Inquiry into the Current State of Australia's Space Science and Industry Sector

Submission by Prof Don Sinnott, University of Adelaide

1. Introduction

This submission is lodged with respect to a specific area considered to lie within the space science and industry sector, the Global Navigation Satellite Systems (GNSS) sub-sector. It addresses, in particular, issues identified in paragraph 2, item b (iv) of the *Information about the Inquiry* page of the Parliamentary website.

This submission has benefited from review by and contributions from several recognised Australian GNSS authorities in the public sector and in academia; their input is acknowledged, while emphasising that the submitter is the prime author and takes responsibility for the content. The submitter's credentials for making this submission are given in the personal statement at the conclusion of this submission.

2. Executive Summary and recommendations

GNSS is a major global utility known best through its initial embodiment in the US government's Global Positioning System (GPS). The Russian Federation operates a less-well-know system, GLONASS, and other States and national groupings (notably the European Union) are planning their own GNSS systems. Within a few years there will be large number of independent GNSS systems offering services globally or regionally, each with constellations of satellites, monitoring and controlling facilities. Australia is fortuitously-placed geographically to benefit in a major way from the coverage of these multiple GNSS services; this opens application and industry development opportunities that need to be seized. International agreements may be needed to underpin these efforts.

The performance of civil GPS, and the open (fee-free) services of other planned GNSS embodiments, is not adequate for all purposes. A large number of space- and land-based augmentation services have been established to address this need, including within Australia. The appropriate degree of government involvement in this sector has not been seriously examined; studies need to be conducted and directions set rather than let the situation evolve in an unmanaged way in which opportunities may be missed and nationally inappropriate "solutions" emerge.

Australian industry penetration of GNSS markets has been spotty and, in the absence of a coherent national strategy, Australian industry struggles to overcome impediments determined by the self-interests of the major international GNSS service providers.

Australia commits significant R&D resources to GNSS development, in academia, public sector laboratories and industry. Australian GNSS 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 in terms of exploitation of innovation. This, if unaddressed, will limit the value of the national investment in GNSS research and ultimately discourage continuing researcher entry.

The national dependence on continuous availability of GPS and, in the near future, other GNSS signals is a largely unexplored area of national vulnerability that threatens client sectors as diverse as road transport and banking. Urgent attention is required 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. Other major economies have taken action on these issues – Australia has not and stands potentially exposed.

The issue of national coordination of GNSS matters is currently not being addressed in Australia, following an earlier attempt to do this through a non-executive, body of *pro-bono* membership, the Australian Global Navigation Satellite Systems Coordination Committee, (AGCC), 2000-2006. The AGCC model is no longer appropriate by itself but the issue of coordination remains as a priority if Australia is to reap benefits from burgeoning GNSS developments and be protected from vulnerabilities exposed by uncritical dependence on GNSS.

Recommendation 1
The Australian government should recognise, and capitalise on, the fact that Australia's geographic location with respect to emerging GNSS services gives it particular advantages in

- exploitation of GNSS services, even in "urban canyon" situations that may, for cities in many other parts of the world, either preclude GNSS use or require expensive GNSS re-transmission systems; and
- development by Australian industry of top-end GNSS equipment.

Recommendation 2
The Australian government should examine the value to Australia of agreements for cooperation with the major GNSS civil service providers and, if the assessment is positive, pursue the establishment of appropriate agreements.

Recommendation 3
The Australian government should resist calls to extend coverage inland of its DGPS systems, as standardised by the IMO for maritime applications, and seek more appropriate solutions to delivering augmented GPS nationally if this is deemed important.

Recommendation 4
A study should be made to capture costs and benefits of national GPS augmentation services, in the light of existing and emerging position, navigation and timing services, and, if the assessment is positive, to examine and recommend appropriate technical approaches.

Recommendation 5
The Committee might note that

- GNSS is a high-growth business area, with *Location-Based Services,* in particular, constituting a major emergent market; and,
- Australian industry has little involvement, and little prospect of growing this involvement, without some level of government industry development encouragement.

Recommendation 6
The Committee might note that

- Australia plays a significant role internationally in research, in international GNSS development and standardisation fora, and in advice into GNSS system development, but in no area is there an appropriate national body to which Australia's international players report, or from which they source guidance as to the national interest, and,
- The absence of a research and industry innovation environment that encourages the exploitation of excellent GNSS research into products and services provided by Australian industry will severely limit both the success of the sector and its ability to recruit able students into fields of study that support GNSS market development.

Recommendation 7
A government-funded study of national vulnerabilities exposed by the civil community's dependence on GNSS should be conducted urgently. The study could learn from related studies in other countries, notably that of the US Department of Transportation's Volpe Centre report of 2001. The study would need to examine the threat environment, its seriousness for Australia and recommended measures to manage responses to threats to GNSS reception.

Recommendation 8
Given that Australia has no agency responsible for a whole-of-government approach to GNSS, including provision of advice to government on GNSS policy, industry development and vulnerability management, a study should be conducted urgently to recommend a way forward in GNSS national coordination. The experience of the Australian Global Navigation Satellite Systems Coordination Committee, 2000-2006, should be taken account of in this study.

3. The international scene and Australia's part in it

3.1 The Global Positioning System, GPS

The most widely-known implementation of a GNSS is that of the United States (US) Government, the Global Positioning System (GPS). GPS currently consists of a constellation of 32 Medium Earth Orbit satellites[1], ground control uplink facilities based in the US, monitoring and reporting stations world-wide and user equipment supplied by a multiplicity of vendors and commercial value-adding chains. GPS was

[1] GPS is managed to guarantee a minimum 24-satellite constellation. To provide for failures there is some in-orbit spare capacity.

initially conceived as a military location and weapons targeting system and underpins crucial military capabilities of the US and its closest allies, including Australia, which are provided privileged access to encrypted robust GPS capabilities denied to civil users. Less robust GPS signals are accessible, without cost, by the civil community world-wide and are used directly or indirectly every day, mostly unwittingly, by most people in the developed world.

As well as finding application in navigation and positioning, GPS signals are widely used for precise timing, on which telecommunications, banking and commerce rely to a little-appreciated extent. GPS-based position, navigation and timing services constitute a major civil electronic infrastructure element on which a truly staggering number of applications rely critically in the developed world. A major industry segment has grown up around GPS-based applications and there is intensive research and development activity worldwide that continues to throw up new applications. The Australian civil community tends to be an early adopter of emerging technology and so makes major and increasing use of GPS and value-added services built on it, with little consideration as to the robustness and reliability of the underlying signals. The submission returns to these dependence and vulnerability issues in section 6.

Given the pervasive and ubiquitous use of GPS, a number of other major non-US States and national groupings have concluded that allowing an electronic civil infrastructure component, critical to their national well-being, to be totally dependent on services provided by another sovereign government places them in a disadvantageous position. They are discomforted not only because the US ultimately controls the operation and quality of the crucial signal source but also because, by controlling the pace and direction of modernisation of the GPS satellite constellation and services, the US is well-placed to dominate the lucrative world-wide market for civil GPS user-equipment and applications. It is therefore unsurprising that other GNSS implementations are emerging, providing an alterative source of signals, features and services beyond those of GPS, and opening different markets and location-based marketing strategies.

3.2 GNSS implementations that are independent of GPS

GNSS implementations independent of GPS include the Russian Federation's GLObal NAvigaton Satellite System (GLONASS) (currently operating with a limited constellation but planned to be upgraded by 2009), the European Union's Galileo (expected to enter full-constellation operational service by 2013), and China's Beidou/Compass system (which has some current functionality and is to be expanded in capability and become fully operational over the next few years). Japan and Korea also have plans for Regional Navigation Satellite Systems (RNSSs).

The launch and ongoing management of a national GNSS constellation is clearly not a game in which Australia would seek to play. It is however important to note that a number of these new constellations provide services selectively in our region (eg those of Japan, India, China). As a result, within a few years Australia will, as the figure below shows, through nothing more than an accident of geography, be blessed with better GNSS satellite coverage that most countries on the planet. "Better" in this sense means multiply-redundant service through access to multiple independent systems as well as greater high-angle satellite visibility, delivering reliable GNSS service even in "urban canyon" and deep-pit mines, than most countries enjoy.

Australia will also be well placed to design and test GNSS receivers that exploit all these systems, i.e. the most capable, most accurate receivers. Having cooperative agreements with all of the system suppliers would obviously help in this development.

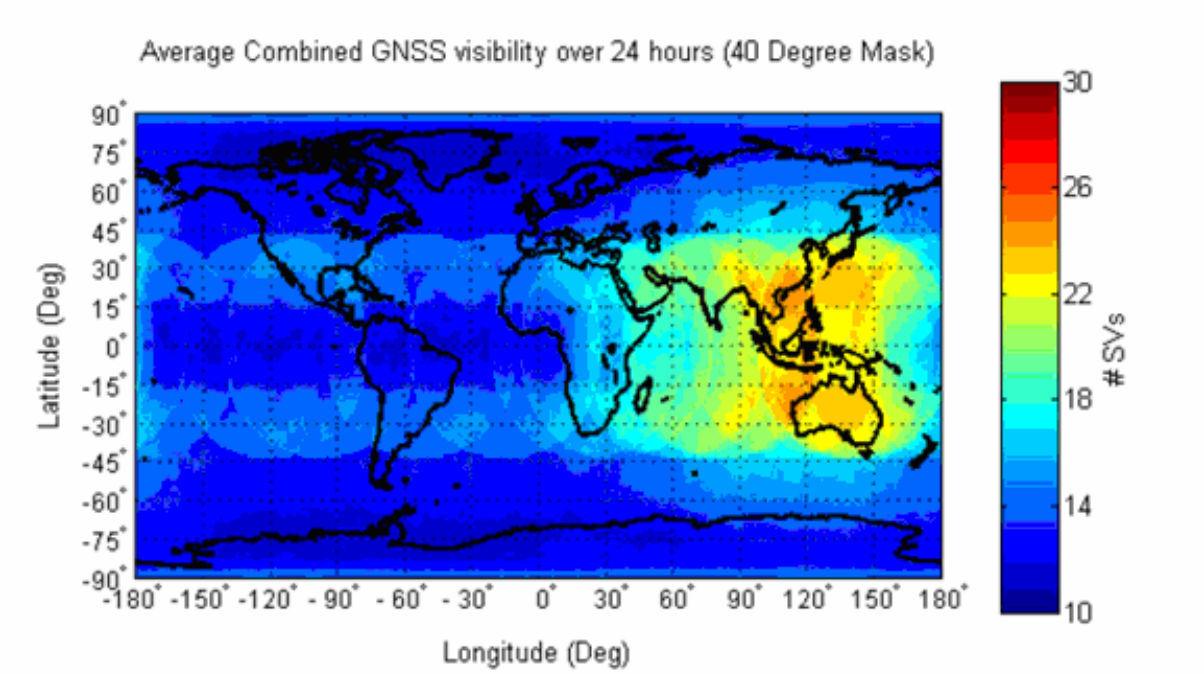

Figure 1. The number of GNSS Space Vehicles (SVs) visible above a 40 degree angle (typical in cities) averaged over a day for all actual and proposed satellite navigation systems.
(Figure courtesy Assoc Prof Andrew Dempster, School of Spatial Information Systems, University of NSW)

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- exploitation of GNSS services, even in "urban canyon" situations that may, for cities in many other parts of the world, either preclude GNSS use or require expensive GNSS re-transmission systems; and
- development by Australian industry of top-end GNSS equipment.

Recommendation 2
The Australian government should examine the value to Australia of agreements for cooperation with the major GNSS civil service providers and, if the assessment is positive, pursue the establishment of appropriate agreements.

3.3 GNSS augmentation systems

In addition to the systems discussed thus far, which are primary GNSS signal sources independent of GPS, there are many operational and planned space- and land-based augmentation systems that improve the performance of the underlying GPS system on a local, regional or global basis with respect to accuracy, integrity and other attributes[2]. It is important to underline that these systems are dependent on GPS: they

[2] Civil GPS generally delivers a positioning accuracy of 10m (often better) but without any guarantee of accuracy, availability or integrity. Current and planned augmentations seek to improve in some or

add value to the GPS service but if the GPS signal is unavailable so too is their value-adding service.

Examples of space-based regional augmentation systems are the US *Wide Area Augmentation System* (WAAS), the EU *European Geostationary Navigation Overlay Service* (EGNOS), Japan's *Multi-transport Satellite Augmentation System* (MSAS), India's *GPS-aided Geo-Augmented Navigation* (GAGAN) system. These are primarily targeted at aviation users. Commercial, fee-for-service, space-based augmentation systems such as those operated by Fugro target industries such as agriculture, mining and other applications requiring accuracy down to centimetre levels for machine control. There seems no case for Australia to enter into the space-based global or regional augmentation arena, especially as a number of the actual or planned systems cover our region adequately for most purposes.

Ground-based augmentation systems include those standardised by the International Maritime Organisation (IMO) for maritime use (the Australian Maritime Safety Authority operates 16 such *Differential GPS* (DGPS) stations at coastal locations). In some countries (eg the US) DGPS has been expanded as a government-funded national facility covering inland as well as littoral areas. Australian agriculture located close to the coast can and does make use of the DGPS service intended for maritime use and there are pressures from time to time to extend the Australian DGPS service to other inland locations to provide, at no cost to users[3], location accuracy superior to unaugmented GPS. This submission finds no credible case for such a plan in the Australian situation.

Recommendation 3
The Australian government should resist calls to extend coverage inland of its DGPS systems, as standardised by the IMO for maritime applications, and seek more appropriate solutions to delivering augmented GPS nationally if this is deemed important.

Airservices Australia has its *Ground-based Regional Augmentation System* (GRAS) at an advanced stage of development. GRAS provides for a range of positioning applications including, but not limited to, approaches with vertical guidance, to regional airports in particular. With certification expected in late 2008 the system is expected to find more widespread aviation application. It could also serve as a national augmentation system if such a roll-out were to be deemed important. This submission takes no position on whether a national GPS augmentation system makes sense for Australia and, if the answer is affirmative, what solution is most appropriate. It is, however, important to have answers to these questions.

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all of these dimensions – eg down to metre or centimetre accuracy, with a loss-of-integrity warning or even an integrity guarantee with opportunity for legal redress in case of failure in performance delivery.

[3] There are commercial providers of encrypted augmentation services in Australia delivering a range of location accuracies from "comparable to" to "markedly superior to" the open government-provided DGPS maritime service. Costs of encryption keys to such commercial services relate to the accuracy required. A perception of a free government service competing with a commercial service has, in the past, led to a *competitive neutrality* complaint from one Australian commercial augmentation services provider. But with the accuracy requirements of most users now greater than that provided by the free DGPS service this debate is now largely sterile.

Recommendation 4
A study should be made to capture costs and benefits of national GPS augmentation services, in the light of existing and emerging position, navigation and timing services, and, if the assessment is positive, to examine and recommend appropriate technical approaches.

The IMO and the International Civil Aviation Organisation (ICAO) have produced Standards And Recommended Practices (SARPs) to enable interoperability of augmentation systems within the communities they serve. Other agencies have produced Minimum Operational Performance Standards for user equipment in their own area of operations. There is no call for Australia to do more than it is currently doing in these areas of standardisation.

Ground-based augmentation services to cover very local areas can be set up on an *ad hoc* basis (eg for a survey operation) or more permanently (eg for automated stevedoring, as implemented in several Australian ports). This is a market in which no intervention is required.

Finally, the International GNSS Service (IGS) operates an independent world-wide network of over 400 geodetic-grade GPS receivers that is crucial for ultra-high accuracy applications in the geosciences, including critical global change monitoring of sea level rise, icesheet melting, and related effects. Many countries and state governments operate networks of GPS continuously operating reference stations (CORSs), essentially a form of ground-based augmentation for precise mapping, surveying, machine guidance and navigation applications. These are estimated to number in the tens of thousands globally – representing the largest civilian investment in GNSS ground-based augmentation systems. There appears no substantial case for Federal government intervention in the way this network functions in Australia as State governments appear to have resolved most interface issues that arise near State boundaries.

3.4 Collaboration with GNSS signal providers

A major justification for the EU's Galileo GNSS initiative, which will cost the members states at least €4B and probably considerably more, is expansion of the market environment for their own industry in GNSS user-equipment. Australia has not been proactive in forging a relationship with the EU on Galileo that could open industry and other LBS opportunities for Australia. Australia does not have an articulated position on dealing with Russian, Japanese, Chinese, Korean and Indian initiatives on GNSS cooperation. Neither does Australia have a civil GPS agreement with the US. GPS is being modernised, many would claim in response to the commercial threat posed by Galileo, but the only window Australia has on GPS plans is via a Defence agreement with its highly specific non-commercial focus. Australian industry, devoid of any nationally coordinated market attention, can only expect to be sidelined when competing in a playing field that has been specifically crafted by other nations and groupings to give them advantage (see *Recommendation 2*).

4. GNSS industry in Australia

It is fair to describe the Australian approach to science and industry in the GNSS sub-sector as *laissez faire*. Australia has some highly regarded capability in GNSS developments through academic, public sector and industry research and in GNSS

augmentation developments, principally by Small to Medium Enterprises (SMEs) which have emerged without major government encouragement or support.

These capabilities have arisen in response to perceived opportunities or performance deficiencies in basic GPS services. The capabilities developed are typically "one-product" focussed with a short-term horizon. Particularly in industry-based capability development, there has been a high attrition rate in attempting to respond to global markets without a substantial local market or a coherent national GNSS industry-sector development strategy. These conditions are by no means unique to the GNSS sub-sector, of course, but in view of the position in which Australia finds itself with GNSS – attempting to play in a sector populated by major players who, owning or prospectively owning the space assets, are favourably placed to determine the direction of technology development – are severely disadvantaged before hitting the starting post. It is a credit to the courage of those Australian SMEs that do initiate GPS research and development and seek to break into the sector against the odds for success.

A free market in GNSS application development, largely devoid of government intervention or policy and strategy drive, was the environment clearly favoured by the previous Federal government. The Queensland State government has been more interventionist in encouraging GNSS-based industry in its state. It appears to have been rewarded by having the most dynamic clustering of GNSS-based SMEs in the country.

A diverse, rapidly-growing and highly profitable business lies in location-based services (LBS) derived from GNSS signals: for example GPS receiver chips in mobile phones and other portable computing devices are becoming ubiquitous and web-based content providers able to segment and target their market by location are emerging. LBS applications span a spectrum from road-use tolling, vehicle navigation and vehicle separation management, to advising on the nearest restaurant and other points-of-interest.

On an international scale, products and services based on GNSS comprise a major high-growth business sector estimated to be currently creating over US$10B of annual business (and growing at double digit rates each year). Currently Australia is involved in very little of this business but, as a traditional early-adopter and technophile nation, will escalate its demand for the attractive LBS technology (witness our early adoption and continuing embrace of mobile-phones and added-value services). There are significant industry-development opportunities in this dynamic twenty-first Century market sector and it behoves the government to examine how an appropriate level of encouragement can be given to it for the long-term national benefit..

Recommendation 5

The Committee might note that

- GNSS is a high-growth business area, with *Location-Based Services,* in particular, constituting a major emergent market; and,
- Australian industry has little involvement, and little prospect of growing this involvement, without some level of government industry development encouragement.

5. GNSS research and space science

5.1 Australia and the international GNSS research environment

GNSS-related research is characterised internationally by a high level of academic, public sector and industry involvement. There are major international conferences on GNSS topics, some focussing on engineering and design aspects, others on applications in areas such as surveying and geodesy, and still others addressing the whole range of GNSS requirements, implementations and applications. Australia, notwithstanding the fact that we do not have a navigation satellite constellation of our own, is a very visible player in the international GNSS research scene. Increasingly Australian organisations are contacted 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 players as well.

Activity under the aegis of the UN's International Committee on GNSS (ICG) seeks to improve the level of 'interoperability' between different global and regional navigation service providers. The goal is to ensure, as far as is practicable, that user-equipment can track signals from several satellite constellations at the same time, hence improving accuracy, availability and reliability. Several Australians have prominent roles in the ICG.

Other Australians hold senior positions within their industry international organisations (for example, surveying and geodesy); one has an invited position on the US Government Position Navigation and Timing Advisory Board.

Australians involved in GNSS are highly regarded globally. The anomaly is that they cannot articulate or reflect a national position: there is no national forum to which they report or from which they derive guidance as to the national interest. GNSS-related research in academic institutions is similarly conducted in the substantial absence of a strategic context.

5.2 Australian research and development

Notwithstanding these impediments, excellent GNSS research and development work is being done in Australian industry and academia, with some support from

- the Australian Research Council (ARC),
- commitment of internal risk funds by SMEs, with minor industry assistance grants in some cases,
- the Cooperative Research Centre for Spatial Information, and
- the Department of Defence (principally through its Defence Science and Technology Organisation).

Australian research and development addresses specific GNSS system and equipment problems and opportunities[4] and there are far-sighted individuals involved in defining

[4] Examples are GPS interference-rejection modules developed by the University of Adelaide as an offshoot of a Defence contract, Signav Pty Ltd development of weak-signal receivers aimed at indoor GPS applications, and University of NSW work in GPS reconfigurable receivers not locked into a specific GNSS source.

and focussing the research. But there is a great risk that research in this notionally highly applied area will not result in an application of value to the nation because the environment does not support industry uptake of the research outcomes. So too will it become increasingly difficult to attract outcome-driven graduate students to a research area that, while being manifestly highly applied, cannot answer the simple outcome question about the research "what's it for?".

Recommendation 6
The Committee might note that

- Australia plays a significant role internationally in research, in international GNSS development and standardisation fora, and in advice into GNSS system development, but in no area is there an appropriate national body to which Australia's international players report, or from which they source guidance as to the national interest, and,
- The absence of a research and industry innovation environment that encourages the exploitation of excellent GNSS research into products and services provided by Australian industry will severely limit both the success of the sector and its ability to recruit able students into fields of study that support GNSS market development.

6. Vulnerabilities exposed by dependence on GNSS

With so much civil infrastructure critically dependent on continuous access to GPS and other-source GNSS signals it is important to examine the basis for believing that these signals will always be available. This leads to a consideration of the robustness of the satellite transmissions and of the propagation and reception path by which the signals are received.

On the first score, it is somewhat worrying that currently half of the GPS satellites have zero redundancy (onboard failures have consumed the satellite's capacity for substituting backup systems) so that a single satellite-system failure would disable that satellite. Multiple satellite failures in a limited time would degrade the capability of GPS until spare satellites were repositioned or replacement satellites launched and commissioned. This is regarded as a credible scenario - the term "GPS brownout" is being used to describe a situation in which the full constellation is not available for extended periods. In such a reduced-constellation situation the US could be expected to optimise orbital locations of active satellites for its own defence and national civil priorities, at cost to the level of service available to non-US GPS users.

Although "GPS brownout" conditions are conceivable, it would require exceptional circumstances for the US deliberately to turn off, limit or degrade civil GPS signals globally, as the impact on its own GPS-dependent society would be immense. So too, direct attack on GPS satellites, while technically feasible, is only a credible threat in an extraordinarily serious global crisis involving the most technologically-capable nations as US adversaries; the concerns of this paper would be deemed minor indeed in such an international crisis and there is little point in pursuing further this line of "what if?".

Given that denial of GPS transmissions at their source represents a relatively low threat to Australian GPS exploitation, attention needs to focus on the propagation and

reception path by which these signals are received and used. The GPS signals are of exceptionally low power at the point of reception on earth so can be very easily inferred with. Interference to, or jamming of, civil GPS reception on a local or regional basis is not technically difficult[5] and cases of inadvertent jamming are documented. Australia is exposed to an entirely unquantified risk of disruption to commerce, industry and civil activity should a major GPS interference event occur – accidental or deliberate.

There is no extant Australian vulnerability study, as was conducted and acted on in the US in 2001 (the US Department of Transportation's Volpe vulnerability assessment), and we have no contingency plan addressing loss of GPS signals on a local or regional basis (the US continues to fund and enhance its LORAN system, established immediately after World War II, as a GPS critical infrastructure back-up, and the US Coast Guard acts as the point-of-contact for GPS interference reports). The absence, in Australia's case, of such vulnerability studies, assessments, risk abatement plans and an interference-response agency[6] constitutes a serious unaddressed Federal government responsibility. That this responsibility has not been taken up is bad enough; that there is not a recognised and credible advisory body in a position to press for such studies, and no agency on which pressure may be exerted, mean that the situation will not change.

Recommendation 7
A government-funded study of national vulnerabilities exposed by the civil community's dependence on GNSS should be conducted urgently. The study could learn from related studies in other countries, notably that of the US Department of Transportation's Volpe Centre report of 2001. The study would need to examine the threat environment, its seriousness for Australia and recommended measures to manage responses to threats to GNSS reception.

7. Previous National Coordination

The Australian Global Navigation Satellite Systems Coordination Committee (AGCC) was established for an initial three-year term by the then Deputy Prime Minister and Minister for Transport and Regional Services in May 2000 and subsequently had its term extended to June 2006. Its functions were, broadly, to provide an expert GNSS user forum, to provide advice to government and be reflective of the views of the GNSS community in Australia. During its life the AGCC was seen by many stakeholders in positioning, navigation and timing industry sectors, nationally and internationally, as a valuable body with significant outcomes over its six-year term and a defined ongoing program of work. A Galileo official

[5] Jammers, including military-grade high power versions, are available on the international market and designs for construction of low-power jammers, blanketing an area of hundreds of square kilometres, are available on the internet.

[6] While the Australian Communications and Media Authority, ACMA, responds to unauthorised radio transmissions and would be notionally responsible for dealing with reported GPS interference, the reality is that equipment and skills needed to locate a sophisticated GPS jammer are far removed from those required for more typical unlicensed transmitter location. A generalist standards-setting agency of ACMA's type should not be made responsible for a highly-specialist operation of this type with national security overtones.

described the AGCC as a model for the way national GNSS coordination should be handled.

An important early AGCC outcome was the drafting of a significant national policy document, *Positioning for the Future*, (AGCC, 2002). The policy document was developed by a team established by the AGCC that canvassed all major national stakeholder groups and Federal government Departments for concurrence before seeking Ministerial endorsement and release. It is a challenging and forward-looking document that provided a framework for the AGCC's subsequent actions and stands as an enduring challenge.

Another significant AGCC outcome was the banning of GPS jamming devices by the Australian Communications and Media Authority following AGCC representations, a global first that set the bench mark for other States to follow. The AGCC also mounted a major campaign to alert areas of the civil community to the risks of GNSS dependence. This is a task that requires continuing educative effort and is currently not being seriously addressed.

When the then Minister, on advice of his Department of Transport and Regional Services, decided to terminate the AGCC by June 2006 he expected that its work program could be taken up by other bodies. Such hopes have proven illusory and most areas of GNSS coordination at a national level formerly covered by the AGCC are now unaddressed[7]. More broadly, a specific recommendation by the AGCC Chair as to how the previous coordination role of the essentially unfunded *pro-bono* AGCC might be picked up by a designated Commonwealth agency linked to an advisory forum, of membership similar to the AGCC, appears not to have been examined.

There were multiple motivations for the 2000 establishment of the AGCC and these are mostly enduring. Inevitably, as a non-executive body largely devoid of discretionary funds and relying on *pro-bono* time commitment by senior people in the Australian GNSS industry, government agencies and academia, the AGCC found more tasks than it had resources to address. Active areas either under consideration or flagged for attention at the time of its closure included the following.

- optimising Australia's interface with the EU's Galileo system,
- proposing means of engagement with other GNSS and RNSS service providers – Russia, Japan, China, India and Korea, including hosting ground monitor stations,
- assessing the impact on Australia of GPS modernisation,
- advising on national spectrum licensing issues attached to new GNSS services and frequencies,
- advising on interfaces with emerging GNSS and augmentation services providers,
- advising on technical issues attached to accidental or deliberate jamming of and interference to the exceptionally-weak GNSS signals,
- recommending approaches to legal and privacy issues attendant on GNSS application,

[7] An example of the consequences of having lost a national point of contact on GNSS came in 2007 when the US State Department sought to create a communiqué on GPS between the Australian and US Governments and found no appropriate Australian agency through which to deal.

- working with SE Asian and Oceanian countries in developing strategies to maximise benefits of GNSS/RNSS (e.g. education/training, appropriate CORS infrastructure, etc.), especially in the light of multi-GNSS/RNSS,
- monitoring the relentless development of GNSS applications technology that, in the national interest, may warrant some oversight at national level but is not the responsibility of any specific ministerial Portfolio of government Department, and,
- raising awareness of the vulnerability of critical services whose operation is dependent on access to GNSS signals and the potentially serious societal consequences of an attack on GNSS infrastructure.

These remain as key areas to be addressed if Australia is seriously to seize opportunities in the GNSS sub-sector and to protect itself against the hazards of assuming we will always have continuous interference-free access to GNSS signals.

Given this environment it is nevertheless difficult for governments to assign Portfolio and Departmental responsibility for GNSS matters – GNSS does not fit well with the silo-like operations of government departments in most free-market economies. In the US and the EU governments, government transport agencies play a major role in GNSS matters but they find it necessary to establish pervasive inter-agency linkages and cooperative arrangements.

No single Australian government Department has responsibility for GNSS. In cost-conscious times, in which Departments are accountable against closely-defined objectives, it must be expected that, unless specifically directed, none will take up responsibility for GNSS on a whole-of-government basis. The flavour of this was conveyed by the then Minister for Transport and Regional Services in advising the author of this submission of his intent to disband the AGCC in 2006: "… It is the case now that the transport sector, while still a beneficiary of GNSS applications is now just one of a number of ever growing GNSS users." and primarily on this basis declined to support whole-of-government coordination through his Department. It is true to say that, in Australia, GNSS is "everybody's business but nobody's responsibility".

It is interesting to note that the US, recognising the pervasive user base for GPS, has established a high-level *National Executive Committee for Space Based Positioning Navigation and Timing* with a funded support office and advisory board. Defence and Transportation share the lead in this committee and the advisory board includes some international membership, including one from Australia. Of course a major focus of the committee is on the control and evolution of the US government's GPS itself; Australia does not have these considerations, but it does have whole-of-government issues very similar to the other interests of the US committee.

Recommendation 8

Given that Australia has no agency responsible for a whole-of-government approach to GNSS, including provision of advice to government on GNSS policy, industry development and vulnerability management, a study should be conducted urgently to recommend a way forward in GNSS national coordination. The experience of the Australian Global Navigation Satellite Systems Coordination Committee, 2000-2006, should be taken account of in this study.

8. Conclusion

GNSS has become a major electronic infrastructure element of all developed economies and is an under appreciated but critical element in the Australian economy. The nature of GNSS means that it is taken for granted by most users. There are major opportunities that may be missed and vulnerabilities exposed in the absence of government action.

The submitter

Professor Don Sinnott (PhD, FIEAust, FIEEE, CPEng) is a consultant in electronics systems and is Professorial Research Fellow in Radar Systems with the University of Adelaide. From 2000 to 2006 he was, by invitation of the then Minister for Transport and Regional Services and Deputy Prime Minister, Chair of the Australian Global Navigation Satellite Systems (GNSS) Coordination Committee. At that time he was Professor Sensor Systems with the University of South Australia and CEO of the Cooperative Research Centre for Sensor Signal and Information Processing. Prior to this he held positions as *Chief* of several Divisions in DSTO and *First Assistant Secretary Science Policy* in the Department of Defence in Canberra.