co. Australia has a small but high-quality Space research sector focussed on the solar and planetary sciences.

There are two very important EOS challenges emerging for the near future. First, 19 out of the 22 satellites that provide EOS data today are due to reach the end of their planned lives by 2015 and at this stage there is no strategy for gaining access to alternative sources for the data. Second, major re-investment is needed in EOS ground infrastructure.

The Importance of Space-based Capabilities and Vulnerabilities

Today, Space-based capabilities have become so integrated into the basic infrastructure of Australian society that most people don't even think about it or notice it any more. Australia's reliance on satellites brings significant benefits but also significant risks. Indeed, the problems society would face if it were to lose access to all Space-based assets even for a day are considerable.

The loss of Space-based capabilities, particularly in communications, GNSS/Position, Navigation and Timing (PNT) and EOS would have an immediate impact on the daily lives of all Australians; however, back-up systems do exist to enable continuation of critical functions and activities for a limited period of time. The real problem emerges when the loss extends past a day or two, when back-up systems are relied upon to perform all the functions currently provided by Space assets. Awareness of the importance of Space to commerce in addition to public safety and national security needs to be continually raised, but not in an alarmist fashion.

Awareness of the importance of Space to commerce in addition to public safety and national security needs to be continually raised.

A positive development is that Space is now on the critical infrastructure agenda and the Attorney-General's Department examines critical infrastructure dependencies on Space, especially banking, navigation, and national security. In February 2014, the Space Community of Interest group was established within the Trusted Information Sharing Network to highlight interdependencies between Space-related infrastructure and critical infrastructure in Australia.

Today's military operations depend on Space for a myriad of activities including: missile warning and defence; Intelligence, Surveillance and Reconnaissance (ISR); Space control; communications; weather prediction; Space access; and PNT from the Global Positioning System (GPS). Space capabilities enable the full spectrum of war-fighting and national security activities – such as distributed operations and operational support, command and control, predictive battlespace awareness, operational situational awareness, precision strike, reduced decision-to-action cycle, and data exfiltration. Space has become an integral part of today's military operations.

Mission effectiveness when operating in an environment of contested Space services would be problematic if Satellite Communications (SATCOM) and GPS were disrupted or denied. Military forces have become highly dependent on Space capabilities and it is becoming a contested domain. Australia's military forces have a heightened interest in SSA and Space protection and they are seeking to better understand specific Space dependencies.

Indeed, satellites can be seen as the 'soft underbelly' of national security. The threats to satellites may include a direct attack on the satellite, failure of the satellite, collision of the satellite with man-made orbital debris, adverse Space weather, and jamming and spoofing by adversaries.

AUSTRALIA'S NATIONAL SPACE POLICY

As previously discussed, The Australian Government released *Australia's Satellite Utilisation Policy* in 2013, in which the following principles were articulated:

- Focus on Space applications of national significance.
- Assure access to Space capability.
- Strengthen and increase international cooperation.
- Contribute to a stable Space environment.

- Improve domestic coordination.
- Support innovation, science and skills development.
- Enhance and protect national security and economic wellbeing.

The policy aimed to develop Australian capabilities to actively participate in solving the challenges of the Space environment and fully realise the coming opportunities presented by Space. It argued that Australia's national goal in Space is to 'achieve on-going, cost-effective access to the Space capabilities on which we rely'. Achieving this goal will contribute to five key benefits for Australia:

- Improved productivity.
- Better environmental management.
- A safe and secure Australia.
- A smarter workforce.
- Equity of access to information and services.

Language has been and continues to be an issue for Australia's national Space policy in that there has been little support for a Space policy in the broad, as evidenced by Cabinet's choice of the title for Australia's national policy in 2013 as 'Satellite Utilisation Policy'. Furthermore, the Space policy agenda is not a front-line agenda. Therefore, any attempts to further Space policy should be carried out as part of other agendas. Of note, the incoming Government has indicated that the current policy is extant and is to be pursued.

As an example of a broader agenda, the Defence White Paper 2015 (DWP 15) provides an opportunity to inject Space policy thinking, such as satellite communications; remote sensing; PNT; Space security; and so on. There is also the Government's regional and remote area development policy agenda in which Space policy aspects could be injected.

Australia's role in the search operations for the missing Malaysia Airlines Flight MH370, especially in terms of data analysis and priority setting for search areas and mobilisation of search and recovery operations, underscores the importance of Space capabilities. However, MH370 was also a case study in the strengths and limitations of satellites. Radar satellites do not provide clear pictures of objects; electro-optical satellites that work in the visual light spectrum do not work through cloud; resolution is a critical factor; there is latency in tasking and processing; and nations seek to protect the details of their actual capabilities from being discerned by other nations

Other policy agenda opportunities and event-driven opportunities will arise, which can be leveraged to pursue the Space policy agenda and the building of Space capabilities. There is also cross-cutting agency policy work currently being undertaken, especially in relation to the long-term sustainability of Outer Space activities through developing international regulatory regimes and a code of conduct. In addition, Australia is moving into a far more complicated international engagement posture in Space as Japan and the European Union (EU) become more involved, as well as China, India and the ASEAN countries. Thus, Australia's previous focus on the United States as its major Space partner in civilian and national security matters is being broadened, and high-quality imagery from remote sensing and positioning satellites is now being obtained from many nations.

The recently concluded Australian Space Research Program has successfully developed Australia's niche Space capabilities by supporting Space-related research, innovation and skills in areas of national significance or excellence. The $40 million program was awarded to 14 consortium projects.[3]

The CRC for Spatial Information has been instrumental in furthering the development of policy and capabilities for earth observation and positioning and navigation. The CRC for Space Environment Management has just been set up and will strengthen the nation's research capability; this CRC is discussed in more detail later in this Report

There is a dependency issue that needs to be addressed. Making and launching satellites in Australia is not on the Government's agenda and will not garner support. Industrial, military, security and professional services can be purchased on the international market and Australian corporations such as Optus know how to procure satellites and services that can be drawn upon. So, while design, operations and integration capabilities will be pursued, the ability to make and launch satellites will not.

While previous arguments have been mounted for pursuing an Australian Space Agency, such a move could be counter-productive as proponents are not clear on just what such an Agency would do. Indeed, it might increase the reluctance of Government to focus on Space policy. Furthermore, this Government has shown a reluctance to retain, let alone create, small agencies.

It is clear that Space data is one of the data sources that need to be brought to bear in times of disaster and crisis.

The way forward for the Space community should be to maintain the current consensus on satellite utilisation policy in light of the mounting pressures on public service manning levels, and not be overly ambitious. It is important to connect Space to other front-line policy interests (such as DWP 15, Northern Australia White Paper, and the Agriculture Competitiveness White Paper). There is an opportunity to add information and positioning infrastructures to the infrastructure development equation and seize event-driven opportunities such as the search for MH370 to underscore the value of such infrastructures. In this respect, it is clear that Space data is one of the data sources that need to be brought to bear in times of disaster and crisis. The more clear-cut examples of this, the more valuable will be Australia's Space infrastructure.

SPACE SECURITY

Defence Policy Aspects

Space is a key policy challenge for Defence policy makers, and will need to be a key consideration for the upcoming Defence White Paper. Australia uses primarily foreign, mostly United States, Space services. Australia is not an owner or operator and, therefore, not a heavy investor in Space. There has been little drive to consider Space policy at a whole-of-government national security level, while within Defence,

3 More details on this program can be found at: http://www.space.gov.au/AustralianSpaceResearchProgram/ProjectFactsheetspage/Pages/default.aspx

Space policy has tended to focus more on seizing opportunities as they arise; such as collaboration on the Space Surveillance Telescope and C-Band radar, rather than through a deliberate, top-down strategic planning process.

There is no apparent linkage from Defence's reliance on Space-based capabilities to the impacts if it were to lose access. Reliance on Space-enabled capabilities, and the ensuing risks, do not appear to be considered in planning for the future. For example, what is the impact on new fifth-generation capabilities such as the Air Warfare Destroyer and Joint Strike Fighter?

The vulnerability in Space is a key challenge for policy. Space is vulnerable to deliberate interference and to non-deliberate effects (such as Space debris or Space weather). The growing Allied reliance on Space is leading to counter-space capabilities being developed by certain countries. While Space systems might not be owned by Australia, the nation will nevertheless suffer the effects if access is lost or denied. Thus, Australia needs to leverage the United States Department of Defence's thinking on operating in a Space-denied or Space-degraded environment.

In short, Australia needs to better understand its reliance on Space for Defence activities, ensure access as best it can, and plan for the worst. In this case, self-reliance is about ensuring access, not necessarily about owning and operating the Space systems.

Defence Capability Aspects

Defence has arguably evolved to a critical reliance on Space-based capabilities in support of national security, and the extent of that reliance and the inherent vulnerabilities are not as well understood as they could be. For too long, Space has been regarded incorrectly as a benign environment.

Australia currently has access to the following operational Space capabilities:

- Defence Payload System (hosted on Optus C1).
- Wideband Global Satellite Communications (WGS).
- Ultra High Frequency (UHF) leased payload (hosted on Intelsat-22).
- Space-based Infra-Red (IR) processing.
- GPS.
- ISR – United States and alliance partner support.
- AUS Space Operations Cell (AUSSpOC) within the Air Operations Centre in Headquarters Joint Operations Command (HQJOC).

While the AUSSpOC is an Australian capability, the other listed capabilities are not, which highlights Australia's reliance on access to capabilities and data that are owned and operated by others, and underscores the need for Australia to consider investing more in national capabilities.

Near- and medium-term Space capabilities to which Australia will have access include:

- Combined Space operations.
- C-Band Space surveillance radar.

- Precision laser tracking.
- Space Surveillance Telescope (SST).
- Space-based IR enhancement.

Possible long-term Space capabilities to which Australia will have access include:

- Space Fence (this would be the second one after the one being installed in Kwajalein, possibly in 2020; noting that it would be a US-owned and Australian-operated facility on Australian territory).
- Next generation SATCOM.
- GPS Military- (M-) code.

While the Australian Defence leadership recognises the importance of Space-based capabilities, investment in such capabilities and trained personnel needs to grow but budgets are limited. Thus, Defence will explore various collaborative and SSA options. In this respect, Australia is developing Combined Space Operations (CSpO) which are Space activities with Allies to strengthen deterrence and improve mission assurance while optimising resources across the participating nations. Australia's collaboration vision in this coalition context for SSA is to:

- Strengthen deterrence.
- Improve mission assurance and resilience through burden sharing and niche capabilities.
- Optimise resources across the nations.
- Understand and mitigate Space-related vulnerabilities.
- Provide expert and timely advice to Defence, Government and others.
- Provide a hub for SSA in Australia's immediate region.

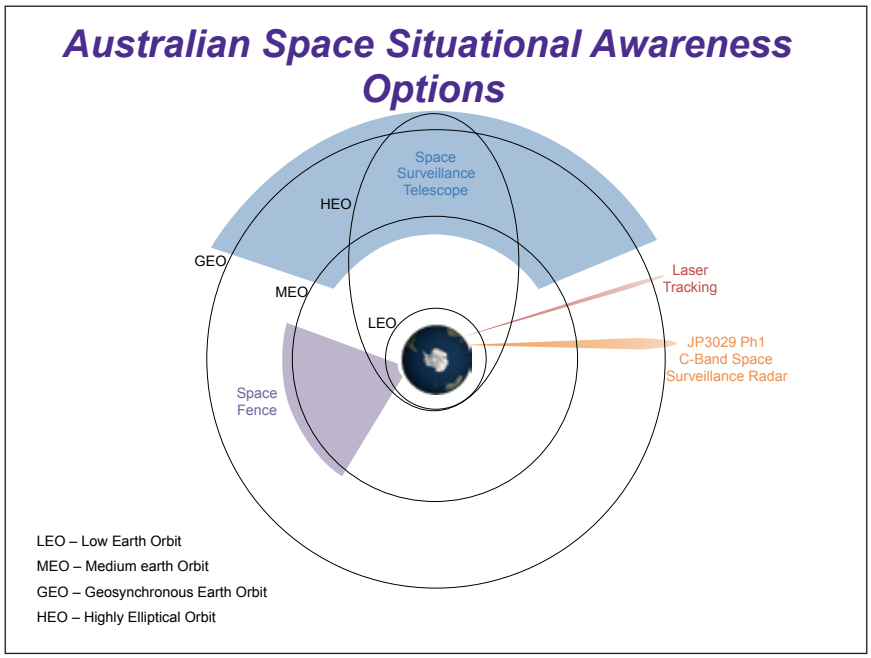
Possible Australian contribution to improved collaboration can be effected through:

- Australia's geography:
  - Siting of sensors;
  - Southern hemisphere launch/re-entry;
  - Southern hemisphere object tracking; and
  - Regional reporting.
- Burden sharing:
  - Sensors (Joint US/Australian and indigenous);
  - Analysis (e.g., conjunction of regional or Australian assigned objects); and
  - Science and Technology.

In a Defence context, SSA involves fusion of many sources of data to form a baseline to predict, detect and warn what may happen to Space assets to ensure continuity and long-term health of Space capabilities. SSA provides the foundation for safe and responsible Space operations, assuring access to and protecting Space capabilities. The basic elements of SSA include:

- Surveillance of everything related to Space – ground, link and Space segments (including Space objects and Space activities).
- Intelligence on adversary Space doctrine, tactics, operations, and systems.
- Reconnaissance of items of interest (e.g., radar image).
- Monitoring and analysing conditions in the Space environment – to distinguish and warn of natural phenomena.
- Monitoring friendly assets, capabilities, and operations.
- Launches.
- Conducting conjunction, fusion, analysis, and dissemination.
- Re-entry of debris.
- Providing Command, Control and Communications (C3) as well as Processing, Exploitation and Dissemination (PED) needed to accomplish all of the above in a coherent, coordinated fashion and then direct action, as appropriate.
- Combining the elements above for actual SSA – e.g., focusing surveillance given inputs from intelligence and correlating information from multiple sensors.

There are several SSA key points that emerge from this discussion. First, SSA is essential for safe satellite operations, event attribution and threat avoidance. Second, the United States cannot continue to effectively carry the SSA burden alone. Third, the US Space Surveillance Network is concentrated in the northern hemisphere, which limits detection and timeliness of some events. SSA options for Australia are depicted in the figure below.



International Policy and Regulatory Aspects

Space security does need a higher policy priority, given modern society's reliance on Space-enabled infrastructure for a wide range of critical services, the economy, and national security. However, there are differing levels of awareness across interested parties of the relevance of Space security to these equities. For that reason, Space security development has to place a premium on consultation and coordination across Government, and with industry and the research community. Furthermore, there is significant and growing interest from Australia's regional partners in Space, particularly in the use of Space-enabled capabilities to address pressing development, environmental and disaster management problems, and increased interest in engaging Australia on Space issues.

Principle Four in Australia's Space policy is to 'contribute to a stable space environment' through Australia having a voice in the international arena on supporting rules-based international access to the Space environment, and promoting peaceful, safe and responsible activities in Space. In this respect, Australia has been seeking to look ahead and actively engaging to help shape the debate and direction of Space development internationally.

It is vital for the Space community to determine how Space relates to core Government policy agendas, and to continue to coordinate effort in this respect. Space is an area of growing cooperation with regional partners, and is an area where Australia is pursuing closer relations with Japan, India and Indonesia, for example. Regional foreign and other ministries are paying more attention to Space issues, including how they fit within the context of other agendas. This presents clear opportunities for the Australian Space community.

Promoting Australian exports is a core objective of the foreign affairs and trade agenda, with the Government's emphasis on economic diplomacy. This includes the promotion of goods and services exports by Australia's highly-capable Space industry. An important facet of Australian diplomacy is promoting the image of Australia as a sophisticated and technologically advanced country. Science diplomacy is also a part of Australia's international engagement. This area, too, can be leveraged to inject Space issues into the agenda. Development assistance is another field in which Space could play a greater role, particularly in disaster management and environmental monitoring by developing nations in the region. In this respect, it is important to understand the agendas of regional countries and, in partnership with them, to determine what role Space could play in Australia's development assistance agenda.

Australia can have a significant influence on regional thinking about Space through a creative and proactive approach that leverages Australia's reputation.

Australia has brought the issue of space security to the attention of the ASEAN Regional Forum, where it continues to be a subject for consideration since the inaugural Space Security Workshop, which Australia organised and co-chaired with Vietnam in late 2012. Australia can have a significant influence on regional thinking about Space through a creative and proactive approach that leverages Australia's reputation. But this puts a premium on stepping up the nation's intellectual and policy efforts on Space security, which in turn demands better connections with industry and the scientific community.

One key pathway forward is to focus on Space-enabled infrastructure that underpins economies, societies and national security. Further efforts to raise awareness within Government is needed, but that does need to link to the Government's priority agendas. As Japan, China, India and South Korea expand their Space capabilities, opportunities arise for Australia to focus more closely on Space within the broader foreign affairs and trade agendas with these countries. This also applies to other countries of the region as they expand their Space capabilities.

Space security is being re-defined. Arms control initiatives have struggled for the past two decades. In recent years, the major debates regarding Space security have centred on three aspects: the placement of weapons in Space, counter-space anti-satellite weapons, and the proliferation of Space debris that poses a danger to satellites and Space craft. Currently, the concerns over the first issue have abated somewhat; while concerns over the second have increased, mainly through the possible asymmetric effect that less-capable nations could have on more powerful nations. It is the third issue - proliferation of Space debris – that is now of the highest concern, and practical ways forward are needed, with some degree of urgency.

While there is a degree of fatigue in the international community because of stasis in arms control discussions, there is an opportunity to take up the Space debris issue internationally. The European Union's (EU) proposal for a Code of Conduct in Outer Space can be a coalescing force that could lead to a practical multilateral approach emerging. The Code focuses on preventing the proliferation of Space debris; covers all Space activities, including military and civilian; and aims to create norms of behaviour by agreeing on safe practices and proscribing irresponsible behaviours leading to the creation of Space debris. Australia is strongly-supportive of this Code as a practical, achievable step in dealing with Space debris as the pressing issue.

Australia also supports the work of a United Nations (UN) Group of Government Experts who developed a report on Space transparency and confidence-building measures. Australia's contribution examined the application of international law to Space.

In international and regional fora, the Australian Government's primary focus is on Space debris. While the EU has attracted some criticism for developing the Code of Conduct outside of a United Nations framework, this has been necessary given that no forum had the requisite broad mandate to deal with both civil and military Space issues. It is important for Australia to help broaden support for this Code of Conduct, which could be completed later in 2014. Australia is encouraging improved regional awareness of the Space debris problem, particularly through the ASEAN Regional Forum.

Australia is well-placed to develop economic opportunities through the presence of foreign-owned ground stations in Australia, while managing national security concerns. This issue is being addressed as part of Principle Seven in Australia's Space policy, which is to 'enhance and protect national security and economic wellbeing'. As this approach matures, it will be released to industry and the research community for comment.

CHALLENGES FOR EARTH OBSERVATION POLICY

The key challenge for Earth Observation policy in Australia is to develop a broad, enduring agenda and narrative that works for Australian society. Australia has developed its Space policy on paper, but to ensure effective implementation, that policy needs to be linked to broader Government agendas. It also needs to be underpinned by continuing stories of success that demonstrate indisputable value to the community.

The key challenge for Earth Observation policy in Australia is to develop a broad, enduring agenda and narrative that works for Australian society.

Establishing the Need for a Space Policy

An important step in establishing the need for a Space policy was the 2005 study by Senator Grant Chapman - *Space: A priority for Australia* – which noted that Australia was unable to make well-informed, nationally coordinated decisions, particularly in the key areas of communications, disaster response, transport, resource management, and competitiveness.

Another important step was the Athena Global Report in 2006 - *National Remote Sensing Data Requirements – Gaps and Opportunities for Australia*. The key issue in this report was the increasing operational reliance on Earth Observation from Space.

In 2008, Brett Biddington published his Kokoda Foundation report - *Skin in the Game: Realising Australia's National Interests in Space to 2025*. The key finding in this report was Australia's dependency on foreign owned and operated satellites for basic services.

Also in 2008, the Senate Standing Committee on Economics released its report - *Lost in Space? Setting a new direction for Australia's space science and industry sector*. The key observation from this Senate report was that it was time to set some clear directions, develop a Space policy and appoint an agency to implement that policy.

Focussing the Development of Earth Observation Policy

These reports all helped focus effort on Space. What was then needed was something more specific to focus effort on determining what an Australian Earth Observation (EO) policy might look like. The first steps in this direction were the aforementioned 2006 Athena Report and the 2008 Senate Report, which noted that the most important commercial aspect of Space for Australia was 'looking down'; thus setting the scene for placing a priority on carrying out earth observations. In 2009, *An Australian Strategic Plan for Earth Observations from Space* noted the following priority areas needed to be addressed: a national strategy; long-term access; international cooperation; acquisition; processing; and research and education.

In 2010, three reports added to this emerging picture for EO policy. First, *Views from the Earth Observation Community* noted Australia's dependencies on EO and identified that 90 Government programs were dependent on EO. Second, *Analysis of Australian Government Activities* highlighted that outlays for civilian agencies were $105 million (0.01% of Gross Domestic Product (GDP)), involving CSIRO, BoM, GA, and others. Third, *Economic value of Earth Observations from Space* highlighted that in GDP terms, EO accounted for 0.3% of GDP ($3,300 million). This estimate was assessed as conservative and growing.

In 2011, *Priorities for Earth Observations from Space* highlighted these priorities: coordination and cooperation, access to observations, communications infrastructure, extracting value, and sustained capability to deliver.

These various efforts in establishing an Australian Space policy and EO policy have led to three important achievements. First, the Satellite Utilisation Policy has been released; although it remains to be seen the extent to which the current Government supports this policy. For now, the Government seems content to use this as extant policy, and the policy is supported by the States. Second, infrastructure plans have been developed but remain unfunded. Finally, there has been improved public dialogue (with less of the 'giggle factor' as discussion centres on satellites rather than Space more generally).

The principal challenge from here is to establish the grand and enduring national agenda that involves Space and Earth Observations. Policy, industry involvement, and capabilities are all needed. Australia needs to identify and foster its advanced industries and determine the nation's digital future in EO.

The lack of data that is made publicly available is a major issue. It is a complex challenge, the solution to which needs to be designed first to determine where best to invest first. As Malcolm Turnbull said in his Speech to the Australian Information Industry Association (AIIA) Navigating Analytics Summit, on 20 March 2014:

> "By making available its extensive data sets, government—through open data—has a critical enabling role to play. Would the real-time app, and countless others, be available without free and easy to access government data".
>
> "Unfortunately, in Australia, the private sector's interest in leveraging public data has been limited simply because of the lack of data that has been made publicly available".

Apart from this immediate-term principal challenge, there are also some other short-term challenges that need to be addressed. Does the EO community simply wait for a clear government agenda and an improved budget position? Or, does the EO community find the place for EO in the delivery of the Government's national agenda and join the dots at the bureaucratic level? In addressing these short-term challenges, it is important to:

- Re-frame the discussion in terms of the challenges of Big Data, timely response, industry involvement and Precise Point Positioning (PPP).
- Continue to build the EO community together.
- Ensure consistent, credible messages.
- Engage (more) with industry.
- Maintain the evidence base.
- Promote achievements.
- Provide continuing stories of success that demonstrate indisputable value to the community, noting that these often come from 'left field'.

Satellite monitoring of ground water, bushfires, and condensation trails that can help locate missing aircraft are all important examples of the value of earth observations.

The National EO Plan is coordinating and leveraging all parties, but capability enhancement is needed in acquiring and extracting data, and genuine transformation is essential to position Australia for the future. Funding remains the biggest issue; for example, it would be useful to set up a national imagery organisation.

In summary, the main challenges for improving earth observation policy are:

- Define just what the challenges are.
- Look for the enduring national agenda that involves Space and Earth Observations.
- Join the dots at the bureaucratic level; i.e., between the science and policy agencies.
- Re-frame the discussion in current terms.
- Maintain the reports that provide evidence of the value of EO.
- Maintain a coherent, consistent and "giggle-free" message from the EO community.
- Continue to build the EO community, and especially include Industry.
- Promote real examples where value is delivered from EO capabilities.

CHALLENGES FOR GNSS POLICY

The sub-text of this topic might well be encapsulated as: *Adopting a whole-of-nation approach to a sustainable, multi-GNSS enabled National Positioning Infrastructure.*

Precise satellite positioning technology will potentially add up to 2.1% to Australia's GDP by 2030 through productivity gains in mining, construction and agriculture alone.

There is no question that GNSS Positioning is transforming Australian Industry. Precise satellite positioning technology will potentially add up to 2.1% to Australia's GDP by 2030 through productivity gains in mining, construction and agriculture alone.

The *Australian Strategic Plan for GNSS*,[4] published in July 2012, argued that GNSS must lie at the heart of a new component of critical infrastructure – the National Positioning Infrastructure (NPI). The NPI should be capable of providing robust, reliable, fit-for-purpose, real-time services to a vast range of PNT applications.

Australia is fortuitously-placed geographically to benefit in a major way from the coverage of the multiple GNSS services coming on line, which opens up application and industry development opportunities that need to be seized. International agreements may be needed to underpin these efforts. However, the national dependence on continuous availability of GNSS signals is a largely unexplored area of national vulnerability that needs attention by Government to assess the level of risk exposure; the potential impact of loss or degradation of GNSS signals, including but not only, as result of interference and jamming; and actions to be taken to limit damage.

4 The *Australian Strategic Plan for GNSS* was prepared at the request of the Australian Space Consortium by a Working Group chaired by Professor Chris Rizos, under the direction of a Steering Committee chaired by the Honourable Gary Nairn.

Importance of Positioning to the Australian Government

Precise satellite positioning is vital for Government service delivery, particularly in terms of: national mapping; the NBN; natural hazards; and emergency management.

The Australian Rail Track Corporation (ARTC) is owned by the Commonwealth of Australia. In terms of rail transport, Positioning allows for: reduced cost of maintaining control of the rail centre-line; reduced cost of maintaining rail curvature; and lower cost provision of accurate curve and gradient data.

Road transport, too, depends on Positioning. Safety systems such as vehicle-to-vehicle and vehicle-to-infrastructure will be introduced into Australia around 2018. Road fatalities in Australia cost $17 billion per annum. Vehicle-to-vehicle communications with high-accuracy positioning/mapping systems can provide Australia a benefit of approximately $20 billion per annum by avoiding congestion, saving 50% of lives and reducing green house gas emissions.

National Positioning Plan

The National Positioning Plan's vision is: 'Instantaneous, reliable and fit-for-purpose positioning and timing services anywhere, anytime across the Australian landscape and its maritime jurisdictions'. The Plan's mission is: 'A coordinated whole-of-government approach towards building a National Positioning Infrastructure to support government services and industries, and deliver economic wellbeing for Australia'.

There are five key recommendations for Australia's National Positioning Infrastructure (NPI):

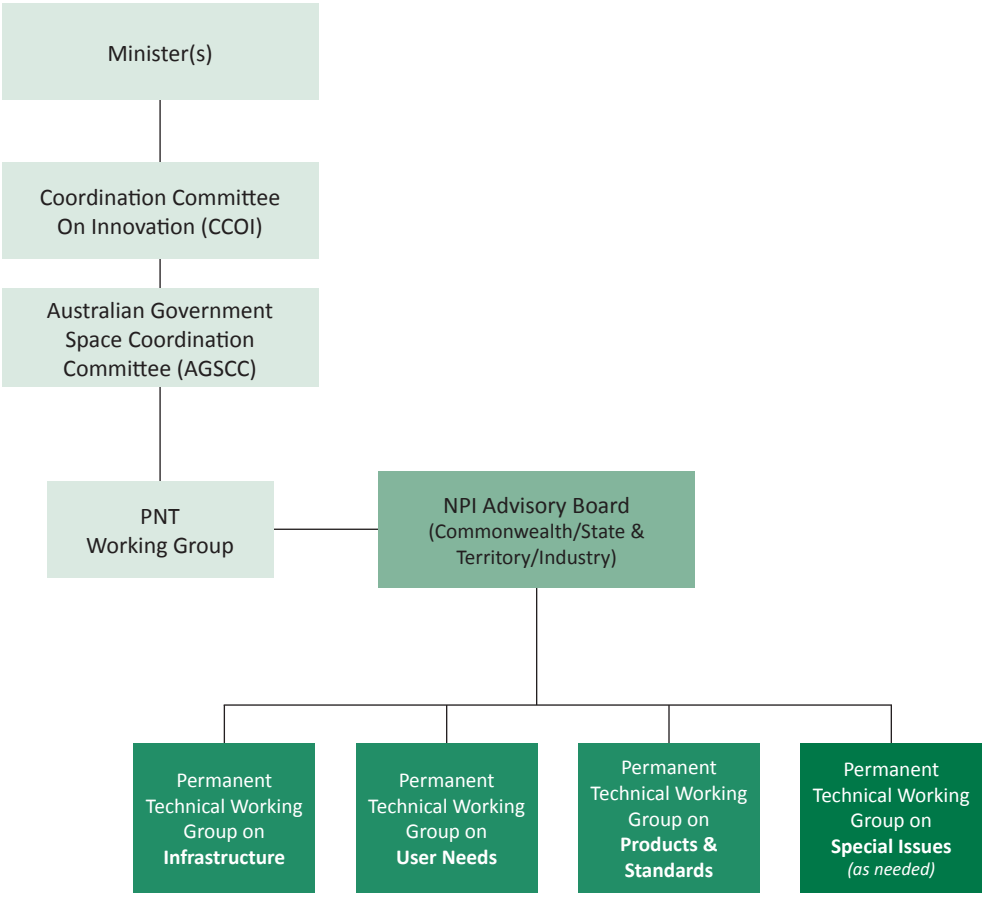
1. Australian Government must provide leadership in designing an NPI that is flexible and extensible to meet the needs of all users of positioning information into the next decade.
2. Endorse a whole-of-government approach for developing and implementing an NPI including the establishment of a governance structure.
3. Endorse the development of standards and guidelines for the implementation and operation of an NPI to align with existing international standards.
4. Develop an overarching infrastructure implementation plan that accounts for physical and ICT infrastructure, to deliver a high integrity national positioning capability that recognises the existing and ongoing investment in positioning infrastructure.
5. Develop a risk mitigation strategy to ensure that Australia's dependence on GNSS systems is mitigated through appropriate agreed contingencies.

Building Australia's NPI centres on improved governance, ground infrastructure development, and GNSS analysis capability. Improved governance occurs through the NPI governance structure which:

- Provides reporting to Government.
- Allows broad participation.

- Addresses key implementation and ongoing utilisation issues:
  - Standards,
  - Users needs analysis (products specification),
  - Infrastructure design,
  - Sustainability models,
  - Spectrum management, and
  - Augmentation delivery method (e.g., Satellite-Based Augmentation System).

The NPI governance structure is depicted below.



Improved International Engagement is also an aspect of improved governance which allows:

- Engagement with system providers.
- Engagement with infrastructure and capability providers.
- Participation in standards development.
- Regional reference frames.

The other two areas for building Australia's NPI - ground infrastructure development and GNSS analysis capability – are summarised below.

Ground infrastructure development:

- Densified high integrity national network.
- Fit-for-purpose for real-time applications.
- Unification of "tiers" of infrastructure into a national capability to ensure cost effectiveness and interoperability.

GNSS analysis capability:

- Sovereign Australian GNSS software.
- Multi GNSS +.
- Designed from the ground up to facilitate real time processing.
- No predetermined technical solution (i.e., Precise Point Positioning (PPP) or Network Real Time Kinematic (NRTK)).
- Open source to support GNSS research sector.
- Structured to ensure agility.
- Provide integrity monitoring for Space and ground (user) segments.

Conclusions

The principal conclusions from this discussion on GNSS are:

- The NPI plan has been developed and implementation has commenced.
- The governance arrangements are being established.
- The design of Analysis Centre Software will begin this year in a joint Auscope / GA / CRC project.
- The unification of infrastructure will also continue.
- NPI will assist Australian users of positioning and timing to take the next big capability step.
- Many Australian industries will retain their competiveness through the use of precise positioning.
- Australia's positioning sector will continue to lead.

COMMERCIAL SSA

There are some important opening thoughts that need to be stated before examining commercial SSA. First, SSA is essentially about Space information and intelligence. Second, asymmetric warfare in Space will likely manifest in its initial stages, as a series of accidents in Space that trigger a debris cascade. The civil and military worst-case scenarios look the same! Third, Australia was involved in the very early tests and experiments supporting GPS and adjunct SSA capabilities were also developed. Fourth, the policy for the past 20 years has been to shepherd commercial SSA requirements into client relationships with Defence and contain disruptive technologies. Events are overtaking this strategy.

Space debris is now considered to be a greater threat than that of asymmetric warfare from Space. All Low Earth Orbit (LEO) satellites are in jeopardy, with the potential for half of those assets to be lost in a handful of years.

Australia's dependence on Space-based capabilities was discussed earlier and it is clear that the economic and social impact on Australia of a loss of access to such capabilities would be considerable; some even suggest catastrophic. Also mentioned earlier, was the observation that Space debris is now considered to be a greater threat than that of asymmetric warfare from Space. All Low Earth Orbit (LEO) satellites are in jeopardy, with the potential for half of those assets to be lost in a handful of years.

Debris is increasing through collisions in Space. One example illustrates the amount of debris that can result from a collision - on 10 February 2009 two satellites (Iridium 33 and Cosmos 2251) collided over Russia. The debris created from this collision resulted in 1,800 pieces greater than 15 centimetres in size and more than 7,000 pieces greater than 1 centimetre.

While the potential for Space debris to impact on working satellites (that represent critical infrastructure) presents a serious societal threat, it also offers a significant commercial opportunity to deal with Space debris. That is why commercial SSA is so important, particularly as the national security interest has broadened to incorporate national economic wellbeing.

Commercial SSA involves satellite proprietors seeking commercial risk-reduction solutions for specific assets, based on known risk factors for asset loss due to collision. Some commercial SSA activities are already operational. These involve organising and optimising current knowledge of Space debris for collision avoidance.

Space investment is now so high ($900 billion of Space assets and trillions of dollars in global economic terms) that the increasing risk means that new debris tracking and collision mitigation technologies can be cost-effective. Not only has it become cost-effective to avoid collisions, it will soon be cost-effective to remove debris. Time is short. There is a 10% probability that within 10 years, 10% of LEO assets will be lost (50% in 25 years) and GEO debris is now cycling back into the plane. Commercial SSA that cost-effectively reduces collision risk can decrease this probability and ultimately could solve the entire Space debris problem by removing it.

Australia has a major role in commercial SSA. It is already a world leader in SSA. There is no economic solution for SSA that does not include data from Australian sites and Australian-developed instruments. Australian industry, through the company Electro-Optic Systems, has developed sensors which can economically expand known catalogues, and accurately refine collision predictions. The Australian approach to SSA is intrinsically commercial and inclusive of government, industry and tertiary sectors. The CRC for Space Environment Management has recently been established in Canberra. This centre is already acknowledged as a global centre of excellence in SSA and also a key international coordination centre for civil and commercial SSA.

The CRC really is a global centre of excellence for Space environment management. New SSA sensors and commercial operations that have been in development for decades are now in the process of being deployed in Australia. The CRC has been kick-started with the injection of selected technology programs from Japan, Australia and the United States, with the express intention of meeting next-generation commercial SSA requirements in five years. The CRC will license new SSA technologies to its participants and the wider commercial community.

In excess of $90 million in up-to-date research facilities are available to the CRC. The CRC includes the world's best debris research facilities at Mt Stromlo ($30 million) and Tokyo ($30 million) as well as major facilities with other partners. So, the CRC already has the SSA infrastructure access it needs.

There are four CRC Programs:

1. *Tracking* – the CRC will research accurate, low-cost optical-tracking sensors and management strategies to enable affordable monitoring of all significant threats.
2. *Orbits* – the CRC will improve orbit determination technology to extend the tracking interval to reduce the future cost of debris tracking.
3. *Collisions* – the CRC will improve collision avoidance prediction to make collision avoidance prediction useful for the first time.
4. *Manoeuvre* – while it is possible to manoeuvre many satellites to avoid collisions, it is now time to start manoeuvring debris.

In summary:

- Commercial SSA is driven by a financial imperative. Increasing investment and risk will together launch commercial SSA operations.
- If the model of launch capability is followed, commercial SSA will overtake all other forms within 10 years.
- Australia will play a central role in current and future SSA operations. Its geography, technology and industry agility have secured its place.
- Commercial SSA will impact national security and government policy considerations, especially in Australia.

TERRESTRIAL BACK-UP FOR GNSS

GPS is critically important and is essential to Australia's economy and critical infrastructures. However, the transmission power of GPS signals is very weak. Signal reception is readily interrupted by obstructions such as man-made structures, terrain, vegetation and sources of radio interference. Hence, satisfactory performance of GPS requires both a clear sky-view (so that a minimum of four satellites can be simultaneously "seen" by a user device), and a "clean" radio frequency environment (free of competing signal transmitters that would overwhelm the GPS signals).

As the *Australian Strategic Plan for GNSS* observed, the dependencies on and vulnerabilities of GNSS in general have boosted interest in the development of alternative PNT technologies, particularly for mission- and time-critical applications. For example, inertial sensor systems can be used to augment GPS-derived positions for short periods of signal outage. Further, the Locata technology, a terrestrial positioning system developed in Australia, provides a useful complement or alternative to GNSS in circumstances where access to satellite signals is restricted or unavailable, including for indoor and open-cut mine application.[5]

The Volpe Report[6] in 2001 warned against undue dependence on satellites and suggested that over-reliance on GPS could lead to serious consequences. Space-based PNT is essential to the world's wellbeing and is pervasive but it should be expanded (which involves more than simple augmentation). PNT might be argued as the next utility but it can't deliver as a utility without a terrestrial back-up component. Indeed, the national Space policy of the United States argues for redundant back-up systems.

Next-generation air traffic control systems rely deeply on GPS. However, a GPS jammer that plugs in to a cigarette lighter in a car can disable GPS within two city blocks of that car.

The problem is that the GPS problems are not easy to fix. Next-generation air traffic control systems rely deeply on GPS. However, a GPS jammer[7] that plugs in to a cigarette lighter in a car can disable GPS within two city blocks of that car. The jammer costs less than $30 and can be very difficult to detect. A 1-watt jammer on Sydney Harbour Bridge would disrupt signals out to Sydney airport. A 10-watt jammer would take out all of Sydney.

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5 The potential unavailability of GNSS was realised on 2 April 2014 (just two days after the Kokoda Foundation Space Policy Workshop) when GLONASS was out of service for about 12 hours. A solar flare affected the GLONASS signals, affecting a number of the larger mining companies operating in Western Australia. Other impacts, not reported, could have been the blinding of Russia's strategic rocket force, and the inability to detect any distress beacons that might have been set off while the system was down.

6 The absence of Australian vulnerability studies (like the Volpe study), assessments, and risk abatement plans continue to be unaddressed Australian Government responsibilities. Furthermore, there seems to be no strong push for such studies and plans, which means that the situation is unlikely to change.

7 While GPS jamming devices are illegal to sell or use, they have become popular with commercial drivers who object to their employers tracking their every move. A jammer prevents a tracking device in the vehicle from determining (and then reporting) its location and speed—but it also disrupts GPS signals for all other users nearby.

Locata has invented a completely new positioning technology to solve the GPS availability problem by creating terrestrial wireless networks that function as a local ground-based replica of GPS. This technology can be thought of as 'a local GPS hotspot' which fills in the GPS holes with something which looks exactly the same as GPS to a user's receiver, be it surveyor or mobile phone user.

Modernisation of the satellite system and more small satellites will not address what should come next after GPS. The world needs superbly reliable Satellite + Terrestrial positioning to create one seamless, integrated system that will allow a user to move between the satellite and ground-based positioning signals, yet never know the difference. While some refer to this as GPS 2.0, it really is about the next iteration of GNSS.

This local terrestrial-based 'constellation' disconnects the PNT function from satellites in Space. It is all about synchronising devices without atomic clocks and gives the user total local control to decide availability. It is perfect for airports and other difficult areas such as urban environments and mines that have poor coverage by PNT satellites, and is ideal for backing-up satellites and UAVs. A GNSS+ (incorporating GPS, GLONASS and Galileo) and Locata receiver has been built and fielded by Leica. It is a fully integrated combined solution.

SSA RESEARCH

There are some key priorities for SSA research that are derived from the United States' National Research Council's recommendation to the United States Air Force Space Command. These include:

- High-fidelity modelling;
- Advanced computational methods;
- Advances in Space surveillance;
- Improved abilities for predicting and avoiding collisions; and
- Developing algorithms for autonomous satellite Guidance, Navigation and Control (GNC) and rendezvous, and for distributed control across formations.

Australia commits significant research and development resources to Space development (particularly GNSS), in academia, public sector laboratories and industry. Australian researchers are well regarded internationally and fill prominent positions in international and overseas-based GNSS associations and agencies. Notwithstanding these evident strengths, there is no assurance of successful research outcomes for exploitation and innovation. This, if unaddressed, will limit the value of the national investment in Space research and ultimately discourage new research.

Furthermore, Australian organisations are increasingly invited to participate in collaborative research projects with international partners. But there is no framework that fosters such collaboration, and certainly not one that allows involvement of Australian industry and government representatives as well.

CONCLUDING COMMENTS AND WAY AHEAD

The distributed nature of activities in the Space environment by various Australian organisations, lack of genuine leadership at a national level and lack of a broad coalescing agenda for Australia's Space development means there is no real cohesion in the Australian Space community. Indeed, some of the participants in Australia's Space development might not accept that such a community is needed. It is, therefore, difficult to see the various participants acting as a genuine community, let alone in a joined up way.

Australia needs to determine its contribution to the world in SATCOM, SSA, EOS and PNT. A national joined-up approach is needed so that Australia, as a nation, is not seen to be freeloading on others.

Australia needs to determine its contribution to the world in SATCOM, SSA, EOS and PNT. A national joined-up approach is needed so that Australia, as a nation, is not seen to be freeloading on others. This means bringing together the commercial side (with money and a commercial agenda) and the Government side (with its policy agenda and little money) and aligning the respective agendas, without being alarmist. Australia needs to develop a policy framework that helps the nation move forward in unison and not simply demand more and more Government funding.

In a sense, Australia's new Defence capabilities should be seen by other nations as a major step in the nation pulling its weight in Space. Technology will always be disruptive to the policy-makers and Australia does need to remain abreast of technology. It is important for the nation to find its niche in a coalition sense and invest in developing that niche capability as a priority.

Notwithstanding the good work carried out in recent years, there is still no policy for synchronising commercial SSA and national security SSA. This is also an important step in shaping and focusing the research agenda. One important initiative would be to identify a national champion within Government, such as the Prime Minister. While current policy acknowledges dependencies and vulnerabilities, and some of these are being mitigated, the challenge remains that no one area has overall responsibility and so Space becomes the responsibility of no one.

Lack of access to satellite services will demand a response but until that lack of access occurs, no one seems willing to take responsibility to address how the nation would respond to a lack of access. It is important for the Space community to grow greater awareness in the Australian public and Government, and identify what can be done to address the key concerns over time. Four years were needed to develop Space policy and over that time an awareness program was developed; so, in a sense, that awareness program can be built upon but work must start now before momentum is lost.

There is no question that policy change or policy development occurs through examples. So, success stories are needed; also needed is evidence that points to areas that need to be addressed as a matter of priority. Public opinion will mobilise public support for Government action.

One key area to be addressed is that of leadership in terms of Australia pulling its weight. Australia is leading in a number of areas such as: international regulatory regimes and code of conduct in outer Space discussions; commercial SSA; SSA research; improving Defence SSA capabilities; niche Australian companies such as Electro-Optic Systems and Locata; and infrastructures for EO, PNT and SATCOM. It is time for the Australian Government to take on more of a leadership role and for the Prime Minster to accept the mantle of national Space Capability champion. This in turn demands policy coverage and support from the agencies for furthering these leadership roles.

The Space community needs to determine what connects the key elements of Space for Australia - SATCOM, PNT, EOS and SSA - and identify what services from Space the nation relies on, and set out what Government should be doing to help in ensuring those services are provided. It also needs to identify the broader commercial imperatives that might drive further Australian investment in terms of dollars, facilities, human capital, thought leadership, and so on.

The Space challenge is all about the information. It is important to differentiate between owning the assets that provide the information and controlling them. Satellites are used to gather data and Australia needs to be assured that the data is there when it is needed. Thus, Australia's data requirements need to be the first priority, not second or third behind the priorities of other nations. So, in this sense, while outright ownership of satellites will remain with others, Australia can endeavour to ensure it has control over its data requirements and the priorities afforded those requirements.

A related aspect is that Australia's Space policy should address the need for agility when it comes to national data collection requirements. Currently, there is no synergy between classified and commercial capabilities; for example, the Australian Geospatial-Intelligence Organisation (AGO) has access to classified information from other countries, but it can also access or acquire commercial imagery; however, it is then restricted in the distribution of that commercial imagery. Commercial systems should play a more integral and integrated role in Australia's national Intelligence, Surveillance and Reconnaissance (ISR) capability. They do not do this currently, as evidenced in Australia's border protection activities.

Space policy should also address the ability to use commercially-captured data that can be shared with Coalition partners who are not able to access classified systems. In this respect, Industry needs to play a much broader role, particularly in the acquisition, analysis and management of satellite data. Government agencies can sometimes be too steeped in process and bureaucratic mechanisms that reduce the agility needed.

Finally, there is a balance needed between Australia being frugal and being regarded as a 'data welfare' State. The nation needs to be investing in more control over its data requirements. It also needs a stronger Processing, Exploitation and Distribution (PED) capability, where data is accessible to appropriate users across the wider ISR community. Activities are still being carried out in 'stovepipes'.

RECOMMENDATION AND OBSERVATIONS

The Kokoda Foundation makes just the single recommendation and that is for the Space community to maintain the momentum from the March 2014 Workshop and to continue their dialogue through regular Workshops or Colloquiums that bring the community together. To support such future dialogue, the Kokoda Foundation offers the following key points or observations that flow from the Workshop discussion:

- Participants in Australia's Space development need to come together as a genuine community to determine the priorities for Space developments and activities, identify the risks to achieving national aspirations in Space, determine the mitigating actions needed, and develop a national Space strategy and action agenda.
- Australia needs to determine its contribution to the world in SATCOM, SSA, EOS and PNT and ensure a national joined-up approach so the nation is not seen to be freeloading on others. It is also important for the nation to find its niche in a coalition sense and invest in developing that niche capability as a priority.
- The Australian Government needs to be encouraged to take on more of a leadership role and the Prime Minster needs to be encouraged to accept the mantle of national Space Capability champion.
- The Space community should maintain the current consensus on satellite utilisation policy in light of the mounting pressures on public service manning levels, and not be overly ambitious. It is important to connect Space to other front-line policy interests (such as DWP 15, Northern Australia White Paper, and the Agriculture Competitiveness White Paper), and to event-driven opportunities such as the search for MH370. The Space community should argue for information and positioning infrastructures to be added to the Prime Minister's national infrastructure agenda.
- The Space community needs to build on the awareness program that led to the development of Australia's Satellite Utilisation Policy and grow that awareness in the Australian public and Government, identify what can be done to address the key concerns, identify the success stories, and provide the evidence that points to areas that need to be addressed as a matter of priority. Public opinion will mobilise public support for Government action.
- Clear-cut examples of the use of Space data as a prime data source that needs to be brought to bear in times of disaster and crisis can highlight how valuable Australia's Space infrastructure is to national wellbeing.
- Space security does need a higher policy priority, given modern society's reliance on Space-enabled infrastructure for a wide range of critical services, the economy, and national security. Space security development has to place a premium on consultation and coordination across Government, and with industry and the research community. Australia should continue to look ahead and actively engage to help shape the debate and direction of Space development internationally.
- Space is an area of growing cooperation with regional partners, and is an area where Australia is pursuing closer relations with Japan, India and Indonesia, for example. Regional foreign and other ministries are paying more attention to Space issues, including how they fit within the context of other agendas. This presents clear opportunities for the Australian Space community.

- Australia should maintain its current international Space security focus and effort on the European Union's proposal for a code of conduct in outer Space as this can be a coalescing force that could lead to a practical multilateral approach emerging, especially in terms of transparency and confidence-building measures.
- Proliferation of Space debris is now of the highest concern to the Australian Government and practical ways forward are needed, with some degree of urgency.
- Defence should ensure that Space-based capabilities are being acquired through a deliberate, top-down strategic planning process, rather than opportunistically. Space should be a factor in planning for the future use of new fifth-generation capabilities.
- Australia needs to better understand its reliance on Space for Defence activities, ensure access as best it can, and plan for the worst. In this case, self-reliance is about ensuring access, not about owning and operating the Space systems.
- Defence should continue to explore various collaborative and SSA options as it develops its thinking around Combined / Coalition Space Operations to strengthen deterrence and improve mission assurance while optimising resources across the participating nations. Use of Australia's geography (for siting and reporting) and more focused burden sharing (with sensors and analysis) are two key areas to be further developed.
- Australia needs to develop a strategy for gaining access to alternative sources for EOS data as 19 out of the 22 satellites that provide EOS data today reach the end of their planned lives by 2015. Major re-investment is needed in EOS ground infrastructure.
- In improving earth observation policy, the Space community should help:
  - Define just what the challenges are.
  - Look for the enduring national agenda that involves Space and Earth Observations.
  - Join the dots at the bureaucratic level; i.e., between the science and policy agencies.
  - Re-frame the discussion in current terms.
  - Maintain the reports that provide evidence of the value of EO.
  - Maintain a coherent, consistent and "giggle-free" message from the EO community.
  - Continue to build the EO community, and especially include Industry.
  - Promote real examples where value is delivered from EO capabilities.
- Australia's dependence on continuous availability of GNSS signals needs attention by Government to assess the level of risk exposure; the potential impact of loss or degradation of GNSS signals, including but not only, as result of interference and jamming; and actions to be taken to limit damage.

- Improvements in GNSS will come as the NPI plan is implemented, the governance arrangements finalised, and the unification of infrastructure continued. However, the policy still needs to ensure that the NPI assists Australian users of positioning and timing to take the next big capability step, and that Australian industries are able to retain their competiveness through the use of precise positioning.
- Further policy consideration and encouragement of a terrestrial back-up for GNSS is needed.
- Policy is needed for synchronising commercial SSA and national security SSA. It is important to recognise that commercial SSA is driven by a financial imperative and that increasing investment and risk will underpin commercial SSA operations. However, for Australia to continue to play a central role in future SSA operations, its technology and industry agility must be assured.
- A research framework is needed that fosters collaboration, and that allows involvement of Australian industry and government representatives as well.
- The Space community needs to determine what connects SATCOM, PNT, EOS and SSA for Australia; identify what services from Space the nation relies on; and set out what Government should be doing to help in ensuring those services are provided. It also needs to identify the broader commercial imperatives that might drive further Australian investment in terms of dollars, facilities, human capital, thought leadership, and so on.
- Australia should ensure it has control over its data requirements and the priorities afforded those requirements even though it does not own the assets.
- Greater agility is needed in national data collection requirements, ensuring synergy between classified and commercial capabilities.
- Space policy should also address the ability to use commercially-captured data that can be shared with Coalition partners who are not able to access classified systems.
- The nation needs to be investing in more control over its data requirements and needs a stronger Processing, Exploitation and Distribution (PED) capability, where data is accessible to appropriate users across the wider ISR community.

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