SECURING AUSTRALIA THROUGH SPACE: RESILIENT PNT FOR DISASTER RESPONSE

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About the Author

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About the Securing Australia Through Space Policy Papers Series

The Australian Centre for Space Governance hosted a workshop in March 2024 titled “Securing Australia Through Space”, where the question was posed: what does Australia need to secure, and how do space technologies help us to do so?

The workshop was attended by over 90 people, with the vast majority of attendees coming from a range of federal government departments and agencies. Experts from academia, government and industry were invited to give presentations and take part in roundtable discussions. This policy paper series is a result of the workshop.

The papers are authored by those who presented, and edited by Sarah O’Connor, Tristan Moss and Cassandra Steer on behalf of the Australian Centre for Space Governance. The opinions expressed in each paper are those of the authors in their individual capacity, and do not represent the views of any of their employers.

About the Australian Centre for Space Governance

The Australian Centre for Space Governance advocates for Australia’s interests in space in the 21st century and advances the agenda for responsible space governance.

We bring together the nation’s leading experts, in fields such as space law, governance, policy, science and technology studies, security, property, history, ethics, political and social sciences, from across six different universities in Australia (Australian National University, Flinders University, RMIT University, University of Adelaide, UNSW Canberra, and Western Sydney University).

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Summary

- Resilient Positioning, Navigation and Timing (PNT) forms part of location intelligence in undertaking effective disaster response, with timing signals enabling critical infrastructure.
- Australian systems and services – be it government, private, or mass market devices – rely on the United States' Global Positioning System (GPS), alongside other foreign-owned space-based systems, for their PNT needs during disasters and emergencies.
- Australia has an opportunity to coordinate the development of Global Navigation Satellite System (GNSS)-enabled Emergency Warning Services, domestically and in the Pacific, for humanitarian, regional stewardship, and national security reasons.
- Various alternative technologies to GNSS are being developed in Australia for "resilient PNT". However, there remains an interoperability chasm between emerging technologies and our GPS-enabled critical systems. Technology investment that is not anchored to a national PNT strategy will not build resilience for disaster response or emergency management.

Policy recommendations

- The Australian Government should undertake a coordinated civilian and Defence effort to comprehensively map national dependencies on both space- and ground-enabled PNT, including critical infrastructure dependencies, to identify how disruption of PNT could impact disaster response.
- The Australian Government should develop a national approach to PNT to ensure seamless transition between PNT technologies when necessitated, and prioritise which infrastructure to invest in to enable this interoperability.
- The Department of Foreign Affairs and Trade and Geoscience Australia could take a leadership role in the Asia-Pacific region by coordinating an approach to emergency warning services using PNT with our Pacific neighbours.

Position, navigation and timing (PNT) has a ubiquitous role in today's increasingly networked society. In particular, Global Navigation Satellite Systems (GNSS) are a form of PNT that we all use on a daily basis. The United States' Global Positioning System (GPS) is the dominant GNSS used by many other nations including Australia. Much of Australia's critical infrastructure systems for managing and responding to disasters – telecommunication networks, power grids and emergency response vehicles – have been designed to operate effectively using space-based GPS for PNT. While there are emerging alternative PNT technologies being developed, there remains an interoperability gap between these technologies and our foundational systems that have been designed only to use GPS services. Focusing on PNT technology investment without a national framework will not help build resilience for national security, disaster response, or emergency management. A national approach is needed to understand how these technologies switch seamlessly to and from GPS in a disrupted or denied environment, and what infrastructure to invest in as a priority to enable this seamless transition.

Location intelligence for disaster response

The Australian Government Crisis Management Framework recognises that emergency management responds to a combination of natural and human-induced events.[1] Frequent natural disasters in Australia include bushfires, flooding, major storms and heatwaves. If we include the Indo-Pacific region within Australia's sphere of influence and stewardship, frequent natural disasters extend to earthquakes (New Zealand), volcanic events (New Zealand, Tonga), and tsunamis (Indonesia, Japan). Looking beyond our immediate terrestrial boundaries, solar events can produce major risks and impacts to infrastructure and people. Human-induced events include cyber-attacks, conflict and space debris risks.

Location intelligence and timing is critical for disaster response and emergency management. Many people associate location intelligence with visualising and analysing geospatial data (satellite, aerial, drone) for situational awareness and decision-making. However, location intelligence also includes knowing the precise location and movement of people, assets, infrastructure, and information, as well as the precise timing and sequence of events that have occurred, or are expected to occur, for decision-making and response. This precise location, movement and timing is enabled by PNT.

The natural and human-induced hazards cited above can be monitored by PNT. They can also be a threat to PNT. In the event of GPS loss or degradation due to a disaster or deliberate interference, there would be wide-ranging impacts with both known and unknown, unmapped dependencies. An international study on the economic benefits of GPS quantified that widespread GPS disruption would cost a loss of US$1 billion per day to the United States' (US) economy alone.[2]

The prevalence of PNT across federal government portfolios

A variety of government portfolios are responsible for the governance, maintenance and/or development of PNT capabilities for the benefit of national security, maritime domain awareness, diplomatic relations and disaster response. However, there are differing levels of awareness across government of the role of PNT, necessitating a more coordinated national and strategic approach.

The **Department of Foreign Affairs (DFAT)** leads Australia's stewardship role in the Pacific. It has previously sponsored a PNT study and trial of an Emergency Warning System that tested satellite-to-phone alert messages.

The **Australian Antarctic Division** undertakes emergency management, search and rescue, and provides maritime assistance in the Antarctic through positioning and navigation on land and at sea.

The **Department of Home Affairs' Cyber and Infrastructure Security Centre (CISC)** governs the *Security of Critical Infrastructure Act* (2018) (SOCI Act). Under the SOCI Act, PNT is considered part of the Space Technology sector as "position, navigation and timing services in relation to space objects".[3] However, coverage under the Act is extremely limiting.

Spoofing and jamming are major cyber security threats (and human-induced hazards) to PNT, and therefore to PNT-dependent infrastructure and devices. Concerningly, cyber risks to PNT have not been acknowledged in the *2023-2030 Australian Cyber Security Strategy*.[4] Regardless, there is a growing acknowledgement of the risks to PNT being considered material risks to critical infrastructure. CISC recommends that responsible entities make provisions for addressing PNT risks as part of their Critical Infrastructure Risk Management Program Obligations.[5]

The **Department of Defence** needs "assured PNT" in GNSS-denied warfighting environments, including for weapons capabilities, asset and personnel navigation, and precision guidance for long-range weapons and platforms. Its critical infrastructure assets, which depend on geodetic observations, are vulnerable to unsecured PNT technologies. The Joint Capabilities Group is responsible for developing multi-layered, multi-domain PNT capabilities.[6] Defence is also accelerating industry-development of quantum-enabled PNT technologies through AUKUS.

The **Department of Prime Minister and Cabinet** developed the Australian Government Crisis Management Framework. Under the framework, PNT (in the form of GPS) is regarded as a critical service that can be impacted by space weather events.

Geoscience Australia is the major civilian PNT user, research and services agency. It leads the SouthPAN satellite-based augmentation service to improve the accuracy of satellite positioning and navigation systems for a range of applications. The agency provides GPS-enabled geodesy for earthquake and tsunami monitoring in the Indo-Pacific. It also coordinates the Asia Pacific Reference Frame project to create and maintain an accurate geodetic framework to meet growing industry, scientific and public positioning programmes in the region.[7]

Critical infrastructure dependencies on PNT

Many Australian systems and services are designed with an assumption of the reliability of GPS, which creates a structural vulnerability if there were a loss of access to GPS. It is therefore critical that these dependencies are mapped comprehensively to identify how GPS disruption could impact disaster response. The Australian Government as a whole should undertake to map these dependencies nationally, as part of a crisis preparedness strategy.

Telecommunications

Of Australia's critical infrastructure sectors, the telecommunications sector would be

most impacted if GPS services were disrupted during a disaster. Mobile communication networks are vital for personal communication and information sharing during disasters. The networks use precise time synchronisation between clocks inbuilt into network devices, enabling exchange of calls or messages. The timing requirements for mobile networks in the US were designed to use GPS disciplined clocks and GPS standards, as it is in Australia. These clocks are located at cellular sites such as cell towers alongside other communications equipment. In the US, there are an estimated 1 to 3 GPS clocks at every cell site, amounting to between 350,000 and 1 million GPS clocks in service.[8] This number will likely triple within a few years with the rollout of 5G technologies, which require even more cell sites for improved mobile coverage.[9] Much like the transition from 4G to 5G, an anticipated shift to 6G to accommodate enhanced connectivity would likely compound the number of cell sites, and hence GPS clocks. There is no easily accessible count of such devices across Australia, but the dependencies of our telecommunications networks on timing – particularly GNSS-enabled timing – is clear.

Energy

Catastrophic weather such as lightning storms, heatwaves, bushfires and cyclonic weather can damage power plants, towers and transmission lines. A recent example is the Victorian storms in February 2024. The resulting power outages affected 500,000 homes, led to a reduction in the energy supply, and caused power price hikes in the midst of a heatwave.[10] While PNT cannot fix physically-damaged infrastructure, it is used (through time synchronisation devices in power plants and substations) to quickly locate where on the line the damage occurred. This allows authorities to isolate affected infrastructure and minimise further failures.

Emergency services

Emergency services are not classified as a critical infrastructure sector within the SOCI Act but are “critical infrastructure assets” that provide essential services. Police, ambulance and fire emergency vehicles in Australia are starting to use satellite-enabled tracking tools such as Automatic Vehicle Locators (AVL), which operate on GPS connectivity, to make emergency response as effective as possible. For example, South Australia installed AVLs across its 1400 fire emergency vehicles in 2021.[11]

Opportunities for emergency warning satellite services

Emerging uses of GNSS include using CubeSat GPS data to monitor ionospheric disturbances from the 2022 Tonga volcano eruption, with the disturbances potentially used for advanced tsunami warnings. GNSS can also be utilised for emergency warning services (EWS). Japan already uses its Quasi-Zenith Satellite System to disseminate alert messages for tsunami warnings through mobile phones and other public infrastructure such as electric signboards. Similarly, the European Union provides EWS services through its Galileo GNSS, benefitting populations in areas with no or poor mobile signal.

Neither Australia nor its Pacific neighbours have the capability for GNSS-enabled EWS yet, though the benefits of such a service are clear for a coordinated approach to disaster response across the Australian continent and its immediate Pacific jurisdiction. A trial was conducted in 2019/2020 in Melbourne, utilising Japan’s EWS service to send an alert message about a simulated bushfire incident.[12] There has been exploratory engagement

with DFAT since the trial to further conceptualise QZSS-enabled EWS in the Pacific. However, there have been no publicly released outcomes of these studies, and the initiatives have not yet been linked to a wider PNT or disaster response framework.

China has also been trialling EWS services through its BeiDou satellite navigation system, which has capabilities that are equal to (or potentially exceed) other constellations. BeiDou's satellite navigation system is able to transmit EWS messages to mobile phones and support two-way messaging. The latter is critical for search and rescue in areas with no or poor mobile signals.

China is expanding its GNSS infrastructure into the Southwest Pacific, with ground stations to receive BeiDou signals set up within the grounds of China's Pacific embassies.[13] While the setup of GNSS infrastructure has been done under the umbrella of humanitarian aid and disaster response, such as to assist after the Tonga volcanic event, it has nonetheless raised concerns about China's geostrategic intentions in the Pacific.

Australian R&D on PNT could contribute to broader discussions as to Australia's role in regional national security. Our southern hemisphere geography is advantageous for receiving signals and making use of EWS services from European and Japanese constellations. Australia could demonstrate leadership in coordinating an EWS approach with our Pacific neighbours, through DFAT, for a range of humanitarian, regional stewardship and national security reasons, including countering the influence of China on these critical services.

Technology development needs an Australian PNT framework

Australia's partners in AUKUS – the US and the United Kingdom (UK) – have clearly signalled the need for PNT resilience in their respective nations and done so through nationally-coordinated policy structures. This includes the development of national PNT strategies,[14] investment in infrastructure, technology and R&D, supported by strong governance frameworks.

In contrast, Australia does not have a national PNT strategy. Civilian and Defence capability needs have been developed to address organisational or even regional strategies, but have not been necessarily woven into a formal, coherent national PNT fabric. Civilian strategic programmes include Geoscience Australia's National Positioning Infrastructure Capability, and its billion-dollar SouthPAN satellite-based augmentation system for precise positioning, as well as the Australian Space Agency's conference presentation on a roadmap for PNT technology.[15]

In May 2024, there was a coordinated effort between the Department of Home Affairs, Bureau of Meteorology, National Emergency Management Agency and Geoscience Australia to undertake a national preparedness and response exercise to a space weather scenario.[16] This exercise, involving a range of critical infrastructure sectors, coincided with a real geomagnetic storm in Australia which reached a severity of G4 on the geomagnetic scale (with G5 the highest rating). The impact on PNT in Australia was minimal but observable; it resulted in significant errors in broadcasted SouthPAN signals, leading to a government decision to temporarily turn off its signal until the geomagnetic storm passed.[17]

Meanwhile external policy drivers are accelerating Defence investments in quantum-assured PNT, such as via the AUKUS Quantum Arrangement.[18]

Emerging technologies being developed with industry could include quantum sensors (for positioning and navigation) and quantum clocks (for timing). This progress is good, but it should be noted that the US and UK are investing in quantum PNT against a backdrop of their own national strategies. Australia, in contrast and in effect, is developing quantum as an isolated piece of technology.

There is no clear roadmap for geolocation-dependent sectors and mass market consumers to access the benefits of emerging technologies. Barriers to adoption include significant technical support, retrofitting of aging and vulnerable infrastructure with updated capabilities, and interoperability challenges between various technologies and platforms. Until significant efficiencies can be realised, GPS remains the primary form of accessible PNT for everyday Australians. In achieving resilient PNT for disaster response, the question is not which technology is superior, but how to switch to and from primary and backup modes of PNT depending on the need and environment.

The Government's focus on new PNT technologies without a national framework will not build resilience in disaster response. There remains an interoperability chasm between emerging technologies and our GPS-enabled critical systems. As well, users and adopters of PNT technologies, including critical infrastructure sectors, emergency responders and equipment manufacturers, should be included during strategy development rather than tacked on as a downstream afterthought.

A national PNT framework that is capability- and mission-based would help place emerging technologies within the context of disaster response, national security and other national priorities. The framework should help government and industry understand how these technologies switch seamlessly to and from each other in the event of GNSS denial or disruption, and what infrastructure to prioritise investment in to enable this seamless transition. Our national and regional resilience may well depend on it.

Notes

[1] Department of Prime Minister and Cabinet, *Australian Government Crisis Management Framework*, Commonwealth of Australia, September 2023, accessed 6 October 2024, https://www.pmc.gov.au/sites/default/files/resource/download/australian-government-crisis-management-framework_0.pdf

[2] Alan C. O'Connor and Michael P. Gallaher, *Economic Benefits of the Global Positioning System (GPS)*, 17 September 2019, accessed 6 October 2024, https://www.gps.gov/cgsic/meetings/2019/oconnor.pdf

[3] A detailed treatment of these complexities with regards to PNT and SOCI is presented in Joshua Critchley-Marrows, Eldar Rubinov, Phil Delaney, Jia Lee and Alex Linossier, "A Time and a Place for Resilience: Building Resilience Into Positioning, Navigation and Timing Services for Australia", *Frontier SI*, March 2024", https://frontiersi.com.au/wp-content/uploads/2024/02/FrontierSI_ResilientPNT_Report.pdf

[4] Department of Home Affairs, *2023-2030 Australian Cyber Security Strategy*, Commonwealth of Australia, 14 November 2023, accessed 6 October 2024, https://www.homeaffairs.gov.au/cyber-security-subsite/files/2023-cyber-security-strategy.pdf

[5] Department of Home Affairs, *Protecting Critical Infrastructure and Systems of National Significance: Discussion Paper*, Commonwealth of Australia, 23 April 2021, accessed 28 July 2024 https://www.homeaffairs.gov.au/reports-and-pubs/files/co-design-sector-specific-rules-discussion-paper.pdf

[6] Chief of the Australian Air Force, "Building Readiness and Resilience in National Air and Space Power Across the Spectrum of Competition", Royal Australian Air Force, 8 May 2024, accessed 6 October 2024, https://www.airforce.gov.au/news-events/speeches-transcripts/building-readiness-and-resilience-national-air-and-space-power-across-spectrum-competition

[7] Geoscience Australia, *Asia Pacific Reference Frame (APREF)*, accessed 28 July 2024, https://www.ga.gov.au/scientific-topics/positioning-navigation/geodesy/asia-pacific-reference-frame

[8] Michael A. Lombardi, 2023, *An Evaluation of Dependencies of Critical Infrastructure Timing Systems on the Global Positioning System (GPS)*,), Technical Note (NIST TN) – 2189, National Institute of Standards and Technology, 1 November 2021, https://doi.org/10.6028/NIST.TN.2189 ". https://www.nist.gov/publications/evaluation-dependencies-critical-infrastructure-timing-systems-global-positioning, p. 44.

[9] Lombardi, 2021, p. 48.

[10] Angela Macdonald-Smith and Gus McCubbing, "Blackouts stoke Victoria power grid fears", *Australian Financial Review*, 13 February 2024, accessed 28 July 2024, https://www.afr.com/companies/energy/vic-power-system-battling-heat-suffers-major-outage-20240213-p5f4ly

[11] Aimee Chanthadavong, "South Australia to splurge AU$13.5m on GPS tracking for firefighter vehicles", *ZDNET*, 22 September 2021, accessed 6 October 2024, https://www.zdnet.com/article/south-australia-to-splurge-au13-5m-on-gps-tracking-for-firefighter-vehicles/

[12] Suelynn Choy et al., "Australia-Japan QZSS Emergency Warning Service Trial Project", *Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol XLIV-3/WV1-2020*, 2020, https://doi.org/10.5194/isprs-archives-XLIV-3-W1-2020-21-2020

[13] Anne-Marie Brady, "China in the Pacific: from 'friendship' to strategically placed ports and airfields", *The Strategist*, 20 April 2022, accessed 6 October 2024, https://www.aspistrategist.org.au/china-in-the-pacific-from-friendship-to-strategically-placed-ports-and-airfields/

[14] Joshua Critchley-Marrows and Quentin Verspieren, "Ensuring PNT resilience: A global review of navigation policies and roadmaps", *Tokyo, Japan: Graduate School of Public Policy, The University of Tokyo*, July 2023, https://stig.pp.u-tokyo.ac.jp/stig/wp-content/uploads/2023/07/Resilient_PNT_Policy_Report_FINAL_ONLINE.pdf

[15] Jonathan Nally, “GNSS, PNT experts gather at Sydney conference”, *Spatial Source*, 23 March 2023, accessed 6 October 2024, https://www.spatialsource.com.au/gnss-pnt-experts-gather-at-sydney-conference/

[16] Senator the Hon Murray Watt, “Exercise Aurora shines light on the importance of preparedness”, Commonwealth of Australia, 22 May 2024, accessed 6 October 2024, https://minister.homeaffairs.gov.au/MurrayWatt/Pages/exercise-aurora-importance-preparedness.aspx

[17] Based on unpublished minutes from the Space Sector Group, Trusted Information Sharing Network meeting, May 2024.

[18] “FACT SHEET: Implementation of the Australia – United Kingdom – United States Partnership (AUKUS)”, accessed 6 October 2024, https://pmtranscripts.pmc.gov.au/sites/default/files/AUKUS-factsheet.pdf

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