An Australian Initiative

SHIELD

COOPERATIVE RESEARCH CENTRE

Safeguarding Australia's critical infrastructure

Secure, Hardened, Integrity-Enhanced, Location and Timing Defence

Presented By: Professor Allison Kealy

December 2024

Motivation

Australia's critical infrastructure—energy, communications, transport, finance, and emergency—rely heavily on space-based PNT. Any attack to these would disrupt essential services, endanger public safety, destabilise key sectors, and may even threaten our national security. **An urgent and strategic response is required to defend our core PNT services.**

Australia is advancing resilient PNT innovations and asymmetric defence technologies,, but faces challenges in unifying efforts, securing remote areas, protecting infrastructure, addressing emerging threats in the Indo-Pacific region and reducing reliance on foreign systems. **Success hinges on a unified national strategy and close international collaboration.**

SWINBURNE UNIVERSITY OF TECHNOLOGY

What we aim to do

Innovation through collaboration: Foster national and international collaborations between industry, government, and academia to safeguard national security, fortify economic resilience, and enhance the safety and well-being of all Australians, positioning the nation as a leader in critical technology and innovation.

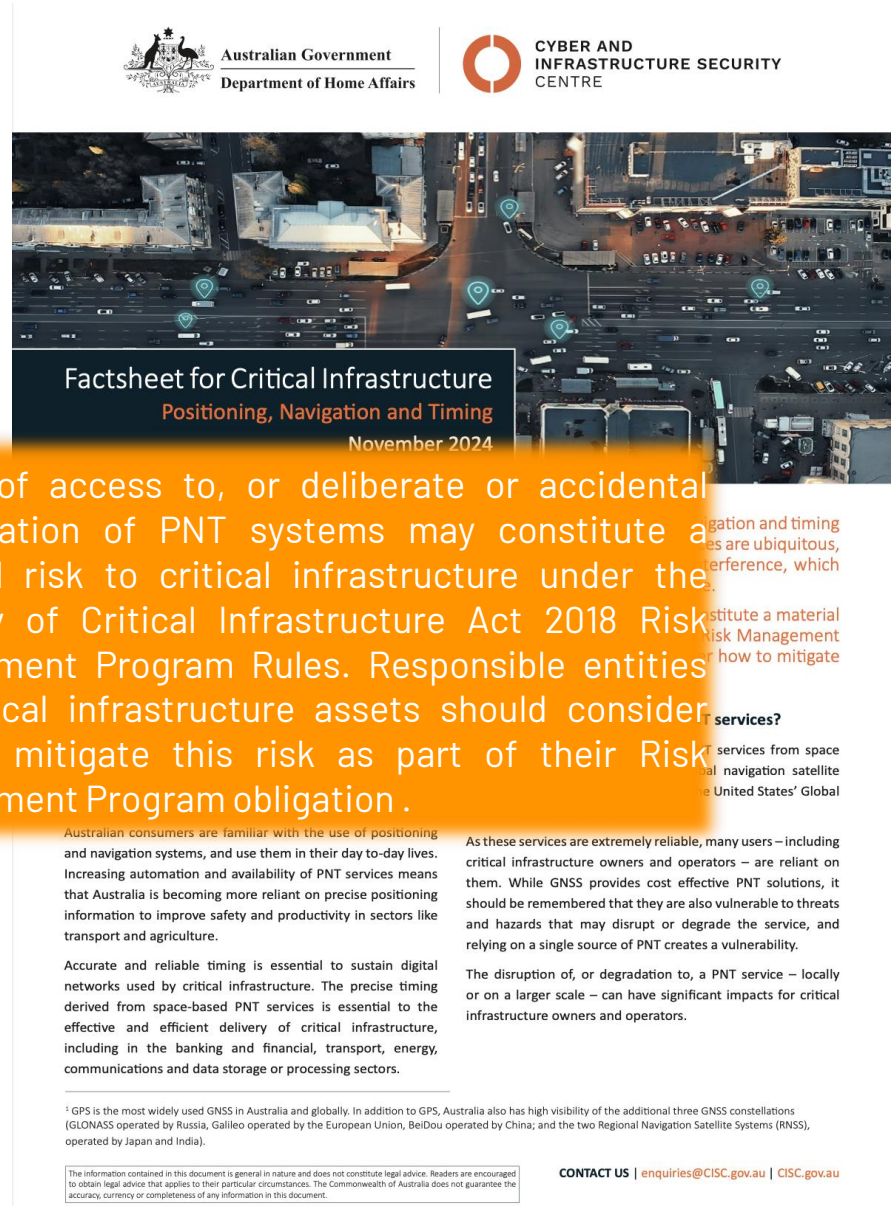
Outcome and Impact – PNT as a utility: A national threat protection and response infrastructure, capable of defending against both natural disasters and deliberate threats to the nation's critical infrastructure.

CRCs: What's on offer?

- **Unique program for scale and duration:** Commonwealth funding typically $40-$70m over 10 years (co-funding by industry and academia typically doubles this)
- **IP:** – Affirmative to industry partners
- **Collaboration, networking, partnering:** Solving problems through R&D
- **Access to world-class R&D resources:** to work on your problems (typically 'at-cost')
- **'Neutral' environment:** To co-develop technical approaches, policy and other solutions
- **Focus on generating outputs:** For use by industry and government
- **Training of future leaders:** Credentials and embedded PhDs
- **R&D Tax Concessions:** For company co-funding.

The Australian Landscape

- **Critical Space Infrastructure Gaps:** The Department of Home Affairs' inclusion of the Space sector under the Security of Critical Infrastructure Act recognises its strategic importance but lacks clearly defined assets.
- **GNSS Dependence:** Supporting systems like SouthPAN rely on GNSS; disruptions directly impact critical sectors (e.g., aviation, agriculture, emergency services).
- **Sectoral Unawareness:** Many industries are unaware of their reliance on PNT, increasing the risk of cascading failures during disruptions.
- **Risk Management Deficiency:** No standardised processes exist for reporting, mitigating, or profiling PNT risks.
- **Stakeholder Vulnerability:** Absence of knowledge and frameworks leaves stakeholders ill-equipped to address threats effectively.



Australian Government
Department of Home Affairs

CYBER AND INFRASTRUCTURE SECURITY CENTRE

Factsheet for Critical Infrastructure

Positioning, Navigation and Timing

November 2024

A loss of access to, or deliberate or accidental manipulation of PNT systems may constitute a material risk to critical infrastructure under the Security of Critical Infrastructure Act 2018 Risk Management Program Rules. Responsible entities for critical infrastructure assets should consider how to mitigate this risk as part of their Risk Management Program obligation .

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isk Management
how to mitigate

services?

services from space
al navigation satellite
United States' Global

Australian consumers are familiar with the use of positioning and navigation systems, and use them in their day to-day lives. Increasing automation and availability of PNT services means that Australia is becoming more reliant on precise positioning information to improve safety and productivity in sectors like transport and agriculture.

Accurate and reliable timing is essential to sustain digital networks used by critical infrastructure. The precise timing derived from space-based PNT services is essential to the effective and efficient delivery of critical infrastructure, including in the banking and financial, transport, energy, communications and data storage or processing sectors.

As these services are extremely reliable, many users – including critical infrastructure owners and operators – are reliant on them. While GNSS provides cost effective PNT solutions, it should be remembered that they are also vulnerable to threats and hazards that may disrupt or degrade the service, and relying on a single source of PNT creates a vulnerability.

The disruption of, or degradation to, a PNT service – locally or on a larger scale – can have significant impacts for critical infrastructure owners and operators.

[1] GPS is the most widely used GNSS in Australia and globally. In addition to GPS, Australia also has high visibility of the additional three GNSS constellations (GLONASS operated by Russia, Galileo operated by the European Union, BeiDou operated by China; and the two Regional Navigation Satellite Systems (RNSS), operated by Japan and India).

CONTACT US | enquiries@CISC.gov.au | CISC.gov.au

The Australian Landscape

Developing alternative position, navigation and timing capabilities:

- **Enhanced Precision**:
  Strike accuracy down to metres or centimetres.
  Navigation ambition: <0.1% for autonomous systems (ambition 5km error over 5000kms).
- **Autonomy Dependency**:
  Robust PNT essential for autonomous systems.
  Lack of assured local or global PNT undermines "smart-small-many" RAS strategies.
- **SWaP Considerations**:
  Scalable solutions: from compact, low-cost systems (e.g., Cube systems) to larger systems (e.g., QuantumPNT "bar fridges").
- **Geopolitical Context**:
  Adversaries advancing; China integrates BeiDou, LEO, terrestrial broadcasts, and eLORAN to complement GPS.
- **Threat Landscape**:
  GNSS vulnerable to ASAT, electronic, and cyber warfare by state and non-state actors.

The Australian Landscape

- **JP9102 satellite program cancelled.**
- **JP9380 Objectives:** Assured PNT in GPS-denied/degraded environments. Phase 1 focuses on:
  - Establishing a Navigation Warfare Centre to build PNT knowledge and support Defence activities.
  - Developing a multi-layered PNT strategy to enhance navigation resilience.
- **Emerging PNT Technologies**: Quantum sensors, Digital FOG INS, multi-sensor, and multi-platform exploitation.
- **Behaviour-Based Navigation:** Utilises external signals (e.g., EM, acoustic, visual, oceanographic) with information theoretic behaviour to maximise "accuracy" salient to need. Maximizes "accuracy" based on mission-specific needs.
- **Funding Challenges:** Minimal investment in PNT resilience beyond JP9380.


GLOBAL, SPACE

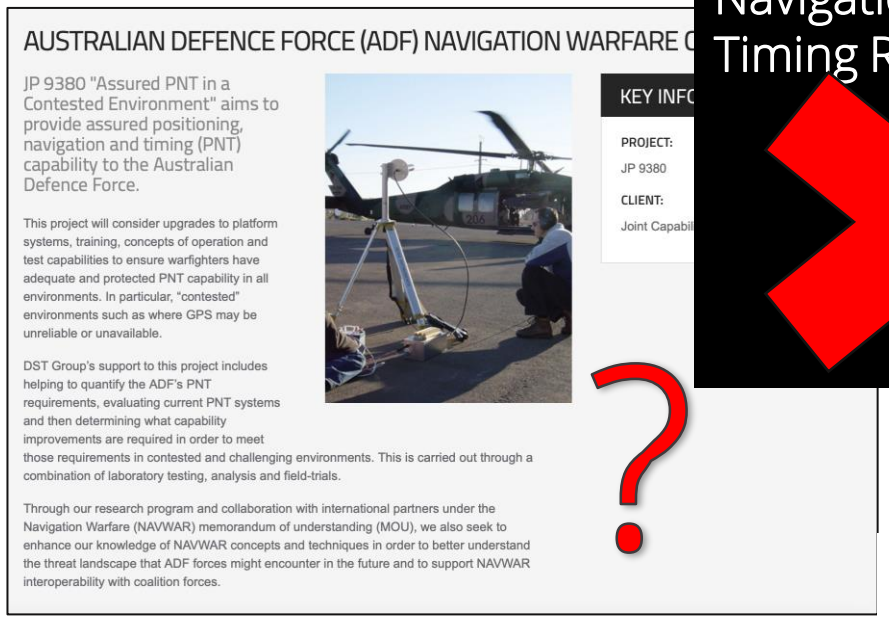
Australia kills $5.3B military space program with Lockheed

"I am sure some companies will seriously conside business case for dealing with se as a customer in the future, which I worry will mean our warfighters will miss out on homegrown in t can make a differenc ttlefield," Jeremy Hallett, head of the Space Industry Association of Australia, said in a statement

By COLIN CLARK on November 04, 202

Australian Space Agency

Positioning, Navigation and Timing Roadmap


AUSTRALIAN DEFENCE FORCE (ADF) NAVIGATION WARFARE C

JP 9380 "Assured PNT in a Contested Environment" aims to provide assured positioning, navigation and timing (PNT) capability to the Australian Defence Force.

This project will consider upgrades to platform systems, training, concepts of operation and test capabilities to ensure warfighters have adequate and protected PNT capability in all environments. In particular, "contested" environments such as where GPS may be unreliable or unavailable.

DST Group's support to this project includes helping to quantify the ADF's PNT requirements, evaluating current PNT systems and then determining what capability improvements are required in order to meet those requirements in contested and challenging environments. This is carried out through a combination of laboratory testing, analysis and field-trials.

Through our research program and collaboration with international partners under the Navigation Warfare (NAVWAR) memorandum of understanding (MOU), we also seek to enhance our knowledge of NAVWAR concepts and techniques in order to better understand the threat landscape that ADF forces might encounter in the future and to support NAVWAR interoperability with coalition forces.

KEY INFO

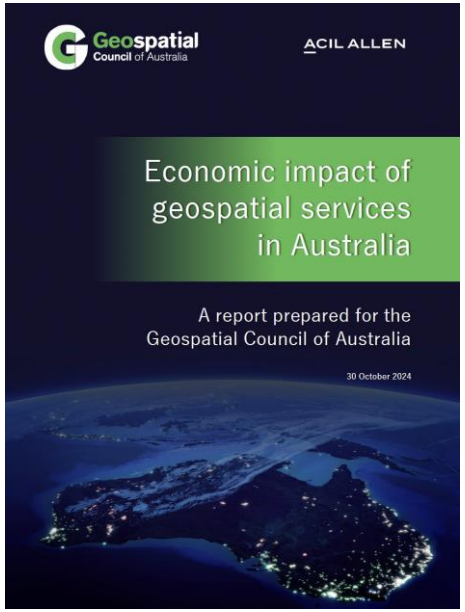
PROJECT:

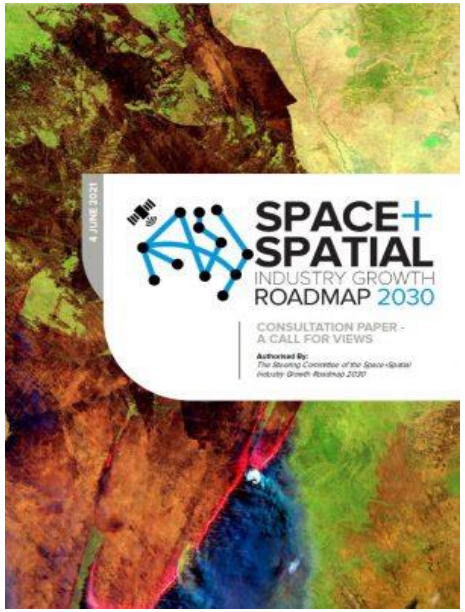
JP 9380

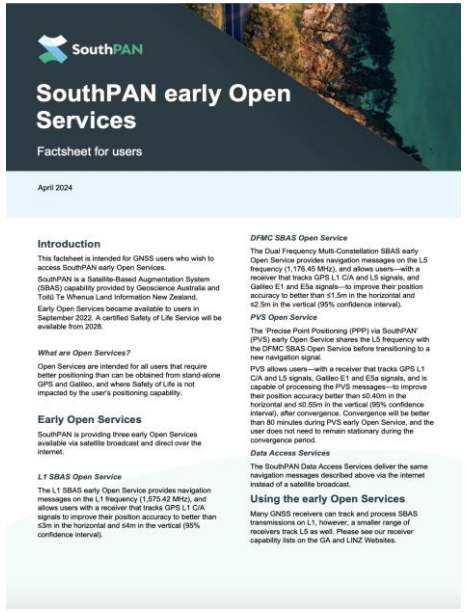
CLIENT:

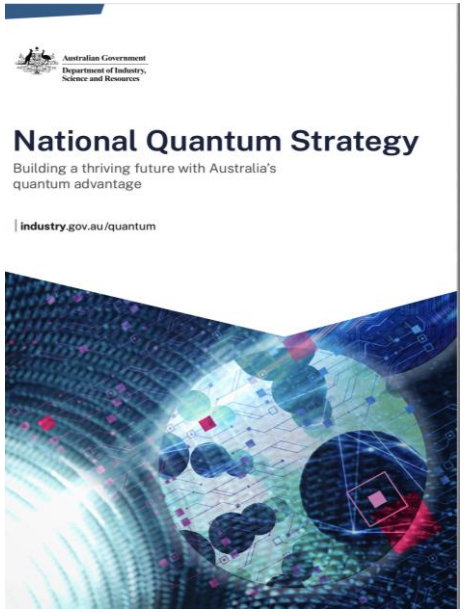
Joint Capabil

The Australian Landscape – no shortage of problem recognition









The Australian Landscape – no coordination towards an end goal

SBAS

Government departments

Start ups

Critical infrastructure sectors

Academia/R Sector

LEO

Quantum

Cybersecurity

AI

Potential R&D Opportunities – what we have heard so far

AUSTRALIAN PNT ADVISORY COMMITTEE

Detect	Augment	Secure	Protect
Identify/prioritise potential threats and autonomously report on them	Alternative technologies rating for resilience	Integrated cybersecurity for PNT	PNT as a Service/Utility
Self-Healing PNT Systems :Graceful degradation protocols and service	Autonomous, seamless sensor selection and integration	Workforce and PNT supply chain	PNT Security as a Service
AI driven threat mitigation	Retrofitting vs plug and play	Real-time threat intelligence network	Provide a test environment to prove resilience, resulting in a resilience level
Anomaly detection	Dynamic calibration and environment sensing	Signal authentication and validation methods	Develop standards and recommend policy
			Provide PNT Assurance for companies: profile and recommend
			Geodetic infrastructure and products that support new PNT technologies.

WAR GAMING/MISSION SIMULATION

CRISIS MANAGEMENT/DISASTER PREPAREDNESS DRILLS

Detect and Report – GRIFFEN/GRIST

- **PWSA and LEO Testing in Australia:**
  - Observations at Keilor Park reveal Link-16 communications testing from LEO using radar L2 band (1237 MHz).
  - Deterrence signals also observed, hinting at potential future GNSS jamming and spoofing capabilities.
- **GRIFFIN Evolution to GRIST:**
  - Originally focused on terrestrial GNSS protections .
  - Now expanding to address space domain threats, including adversary mega-LEO constellations designed for regional GNSS
- **Global LEO Deployment Trends:**
  - US PWSA: 400+ satellites in Tranche 0 and 1, with Tranche 2 launching by late 2025.
  - China's 1000 Sails: 13,000+ satellites; early launches underway.
  - Russia: 1,200 satellites expected from 2025.
  - Other : India and Europe progressing with LEO investments.
- **Current GRIST Mission:** ANZ-focused network for identifying malicious LEOs amidst benign satellites.
  - Keilor Park, VIC (operational).
  - Ohau, NZ (online mid-Dec 2024).
  - Newcastle, NSW (online mid-Jan 2025).

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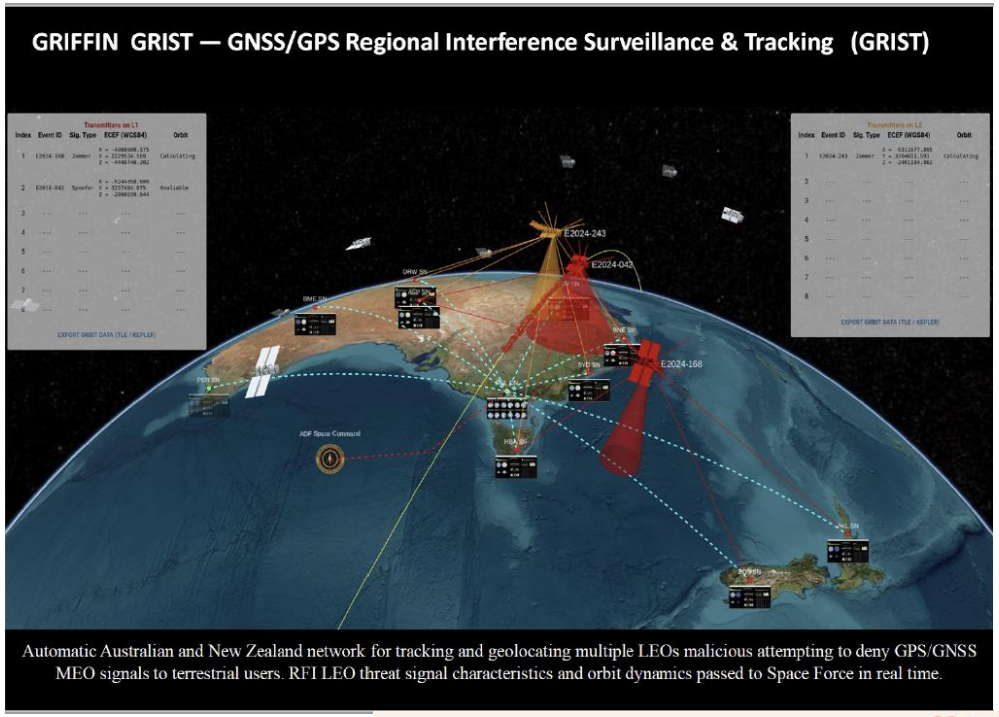
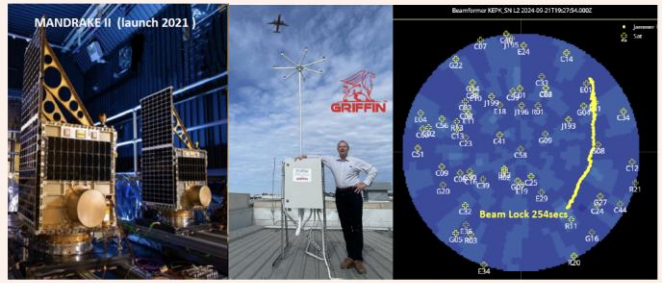


Automatic Australian and New Zealand network for tracking and geolocating multiple LEOs malicious attempting to deny GPS/GNSS MEO signals to terrestrial users. RFI LEO threat signal characteristics and orbit dynamics passed to Space Force in real time.

GRIFFIN Update — MARQUEE LEOs (PWSA)

November 2024

GPSat's GRIFFIN project team is pleased to announce that Melbourne monitoring station is successfully monitoring and tracking US Space Development Agency's (SDA) new MARQUEE Traunch0 LEO constellation space vehicles. Launched early 2023, Qty 27 Marquee SVs are testing both new Link16 comms between space to ground and inter satellite laser communication technologies. These experiments recently reported by Aviation & Space news, are being conducted over both Australia and adjoining international waters (Tasman Ocean), while US FAA/ FCC frequency licences are being considered for future space operations. The GRIFFIN technology with its space optimised phased array antenna system, effortlessly tracks the MARQUEE low level test signals over mid the Tasman Ocean. MARQUEE testing is expected to be ongoing until late 2025.



MARQUEE is part of US Space Force's new Proliferated Warfighter Space Architecture (PWSA) future mega LEO constellation. Regular new tranches of SVs, delivering low-latency Comms DELIVERY, ballistic missile TRACKING, with enhanced Battle Management, NAVIGATION (PNT), and EW DETERRANCE from space..

Secure and Protect– FrontierSI

Scenario 1 - Background

- It is early 2025
- The Bureau of Meteorology (BoM) reports a Coronal Mass Ejections event associated with the recent solar maximum. Extreme ionospheric activity will occur worldwide and will persist for approximately 24-48 hours.
- The US Space Force (USSF) reports degraded GPS satellite signals, and Geoscience Australia advises that SBAS signals from the civilian SouthPAN service, which augments GPS signals for safety-of-life aviation systems, are also degraded. The EU, Russia and China also report minor degradations to their GNSS constellation signals . Media channels report that both military and civilian users worldwide have reported increased positioning noise, up to 20 m for some common receiver products.
- Australia's power supplies are also affected, and the Trusted Information Sharing Network (TISN) has advised that several power grid stations in NSW are experiencing disruptions to normal operations. Defence Estate has reported that several Defence bases in NSW and QLD are using backup emergency power supplies. Early investigations from energy companies indicate the disruption is being caused by time synchronisation errors, related to GNSS signal degradation.

PNT- **Time** for metrology-level, wide area RF distribution

New capabilities now being trialed by **National Metrology Institutes for RF-based time transfer**

Locata

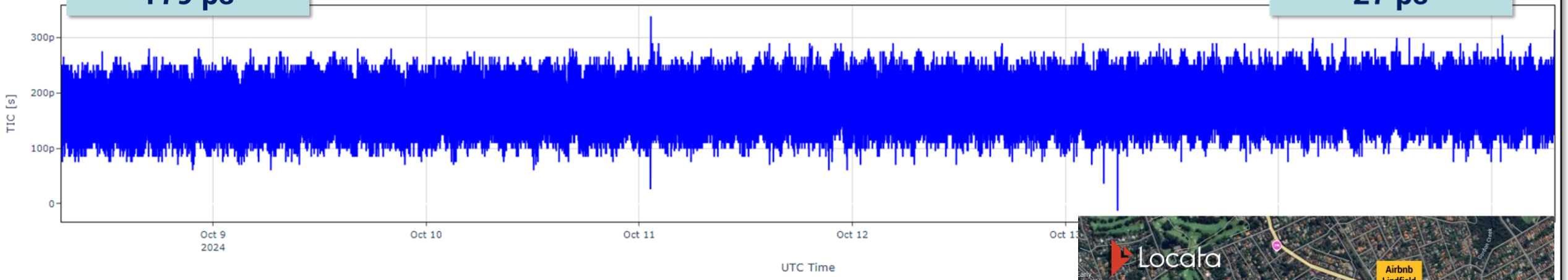
TimeLoc - Locata Internal Synchronisation

Mean [ps]	Standard Deviation [ps]	Peak to Peak [ps]	Num Samples
179.338	27.592	351.562	605547

Mean **179 ps**

7 day log: Locata distributing Australia's UTC clock in Sydney area

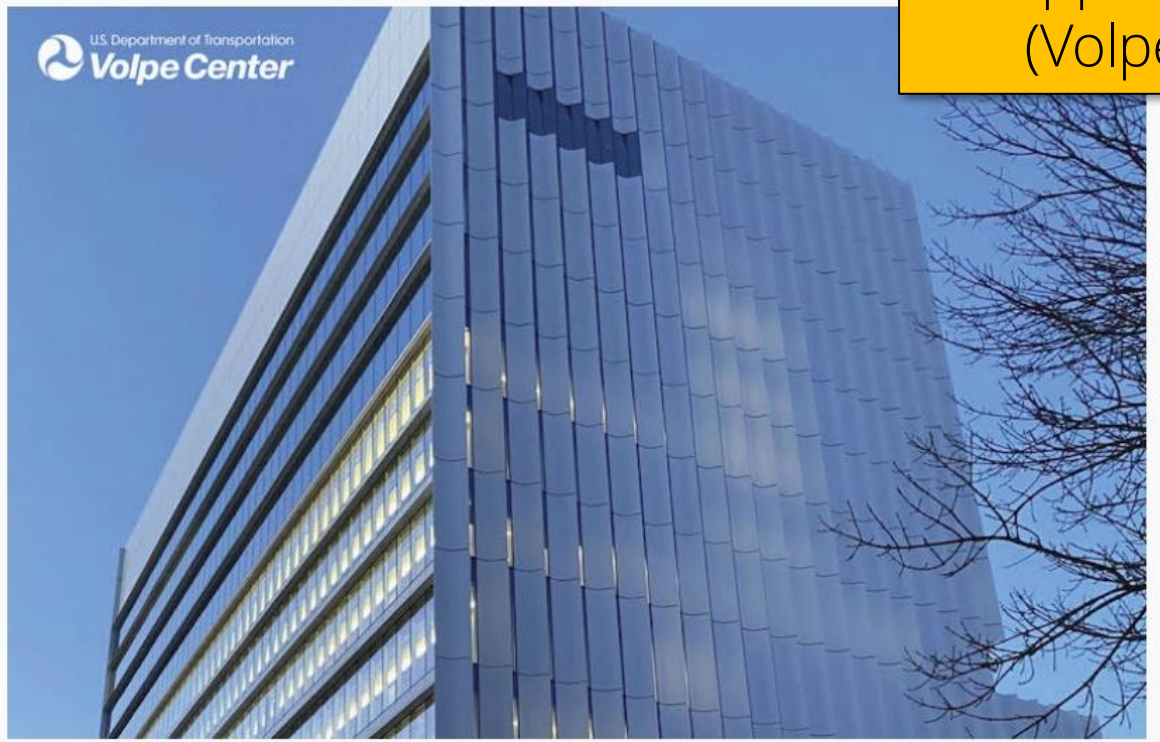
Standard Dev **27 ps**



- **Now demonstrating unique local, regional & wide-area "NMI-grade" RF time transfer**.
- Synchronizes transmitters wirelessly **to picosecond levels *without* GNSS** or any external corrections. Over 105 km distance already trialed. **Proven - TRL8**.
- **Allows *unprecedented flexibility*** deploying non-GNSS national timing backbone networks.
- Fundamentally: **Comparable to White Rabbit performance *but without needing fibre!***

DOT CPNT RFI Contract Award Details Released

June 19, 2024 By Inside GNSS



According to federal portal SAM.gov, nine contract awards have been announced by the U.S. Department of Transportation for the Complementary Positioning, Navigation, and Timing (CPNT) RFI.

The companies granted contracts according to SAM.gov are:

- Carahsoft Technology Group
- Locata Corp
- Hoptroff Inc.

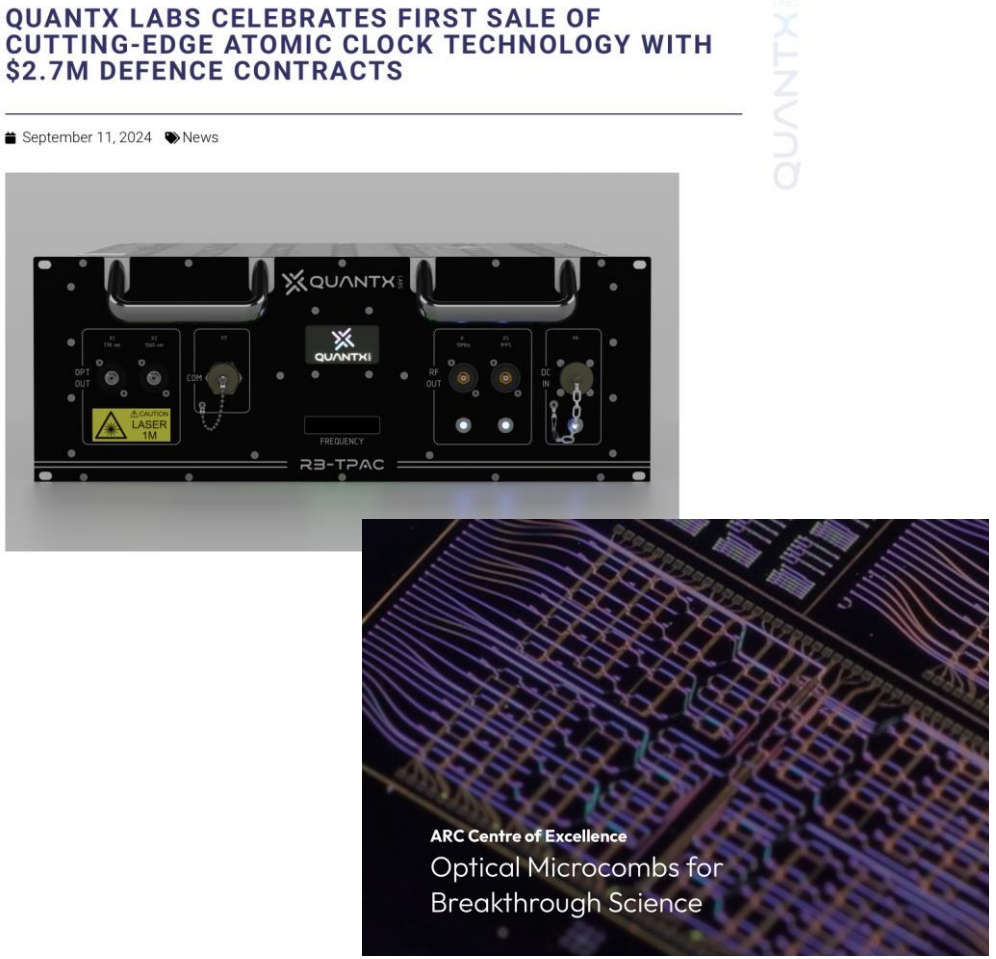
Locata now contracted for field trials for Critical National Infrastructure applications, to be run by US DoT (Volpe) at 3 test sites in the USA.

- Following very successful independent testing run by the EU last year, **Locata has now also won** a US DoT contract for Critical National Infrastructure field trials.
- These trials are part of the **DoT's Complimentary PNT Action Plan** to strengthen civilian PNT for their nation.
- Volpe will impartially analyze **Locata P, N *and* T performance** at 3 sites in the USA.
- These trials will inform DoT decision making on **technology acquisitions for CNI use**.

Locata

Augment and Toughen – Clocks and COMBS

- Turn-key optical atomic clocks to customers for field operations. Microfrequency combs being investigated to offer high-purity electronic signals in miniaturised electronics for PNT applications.
- QuantX Labs, and University of Adelaide deployed autonomous leading-edge clock technology on maritime vessels where they have operated successfully for weeks.
- The shift to optical technology confers higher performance and smaller SWaP than their conventional microwave equivalents.
- QuantX is also working on space-clock technology based also on an optical atomic clock. Part of this technology is scheduled for launch in 2025, with the full clock to be launched in 2026.



Augment and Toughen

- Phasor quantum deployed a quantum diamond vector magnetometer on an aircraft in a joint Aus/US airborne trial
- World's first aircraft-deployed Diamond NV magnetometer
- Collected >8000 km of flight data
- Successfully performed GPS-independent navigation.

Phasor Quantum

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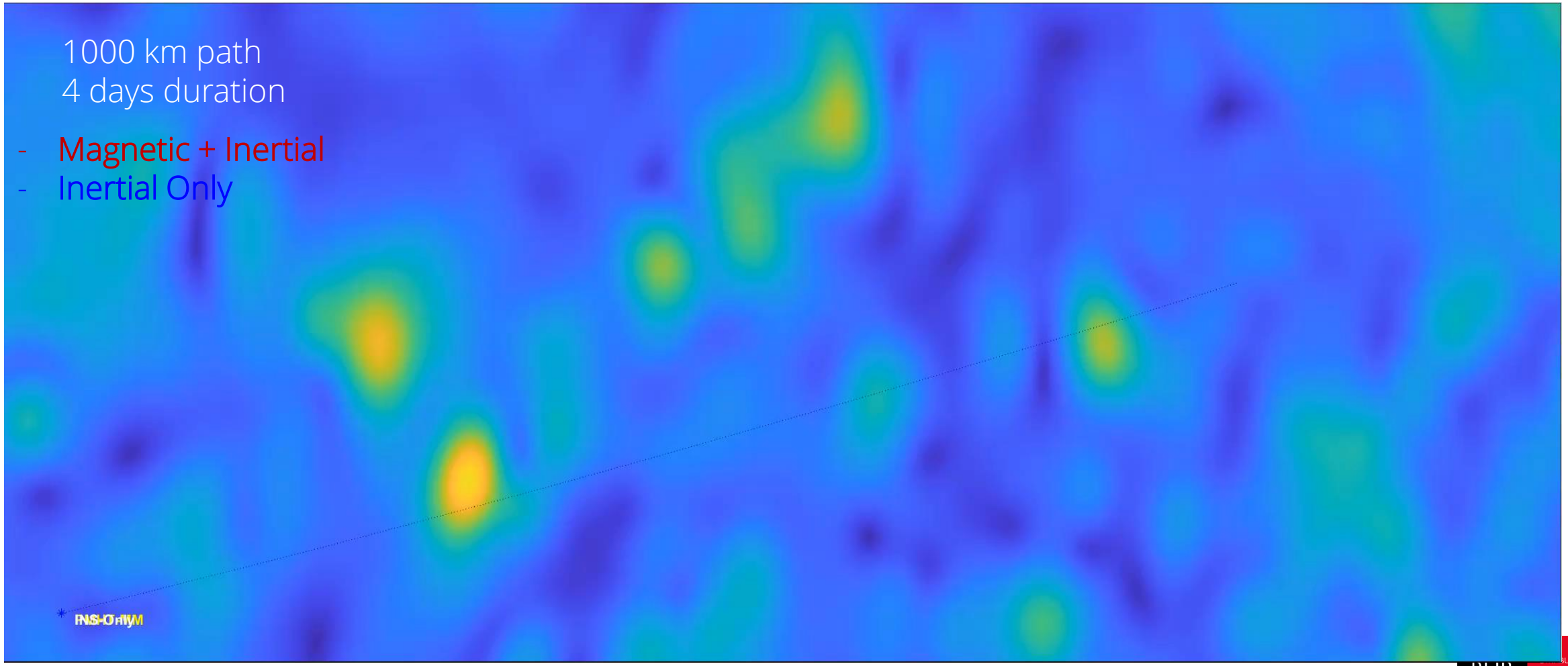
Deep ocean navigation (simulation)



Map: Enhanced Magnetic Model (51km resolution), INS: Navigation grade FOG

How to get involved?

- **Feedback on Objectives:** Provide insights on the overarching goals and vision of the CRC to align with industry and national priorities.
- **Proposal of Research Themes::**Suggest innovative themes or areas to focus on based .on national, international, adjacent sector best practice.
- **Use-Case Scenarios:** Share real-world use cases to illustrate the practical impact of proposed research projects.,
- **Consortium Building**: Introduce potential partners from industry, academia, or government to strengthen the consortium.
- **Workshops and Engagement:** Attend one of our 'listening' industry workshops and become part of shaping the research agenda
- **Memberships and Partnerships:** Talk to us about becoming a partnerships and memberships

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Interested?

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