

A RESILIENT PNT WHITE PAPER



A TIME AND A PLACE FOR RESILIENCE

WHY BUILDING RESILIENCE IN POSITIONING,
NAVIGATION AND TIMING TECHNOLOGIES IS
CRITICAL FOR AUSTRALIA'S FUTURE

MARCH 2024

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1 CONTEXT

WHAT EXACTLY IS PNT TECHNOLOGY?

Similar to a smartphone's GPS, Positioning, Navigation and Timing (PNT) technology helps users figure out where exactly they are, where they're going, and what time it is, using satellite signals and a network of ground communication sites. Most Australians are now familiar with and heavily reliant on PNT technology through everyday applications such as accessing their current position, navigating to a location on their phone or through their vehicle's SatNav. PNT also plays a key role in major parts of our economy, for example in automation across mining sites, or the use of precision-guided equipment on our farms.

Fewer Australians would be aware of the essential role of the Timing part of PNT. The atomic clocks onboard the global navigation satellite systems (GNSS) allow nanosecond, globally coordinated accuracy in our financial transactions. With a billion global transactions a second, this ensures the integrity of transactions from supermarket purchases to stock trades.

Almost every part of our current and future economy is in some way reliant on PNT. This includes managing the routing of our mobile phone communications, intelligently distributing energy across our power



grids, providing critical safety to our emergency and disaster response teams, and of course supporting the movement of people and goods in the air, on the water, and on the road.

WHAT IS THE PROBLEM?

For over 40 years PNT systems have been available to the public, and in that time, we have become increasingly dependent on them as consumers and across Australian industries. However, in recent years technology failures and targeted cyber-attacks have led to increased disruptions to the people and organisations relying on the technology. For example, in April 2023, when the satellite signal providing precise positioning corrections used to improve positioning accuracy for government and commercial services in Australia went down, it heavily affected the agriculture and maritime sectors which depend on the signal for precision guidance and safety. Cyber-attacks have also attempted to disrupt supporting infrastructure on multiple occasions, leading to challenges in locating and directing both people and infrastructure in military, consumer, and industrial applications.

While Australian investments in improving redundancy and accuracy, such as through [SouthPAN](#), are critical to reducing the impacts of these disruptions, PNT vulnerabilities still exist both on the ground and in space. This could lead to substantial financial or supply chain disruptions or even loss of life. While many of these vulnerabilities are outside of Australia's control, proactive measures can be taken to mitigate or prevent some impacts on the user. This white paper focuses on efforts to mitigate disruptions to PNT which will be referred to as Resilient PNT.

WHY NOW?

Australia has never been more reliant on PNT for economic growth, safety, defence, and disaster response. However, we have never been more vulnerable to disruption either. With the Australian economy finally emerging from the major disruptions caused by the COVID-19 pandemic, as well as the current cost of living crisis, Australia cannot afford the economic and supply chain disruptions that

would be caused by a major PNT incident. As with all vulnerabilities, the best time to address these is in the past, and the next best time is now. Waiting for a more serious incident than the ones we have already experienced will be too late.

Further, this is an issue with an increasing global focus, with countries such as Canada, China, the EU, India, Japan, the UK and the USA all producing policies and roadmaps to improve PNT Resilience. Australia can address the vulnerabilities by taking internationally released lessons and plans and customising and improving them for the Australian context.

WHAT IS RESILIENT PNT?

As PNT is a sophisticated system of technologies across the globe and in space, there are many approaches to ensuring resilience in the system, and many terms and definitions as well. For the purposes of Australia's future and this white paper, we will be using the following definition of Resilient PNT:

Ensure the ability of PNT services to withstand and recover from disruption, both natural and man-made, to provide availability and continuity, and encourage trust.

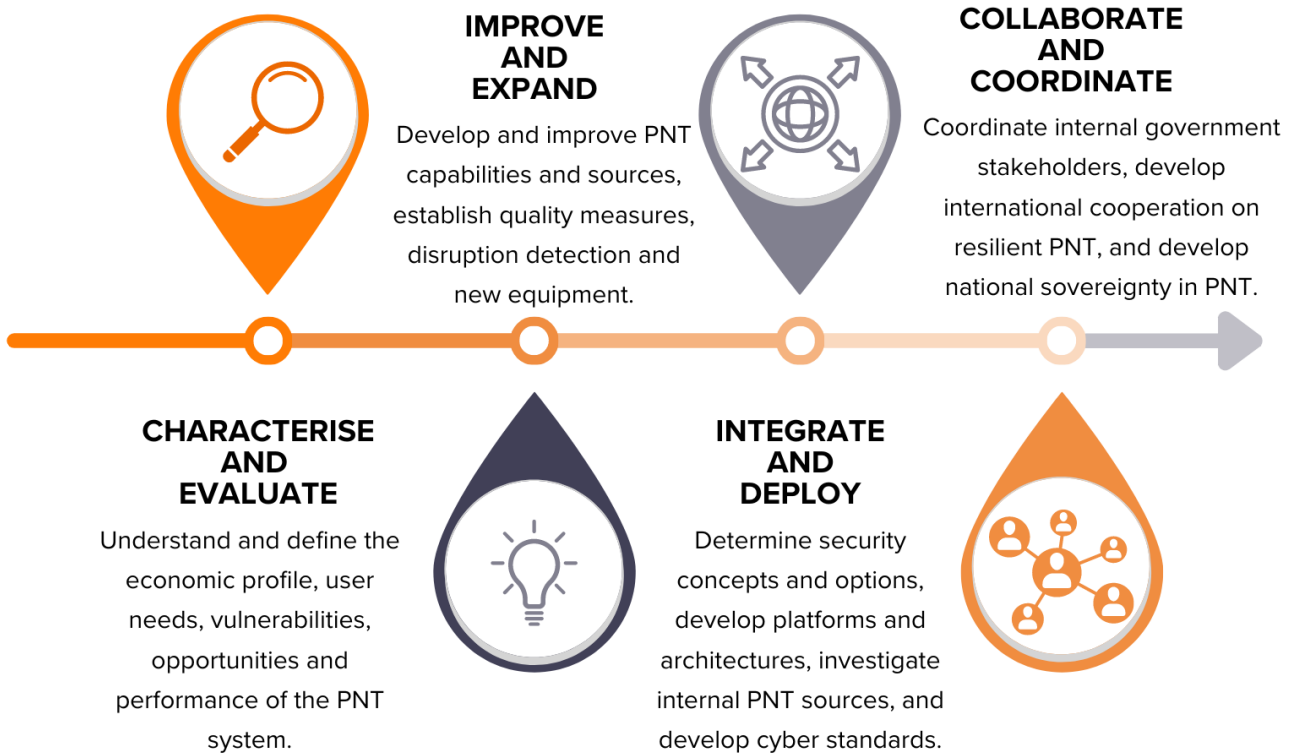
Within this resilience, four key themes help address resilience. These are:

- Assured PNT – Removing doubt that PNT services will be continuous and available, for example through legislation.
- Robust PNT – Using a suite of technology to ensure PNT services will recover and continue for critical needs, even if in a degraded form.
- Augmented PNT – Using additional technology to improve the performance of the PNT system, such as accuracy, precision, availability, continuity, and integrity.
- Alternative PNT – The use of a technology independent of the Global Navigation Satellite Systems to calculate PNT information that meets the current critical application needs.

FrontierSI, in line with global trends in resilient PNT policymaking, uses the following framework to guide the implementation of a Resilient PNT Roadmap for Australia:

FrontierSI is focused on anticipating and solving major problems using space and spatial technology. We have created this paper to raise awareness of PNT vulnerabilities, and to suggest a path forward for the nation. A more [detailed report](#) covering the background, consultation, findings, and recommendations can be found in the expanded technical report.

RESILIENT PNT ROADMAP FOR AUSTRALIA



2 PNT USE ACROSS AUSTRALIA

To help further characterise and evaluate the PNT needs and vulnerabilities for Australia, FrontierSI has undertaken initial consultation with leaders across federal government departments within Australia. Whole of industry consultation has been covered

within other reports, that will need to be refreshed in the future. This report focused on inputs from federal departments to help outline the policy and industry drivers for the Australian government to actively invest in resilient PNT activities.

AUSTRALIAN PNT APPLICATION

PNT NEED

RISK / VULNERABILITY

AGRICULTURE



- Empower the Agriculture sector to increase crop yields and general productivity.
- Deliver an increased adoption of digital infrastructure in rural areas.
- Ensure continuity of service and avoid technology distrust by agricultural communities.

- Sole reliance of precise agriculture and digital agriculture on GNSS
- Failure of automated tractors, geofencing systems, leading to loss of productivity and decrease in export value.

TIME



- Support the dissemination of Australian UTC (Universal Time Coordinated) across the continent.
- Ensure private operators, such as telecommunication and energy providers, can synchronise time across their networks.
- Provide critical supply of atomic clock technology for Australian critical infrastructure.

- Remote calibration services provided by the National Measurement Institute stop after 3 months.
- Time and frequency distributed to users via the Internet stops after 1 month.
- Atomic clock manufacturing supply chain is disrupted.
- Critical infrastructure sectors cease to function.

AUTOMOTIVE



- Delivery of safety, security, and privacy concerns for road transport users.
- Be prepared for disruptive changes that may occur to PNT technology.
- Paving the way for new autonomous automotive technologies on Australia's roads.

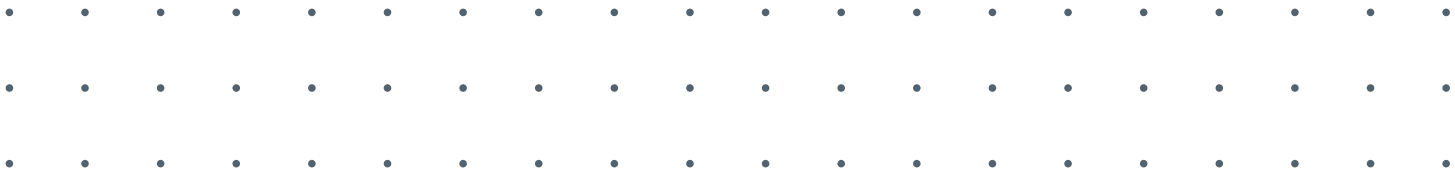
- Insufficient information from GNSS solutions and security risks delay system readiness of connected vehicle technology.
- Cybersecurity risks to PNT lead to increased risks of road-related accidents and inhibit progress in future transport mobility.
- Disruptions to GNSS impact vehicle compliance monitoring.

AVIATION



- Ensure aviation safety for Australian-flagged airships within Australia and overseas.
- Enable the safe introduction and sustainable growth of unmanned aerial vehicles in Australia.
- Support Australian aviation resilience under an increasingly congested radio communication spectrum.

- Cyber-related risks, including PNT, to airports, airlines, air traffic management and airspace management.
- Degraded or denied GNSS to airlines poses a risk to airspace administration in Australia and internationally, as well as risks to public safety.



AUSTRALIAN PNT APPLICATION

PNT NEED

RISK / VULNERABILITY

DEFENCE



- Support industrial capability in scenarios where our geographical separation leaves Australia at a disadvantage.
- Provide operational resilience for Australian defence forces when GNSS is compromised.
- Achieve advanced R&D ambitions for the Australian defence industry.

- Defence capabilities are completely reliant on foreign-owned GNSS (GPS) alone for operating effectively, representing a single point of failure in infrastructure.
- Alternative PNT, such as quantum technology, are at low maturity levels to back up or augment GNSS.

FOREIGN AFFAIRS



- To deliver on the consular services charter, that strives to serve Australians overseas.
- To provide safety and security for Australian government staff overseas.
- To aid in the joint development of Australia's Pacific Island partners.

- Impact on Australia's stewardship role, including provision of critical services and search and rescue, in the Indo-Pacific, Antarctic region and internationally in the event of disrupted GNSS and telecommunications.

MARITIME



- Ensure the responsible regulation and safety oversight of all vessels, Australian and foreign, located in Australian waters.
- Lead the digitisation and automation of Australia's port infrastructure.
- Provision of precise timing for maritime communication systems.

- Reliance on GNSS as the primary form of navigation, with low level of adoption in alternative / emerging PNT technologies.
- The accuracy of emerging PNT services is still dependent on timing synchronisation via GNSS.
- Disruptions to PNT systems impact onboard safety of navigation, aids-to-navigation, port operations, supply chains, search and rescue operations, and maritime assistance operations.

METEOROLOGY



- Ensure the continued operations of essential climate and weather monitoring systems.
- Support Earth and climate science research and prediction services.
- Protect Australian infrastructure from serious space weather events.

- Adverse impacts of space weather on GNSS-supporting infrastructure and GNSS-reliant critical infrastructure.
- Weather monitoring station depends on GNSS and at risk of failing if GNSS is degraded or denied.

TELECOMMUNICATIONS



- Effectively regulate against jamming and spoofing threats to GNSS.
- Regulate without risk new Australian satellite constellations, which would critically depend on GNSS-based services.
- Coordination of new frequency bands that would deliver alternative radio-based PNT.

- Illegal and unregulated jamming and spoofing of GNSS, leading to degraded or denied telecommunications services.
- Loss of GNSS timestamping would disrupt nationwide telecommunication services.

CRITICAL INFRASTRUCTURE



- The Security of Critical Infrastructure (SOCI) Act 2018 was established to regulate and protect critical infrastructure.
- PNT is mentioned in the act, however, as Australia does not own space-based assets the act does not apply specifically to PNT.

- Failure of PNT services is a significant threat to Critical Infrastructure in Australia.
- As Australia does not own space assets, this may lead to confusion in the responsibility to address CI vulnerabilities.

3 AUSTRALIAN RESILIENT PNT ASSESSMENT

Utilising the proposed Resilient PNT roadmap framework, the table below outlines a traffic light assessment of Australia’s current activities in each

of the framework components. The full details of Australia’s activity in each framework component can be found in the detailed companion report.

- Significant progress or activity
- Some progress, progress limited to one sector or outdated activity
- No publicly available progress or activity

THEME	COMPONENT
1. CHARACTERISE AND EVALUATE	a. Perform an economic assessment to the cost of disruption to PNT
	b. Characterise PNT needs and requirements of relevant market sectors
	c. Evaluate threats and vulnerabilities to current PNT systems
	d. Understand existing technologies available that deliver PNT
	e. Appraise test capabilities and test protocols for assessing PNT infrastructure, equipment and services
	f. Assess tools to qualify the performance of PNT equipment and services, both individually and as an integrated system
2. IMPROVE AND EXPAND	a. Develop and improve internally-derived capabilities of PNT
	b. Develop and improve external sources of PNT, both man-made and natural
	c. Establish quality assurance measures for a wide range of end-users
	d. Improve and expand disruption detection and mitigation methods
	e. Prototype and demonstrate consumer equipment to adopt new PNT services
3. INTEGRATE AND DEPLOY	a. Determine concepts and techniques for securely integrating multiple sources of PNT services
	b. Development of common hardware platforms and signal standards, if appropriate, for multiple sources of PNT information
	c. Develop resilient PNT system architectures and frameworks
	d. Investigate using internal sources as primary sources of PNT service
	e. Develop cybersecurity standards, best practices, and other guidance to achieving resilient PNT
4. COLLABORATE AND COORDINATE	a. Internal coordination and collaboration between government actors
	b. International cooperation and adoption of resilient PNT systems
	c. Develop national/regional sovereignty in PNT

4 RECOMMENDATIONS FOR THE AUSTRALIAN GOVERNMENT

The engagement and subsequent analysis have led to a consolidated list of recommendations for Australian policy directions towards resilient PNT. These are complementary to the other subsections on delivering an Australian solution.

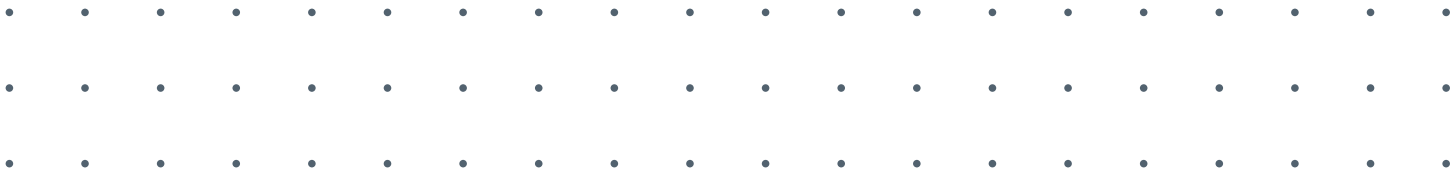
Delivery of resilient PNT involves a coordinated response from both a technological and policy perspective. FrontierSI, with strong expertise in PNT technology and experience in the Australian context, looks forward to supporting efforts of resilient PNT

for Australia by the Australian Government. FrontierSI intends to support activities to achieve PNT resilience for the nation.

We encourage all interested people to [contact us](#) to explore how we can work together towards a resilient future for PNT in Australia. Together, let's innovate and protect the backbone of our daily operations and national security.

contact@frontiersi.com.au

RECOMMENDATION 1	Building resilient PNT services should not be treated as an outcome to enforcement of legislation (e.g. SOCI Act). Other methods should be considered to achieve the same level of resilience as other Australian Critical Infrastructure assets.
RECOMMENDATION 2	Home Affairs' Cyber and Infrastructure Security Centre should provide mitigation pathways that asset owners/operators can use to mitigate risks to disruption or degradation of GNSS.
RECOMMENDATION 3	Australia needs to develop an alternative source of timing, either through space or terrestrial means, that will aid in synchronisation and dissemination across the nation.
RECOMMENDATION 4	Australia should review and address its supply chain dependencies on atomic clock technology.
RECOMMENDATION 5	Consider Transport Certification Authority GNSS qualification frameworks under any future, nationalised conformance framework for resilient PNT.
RECOMMENDATION 6	Australia needs a comprehensive study and appraisal of all vulnerabilities to a loss of GNSS, with recommended mitigations.
RECOMMENDATION 7	Defence is a fundamental stakeholder of PNT services, including those delivered from civilian infrastructure. Any civilian resilient PNT solution should take a dual-use approach partnered with Defence.
RECOMMENDATION 8	To deliver on international development policy, participation in or development of new sovereign PNT systems should consider their multi-layered impact on diplomacy and relations overseas, especially in the Asia-Pacific community.
RECOMMENDATION 9	Australia's maritime sector is one of the most critical sectors to strongly depend on GNSS and should be treated as a first use case in any future infrastructure developments.
RECOMMENDATION 10	Given the multifaceted intersection of PNT across various Australian Government agencies and departments, a National PNT Office is necessary to consolidate PNT-related outputs and provide governance of PNT issues for Australia.



5 ACKNOWLEDGEMENTS

About FrontierSI

[FrontierSI](#) stands at the forefront of Australia's journey towards resilient PNT infrastructure. Leveraging over 20 years of expertise and collaboration, FrontierSI aims to drive innovation towards a more resilient PNT infrastructure and is well-placed to provide leadership in ensuring resilient PNT for the nation.

FrontierSI, formerly the CRC for Spatial Information, has a strong record of delivering spatial information services throughout Australia, New Zealand and around the world. We harness the transformative power of collaboration and robust networks to curate top-tier teams dedicated to effective problem-solving. As a trailblazing social enterprise, FrontierSI focuses its deep spatial expertise on developing and implementing solutions using applied geodesy, spatial infrastructures, analytics, space technologies, and artificial intelligence.

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