Australian Government
Office of the Chief Scientist

Quantum Meets Public Service Workshop Summary

A workshop led by Australia's Chief Scientist in partnership with the CSIRO, Department of Industry, Science and Resources, ACT Government and ANU.

In partnership with:

CSIRO

Australian Government
Department of Industry, Science and Resources

Supported by
ACT Government

Australian National University

Acknowledgement of Country

The Office of the Chief Scientist acknowledges the traditional owners of the country throughout Australia and their continuing connection to land, sea and community. We pay our respect to them and their cultures and to their elders past and present.

Artwork: Connection to Country, 2021 by Shaenice Allan

Meeting Place icon by DISR employee Amy Huggins

Copyright

Disclaimer

The purpose of this publication is to summarise the events and outcomes of the Quantum Meets Public Service event which occurred in Canberra on 24 July 2024.

The Commonwealth as represented by the Department of Industry, Science and Resources has exercised due care and skill in the preparation and compilation of the information in this publication.

The Commonwealth does not guarantee the accuracy, reliability or completeness of the information contained in this publication. Interested parties should make their own independent inquires and obtain their own independent professional advice prior to relying on, or making any decisions in relation to, the information provided in this publication.

The Commonwealth accepts no responsibility or liability for any damage, loss or expense incurred as a result of the reliance on information contained in this publication. This publication does not indicate commitment by the Commonwealth to a particular course of action.

Microsoft Co-Pilot was used in developing this summary.

Workshop overview

Quantum Meets Public Service was presented by the Office of the Chief Scientist, in partnership with the CSIRO and the Department of Industry, Science and Resources' Quantum Branch. The workshop was held at the ANU Research School of Physics on Wednesday 24 July 2024. Approximately 80 participants attended.

The workshop explored challenges in the public sector and how quantum technologies might present opportunities for novel and effective solutions.

A central theme of the workshop was how quantum technologies can help address the public sector's challenge of delivering different types of services to many people in a very complex and interdependent environment. In this environment there is an overwhelming need for new, at-scale, efficient technological solutions that can support the efficient, effective and equitable delivery of government services.

It is also important that the government has access to advanced, resilient, and secure computing solutions. These are needed to deliver a range of essential services and safeguard sensitive data of millions of Australians.

Another theme explored in the workshop was how quantum technology could contribute to new and emerging challenges.

One example of this was the need for improved threat detection technologies to handle the increasingly complex border environment. This task is becoming more challenging due to higher trade volumes and the rise in illicit cargo.

Other themes included:

- the ethical development and responsible use of quantum technologies, with a focus on community trust and innovation
- how quantum technology could be used to improve Australia's social outcomes as well as economic ones
- how collaboration between researchers, policymakers, and First Nations communities can deliver commercial opportunities and job creation.

Scene setting

In her opening remarks, Dr Cathy Foley, Australia's Chief Scientist, described the workshop as an opportunity to identify potential applications of quantum technology for the public sector. She welcomed the event as part of broader efforts to realise the ambition embodied in Australia's National Quantum Strategy.

Dr Foley introduced quantum technologies − sensors, communications and computing – and the advantages they offer. She also identified examples of how quantum technologies can tackle problems, including through:

- optimisation
- secure communications
- searching unsorted data
- simulating complex phenomena.

These have potential applications in:

- transportation
- emergency response
- supply chains

- sustainability
- 5G and 6G communications
- biosecurity
- data security
- defence.

Dr Foley provided some specific examples of the use of quantum computers:

- optimising soil transport during construction, improving productivity by 10% in Japan
- solving transport scheduling problems in real time
- stowage planning optimisation in strict timeframes at ports
- warfare
- subsurface detection
- materials differentiation for border force detection of banned substances, products and objects.

Dr Foley concluded her remarks by outlining:

- the government's role in embracing quantum capabilities as a regulator, buyer and provider of a skilled workforce
- how Australia's quantum strategy had a world-leading focus on the ethical and equitable introduction of quantum technologies
- the role of government in ensuring Australia and its region can capitalise on decades of investment into quantum physics and technology research.

Mr James Kelly, Head of the Market Conduct and Digital Division at the Commonwealth Treasury, highlighted the intersect between national challenges, such as cost of living and national security, and critical technologies like quantum.

Mr Kelly encouraged government and the quantum sector to work together strategically to explore how public policy challenges might be addressed using quantum technologies.

Image 1. Dr Foley, Australia's Chief Scientist, delivers her opening remarks

Areas of industry impact

Bio and border security

More robust and efficient border and biosecurity control methods are a priority for governments across the world. Quantum-enabled ultra-sensitive sensors can be used for contraband detection and surveillance purposes, including threat detection and monitoring of underwater activity. This includes the ability to monitor through non-metallic packaging.

Defence and national security

Quantum technologies can improve Australia's defence capabilities. Applications range from improved surveillance and detection methods to more secure and reliable communication and navigation systems. Quantum-assured position, navigation and timing (PNT) will enable the Australian Defence Force (ADF) to maintain operations when GPS is jammed, denied or spoofed.

Transport logistics

Each day, Australia's transport networks generate vast amounts of data that require high computing power to analyse. The volume of this data is growing beyond the capacity of current computers. Large-scale quantum computers will potentially be able to analyse and optimise complex data and systems. Potential applications include disaster response, intelligent traffic control, and dynamic scheduling.

Responsible handling of sensitive data

Improved understanding of quantum-enabled cybersecurity technologies and post-quantum cryptography will enable governments to future-proof sensitive and personal data.

Program schedule

Setting the scene

- Dr Cathy Foley, Australia's Chief Scientist
- Mr James Kelly, Head of the Market Conduct and Digital Division at the Commonwealth Treasury

Keynote 1 – Sector challenges

- Mr Charles McHardie AM, Services Australia
- Mr Kamal Jogia, Australian Border Force

Keynote 2 – Quantum opportunities

- Professor Tim Senden, Australian National University
- Mr Mike Baylis, Department of Industry, Science and Resources

Panel 1 – Responsible and ethical use of quantum technologies

Chair: Dr Justine Lacey, CSIRO

- Mr Tim Bradley, Amazon Web Services
- Mr Ed Santow, University of Technology Sydney
- Mr Anthony Murfett, Department of Industry, Science and Resources
- Mr Duncan Kerslake PSM, QLD Government

Panel 2 – Quantum sensing technologies for border, climate, health, and agricultural sciences applications (and beyond!)

Chair: Professor John Close, Australian National University

- Dr Liam Hall, CSIRO
- Mr Kamal Jogia, Australian Border Force
- Ms Anne O'Neill, NSW Health
- Mr Federico Collarte, Baraja

Panel 3 – Cybersecurity, post-quantum cryptography, and resilient data management

Chair: Dr Liming Zhu, CSIRO

- Mr Greg Barsby, Penten
- Mr John Leiseboer, QuintessenceLabs
- Mr Charles McHardie AM, Services Australia

Panel 4 – Optimising complex systems, from disaster management to transport and health

Chair: Dr Marcus Doherty, Quantum Brilliance

- Professor Kavan Modi, Monash University
- Dr Uday Divi, Department of Agriculture, Fisheries and Forestry
- Mr Michael Hall, NEC Australia
- Dr Michael Hush, Q-Ctrl

Breakout sessions

- Five breakout sessions explored public sector challenges where there could be applications for quantum technology

Quantum Australia overview

- Professor Stephen Bartlett, Foundation Director of Quantum Australia

Next steps and closing statement

- Dr Cathy Foley, Australia's Chief Scientist

Keynotes

Challenges and opportunities

Mr Charles McHardie AM, Chief Information and Digital Officer at Services Australia, recognised the importance of access to cutting-edge, resilient and secure computing solutions to meet the growing demand for government services. Quantum computing and communications can support government to deliver essential services, and safeguarding the sensitive data of millions of Australians is paramount. Working with the Australian Signals Directorate and IBM, Services Australia is developing its quantum readiness posture. Services Australia has invested in IBM's z16 'quantum-safe' computers and the agency holds the largest footprint of these mainframe computers in the Southern Hemisphere. Mr McHardie also acknowledged the importance of harnessing quantum technologies responsibly, suggesting agencies take a human-centred design approach and focus on the areas where quantum technologies will most benefit the community.

Mr Kamal Jogia, Director of Trade Technology at the Trade Customs Border Modernisation Branch, Australian Border Force, explained the increasingly complex border environment and the need for improved threat detection technologies. Australia is experiencing higher trade volumes, fuelled in part by online shopping trends, and a rise in illicit and contraband cargo, shipping and fishing vessels. This brings challenges to ensuring the detection of these items, without disruptions to the supply chains. Existing methods are resource and time intensive, classical sensors are unable to detect all biosecurity threats, and classical computers are unable to analyse the amount of complex data involved in the logistics of border trade flow. Quantum sensing may provide more accurate materials detection, and quantum computing may offer improved digital modelling capability and trade flow mapping.

Meeting the challenges with quantum

Professor Tim Senden, Director at the ANU Research School of Physics, highlighted how fundamental questions are the driver of innovation in Australia's quantum sector. Common questions, such as "Why is the sky blue?" and "Why do hot bodies give off light?", lead to a process of discovery and explanation, essential for technological innovation. Professor Senden also discussed Australia's place in quantum internationally.

Mr Mike Baylis, Manager of Quantum Policy at the Department of Industry, Science and Resources, provided an overview of the objectives of the National Quantum Strategy, including current and potential applications of quantum technologies. Australia's quantum industry has huge economic potential and is estimated to value $6 billion by 2045. Furthermore, as a dual-use technology, quantum has the potential to impact all Australians. For instance, quantum sensors can be used for advanced medical imaging, while also being used to improve military capability by providing a highly precise and secure PNT system. Quantum computers will enable the optimisation of military and transport logistics, as well as drug design and modelling, improving community outcomes. Ultimately, growing a thriving onshore quantum industry will boost Australia's sovereign capability and contribute to greater economic and social outcomes.

Australia is actively working to seize the opportunities and address challenges in the public sector with quantum technology:

- The National Quantum Strategy provides a plan to grow Australia's quantum industry, estimated to be worth $6 billion by 2045.
- Services Australia is collaborating with the Australian Signals Directorate and IBM to develop its quantum readiness posture. They have invested in IBM's z16 'quantum-safe' computers, which are crucial for safeguarding the sensitive data of millions of Australians.
- Australian Signals Directorate has, since the workshop, released advice for post-quantum encryption readiness requirements.[1]

[1] https://www.cyber.gov.au/resources-business-and-government/governance-and-user-education/governance/planning-post-quantum-cryptography

Panel composition and discussions

Panel 1 – Responsible and ethical use of quantum technologies

Chair: Dr Justine Lacey, CSIRO

- Mr Tim Bradley, Amazon Web Services
- Professor Ed Santow, University of Technology Sydney
- Mr Anthony Murfett, Department of Industry, Science and Resources

This panel discussed the ethical development and use of quantum technologies, including the role of government as regulator and builder of community trust.

Panellists challenged the idea that consumer and human rights protections are a commercial constraint for emerging technology industries. Lessons from the past, including the mainstream adoption of AI, show that regulation helps innovators to direct their efforts to where it is most useful and in-demand by the community.

The panel highlighted the need to be proactive about ethical quantum now, rather than waiting for widespread adoption of the technology. For example, early quantum computers are already readily accessible remotely via web interfaces and quantum computing languages have school student level educational resources.

Australia can be proactive in developing tomorrow's workforce of quantum programmers and informed end users able to embrace the opportunities of quantum computing.

Image 2. Panel 1 discussion

Panel 2 – Quantum sensing technologies for border, climate, health and agricultural sciences applications (and beyond!)

Chair: Professor John Close, Australian National University

- Dr Liam Hall, CSIRO
- Mr Kamal Jogia, Australian Border Force
- Ms Anne O'Neill, NSW Health
- Mr Federico Collarte, Baraja
- Dr Emma Mitchell, CSIRO

Panellists discussed the wide array of applications that quantum sensing technologies offer for the public service, now and in the future. Many aspects of quantum sensing technology are still evolving, and there is great potential for quantum sensing to contribute to a wide range of different sectors.

Areas where quantum sensors can improve efficiency and effectiveness in the economy include:

- ensuring millions of parcels arriving in Australia are safe and legal
- reducing the need for using animals in pre-clinical testing of medicines
- earlier disease detection (or better access via miniaturisation/mobility) via improved medical imaging
- generating higher quality/value recycling streams via superior classification and sorting of waste.

Any final technological product will have the quantum component as only one element of any solution, and will still need to be incorporated into more conventionally engineered systems. This will include semiconductor electronics, software, algorithms and user interfaces – and these disciplines should not be overlooked.

Panellists called on researchers and policymakers to:

- collaborate and develop clear problem statements to help prioritise the development of quantum sensing applications
- communicate directly with industry and end users so they can accurately understand what people really need.

Image 4. Panel 2 discussion

Panel 3 – Cybersecurity, post-quantum cryptography (PQC) and resilient data management

Chair: Dr Liming Zhu, CSIRO

- Mr Greg Barsby, Penten
- Mr John Leiseboer, QuintessenceLabs
- Mr Charles McHardie AM, Services Australia

This panel discussed cyber risks posed by the emergence of quantum computers, which will be able to undermine current public key encryption algorithms.

The panel reflected it would be helpful for government agencies to anticipate the future requirements and dependencies of their vulnerable systems during the transition to PQC standards. Agencies should aim to be “crypto-agile”, preparing to transition not just once, but continuously.

PQC algorithms may eventually be broken, necessitating quick replacements, such as quantum key distributions. To prepare for this, industry should ensure appropriate modularity of future systems to facilitate upgrading to new encryption protocols is as painless as possible.

The panel recognised that governments have a responsibility to safeguard their systems, applications and data to maintain the trust of Australians and to continue delivering essential services.

Some agencies could consider establishing an inventory of the potential threats in classical and quantum cyber systems, along with a hierarchy of data sensitivity. For instance, personal banking data may require temporary to short-term protection, while national security data would demand long-term protection against the highest level of cyber attacks.

Governments play an important role setting standards for information security. This can help to ensure interoperability across global networks, define mandatory requirements for industry and provide incentives to adopt improved security systems.

Image 5. Panel 3 discussion

Panel 4 – Optimising complex systems from disaster management to transport and health logistics

Chair: Dr Marcus Doherty, Quantum Brilliance

- Professor Kavan Modi, Monash University
- Dr Uday Divi, Department of Agriculture, Fisheries and Forestry
- Mr Michael Hall, NEC Australia
- Dr Michael Hush, Q-Ctrl

Panellists discussed how government and industry can collaborate to identify quantum solutions that demonstrate a true advantage over classical solutions for the logistical challenges faced by government and businesses.

Panellists from quantum companies noted that delivering a proof-of-concept demonstration to government is an effective method of engagement. Similarly, the public servants on the panel highlighted codesign as an effective approach to ensuring that quantum solutions are fit-for-purpose for government departments. Ultimately, quantum companies must demonstrate the economic and social benefit of a quantum solution before government will commit to making an investment in it.

An effective approach is to partner early and to continuously review and revise a roadmap to impact for a particular solution. This can demonstrate and forecast how the capabilities of the quantum technology will improve as technical milestones are achieved. Although the early benefits may be marginal, partners will be best placed to exploit future benefits of technological breakthroughs as they emerge.

With experience, partnerships will rapidly evolve and support the assessment and prediction of the types of problems most amenable to quantum solutions in the future. This will help partners to make more informed strategic investments than their close competitors.

For many problems technical optimisation is not the real bottleneck – it is the people or other factors. Care should be exercised to avoid becoming obsessed with a technical solution when, in fact, it may not help solve the problem.

The panel concluded by discussing some specific applications around the world in which quantum technologies are already generating benefits:

- goods logistics – increasing the speed of buying cycles
- construction of civil works through better management of supply and demand on site
- optimisation of waste collection
- electrical grid applications
- improving pricing/economics.

Image 6. Panel 4 discussion

Breakout sessions

The five breakout sessions focused on opportunities and challenges for the adoption of quantum technologies in the public sector.

Image 7. Breakout sessions

Discussions focused on:

- quantum sensing for border control
- aggregating common challenge statements across diverse public services
- responsible quantum
- quantum solutions to cybersecurity threats
- provenance of materials and source geolocation.

Participants discussed a broad array of topics. Some groups identified specific use cases and other groups discussed approaches to developing and implementing quantum policies and programs across government**.** Use cases and examples are discussed in the appendix.

One group explored how to aggregate common challenge statements across diverse public services to optimise quantum use cases. The group highlighted the effectiveness of taking a “mission based” approach, such as Net Zero, to cross-government quantum initiatives. While the policy priorities of departments and at different levels of government can differ greatly, there is potential to align mission-based objectives that quantum can contribute to, such as improved healthcare and Closing the Gap targets.

Another breakout group explored quantum solutions to cybersecurity, including quantum key distribution and post-quantum cryptography. The group discussed the important role that quantum--safe, high-bandwidth random number generators will play, such as Canberra-based company QuintessenceLabs’ products. Standardisation of quantum-secured communications will also be essential, particularly standards tailored for distinctive use cases. The group recognised that the domestic cybersecurity workforce shortage is a practical challenge for Australia as it prepares for the transition.

Next steps and closing

Professor Stephen Bartlett, Director of the University of Sydney Nano Institute, delivered an overview of Australia's Centre for Quantum Growth, 'Quantum Australia'. Professor Bartlett is the Foundation Director of Quantum Australia and led the formation of the Centre's consortium of research institutions, industry partners and quantum companies. Quantum Australia is due to be established in 2025.

"Quantum Australia gives muscle and momentum to the National Quantum Strategy. Its arrival is a signal that industry, government and academia can work together to further press Australia's quantum advantage." – Professor Stephen Bartlett

The three programs Quantum Australia will be delivering are:

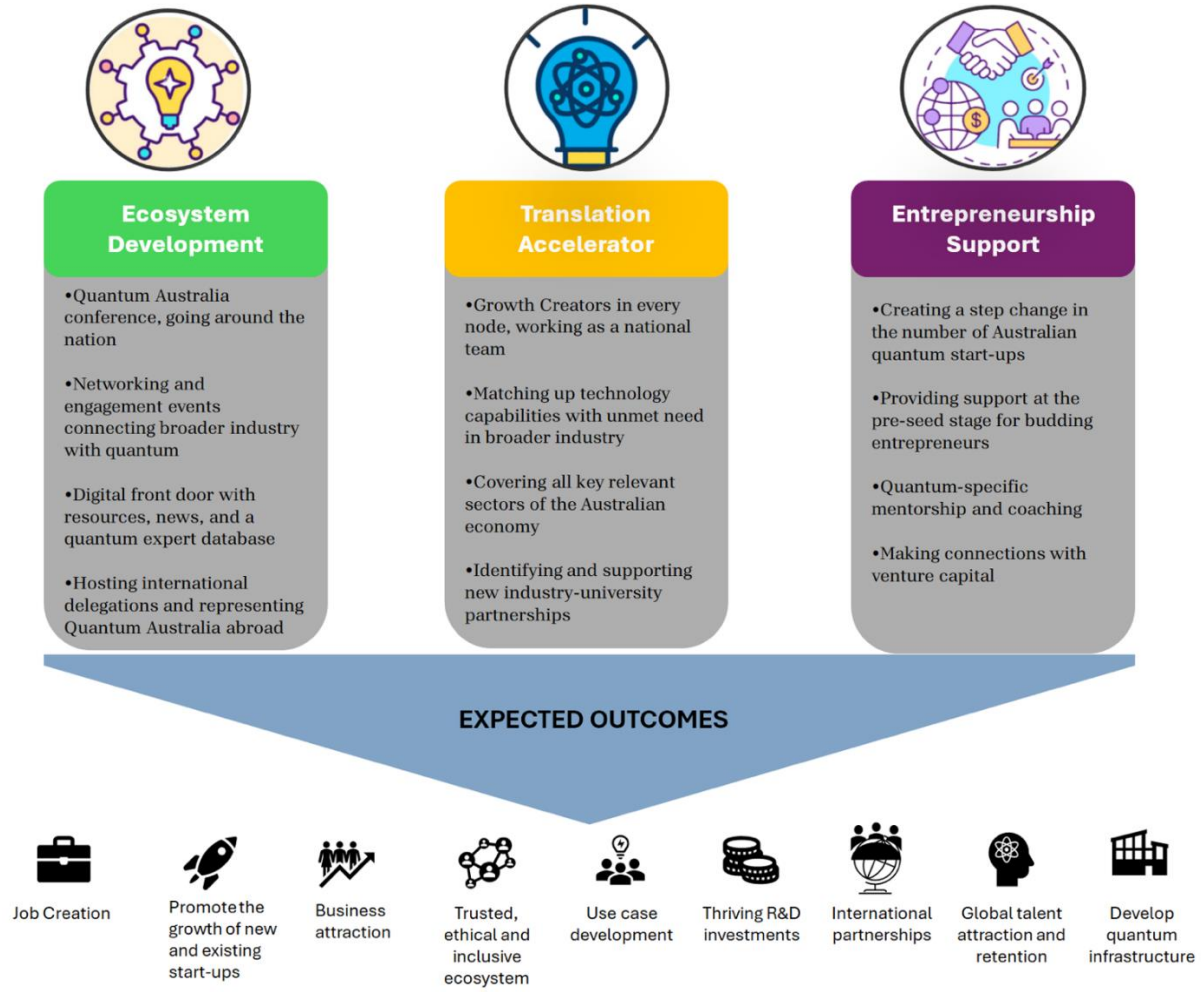

Image 8. Diagram of the 3 programs that Quantum Australia are delivering

Appendix: Case studies

Case Study 1: Quantum sensing for biosecurity and border control

Background

Biosecurity is a critical aspect to keeping Australia safe from diseases, pathogens, contaminants and invasive species. While Australia has a geographical advantage in controlling what enters the country, the risk of unwanted and dangerous imports remains. Technological advancement has also created new threats, such as synthetically created pathogens that have the ability to evade existing bio surveillance systems.

Australia's border has been identified as strategic asset[2]. Due to higher online shopping volumes, trade and contraband cargo volumes have also increased. Quantum-based sensing technologies, such as quantum magnetometers and quantum gravimeters, could serve as an efficient solution to these concerns. For example, detection of biomarkers in ingredients can inform origins of products. Quantum computing, which has higher power and efficiency compared to classical computers, can also provide improved data analysis.

Australia's competitive advantage

Australian companies such as Q-CTRL, Nomad Atomics and QuantX Labs have made advances in quantum sensor technologies, and Australia holds significant expertise in developing quantum sensing solutions.

- Q-CTRL has developed Boulder Opal, a quantum control software that enables users to effectively design, automate and scale quantum sensor hardware, into viable fielded solutions".[3] This software is currently used in earth observation, defence and space, and could be implemented to solve biosecurity problems as well.
- QuantX is also developing a "suite of precision timing and quantum sensor products" used to enhance communications, navigation, surveillance and defence systems.[4]
- Nomad Atomics build "state-of-the-art miniaturised quantum sensors" designed for real-world application. These are sensors that can enhance existing classical sensor methods, allowing for higher accuracy and efficiency. They can be used in resource exploration and defence.
- CSIRO has also developed a portable exploration tool called LandTEM, which uses quantum sensing to detect magnetic fields that are "100 millionth the size of Earth's".[5] The technology has reduced exploration costs by nearly a third.

[2] Cyber and Infrastructure Security Centre, Security of Critical Infrastructure Act 2018 (SOCI)
[3] Q-CTRL, 'Quantum sensing', webpage accessed: 19 Sep 2024.
[4] QuantX Labs https://quantxlabs.com/, webpage accessed 19 September 2024
[5] CSIRO LandTEM, webpage accessed 19 September 2024

Case Study 2: Quantum PNT for Defence and national security

Background

Since 1978, defence forces have been reliant on global positioning systems (GPS) in the field. While the technology has been important in navigation and coordination of troops, it is now outdated considering other technological advances. For example, unstable satellite connections can render GPS unreliable. This poses great risk to troops in unknown areas. Intentional attempts to sabotage, such as electronic jamming or interception of communication lines, is also a common and growing threat.

The Australian Defence Force (ADF) has invested in position, navigation and timing (PNT) capabilities that can support troops in areas where GPS is either degraded or unreliable. The need for these capabilities is further recognised through the inclusion of quantum technology as a strategic priority in the 2024 Defence Innovation, Science and Technology Strategy 'Accelerating Asymmetric Advantage – Delivering More, Together'.[6]

The ADF has tested atomic clocks together with Air Force Research Laboratory (USA), Defence Science and Technology Laboratory (UK) and Defence Science Technology Group (Australia), resulting in 'highly accurate, independent and assured timing signals in GPS-denied environments'.

Australia's competitive advantage: PNT capabilities

Quantum capabilities can ensure increased PNT accuracy and sensitivity across various terrains.

The Department of Defence recently signed two contracts with Adelaide-based company QuantX Labs, to acquire quantum optic atomical clocks to deliver PNT. These will be used to "test and evaluate timing in critical defence hardware, like communication and navigation systems".[7]

QuantX will also deliver clocks under AUKUS Pillar II by the end of 2024. The company has also developed a technology known as Cryoclock, which assures enhanced radio and communications. It supports target detections in cluttered environments and has "ship-based secure ultra-fast communications", both of which are valuable to the military. The Cryoclock is set for inclusion in Australia's Jindalee Operational Radar Network (JORN) in the coming years.

Another Australian company, Nomad Atomics, is also using quantum sensors in navigation, allowing for precise position monitoring, which does not rely on external factors. These will reduce risks of foreign sabotages or interception of communication.

Q-CTRL has partnered with Advanced Navigation to commercialise high performance PNT systems, with maritime and airborne applications.[8]

[6] Department of Defence, 'Defence IS&T Strategy 2024', accessed 20 September 2024
[7] QuantX, "Precision Technologies", accessed 20 September 2024
[8] Q-CTRL, 'Detect the undetectable,', accessed 19 September 2024