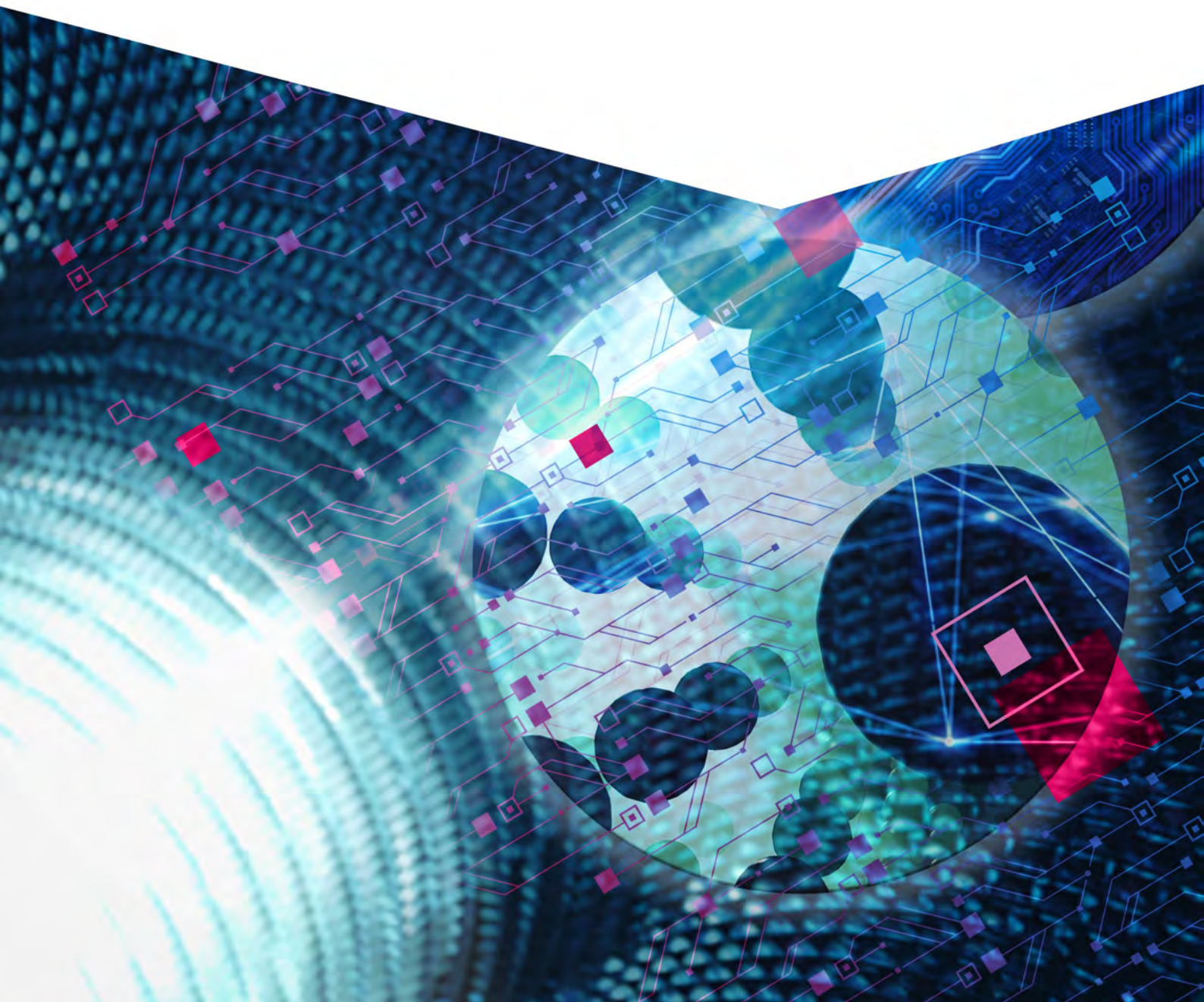
Australian Government
Department of Industry, Science and Resources

Proposed National Quantum Strategy

industry.gov.au/quantum



Copyright

ISBN: (add if required)

Disclaimer

Contents

Quantum computers can perform certain complex calculations with less steps than an ordinary computer. This could be used to improve efficiencies and boost the economy to the benefit of all Australians
[Getty image credit]

Message from the Minister

[Text TBC]

[Minister Husic's signature]

Quantum communications could drive the next generation of cyber security and create high-speed networks, including a future quantum internet. [Getty image credit]

Message from Australia's Chief Scientist

Australia has had its finger on the quantum pulse since Professors RQ Twiss and AG Little published the first paper on time-correlated photons in 1959. Since then and especially in the past 25 years, we've made significant research investment, resulting in an emerging Australian quantum industry that is destined to have a significant impact on all of our lives.

The impact of the quantum revolution will be comparable to the digital revolution that brought us transistors and lasers, which are the basis of all our modern electronics, computers and communications.

Quantum sensors are already enabling the detection of things that were previously hidden to us down to the tiniest scales, bringing new sensitivity in medical imaging and in detection of underground mineral deposits. Australia's quantum industry will improve cyber security with advances in quantum encryption and communications. Quantum computers will enable calculation, modelling and data management in ways impossible for classical computers.

Australia is well positioned to capitalise on the amazing research that is making its way out of the lab. Our entrepreneurial spirit is generating new start-ups and attracting major companies. This is our chance to grow a thriving deep-tech industry, built out of coordinated, long-term government investment and a critical mass of world-class Australian-trained quantum specialists. We are in the top handful of countries embarking on a quantum ambition. But we have to act now, as there is intense global attention on the promise of quantum.

In 2020, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) worked with Australian quantum researchers to prepare a roadmap that articulated the opportunity. The National Quantum Strategy is the next step, with the aim of ensuring we realise the opportunity.

This strategy will evolve and be updated as needed to reflect the rapid changes occurring across the Australian quantum industry, with the creation of new companies, new global investments and a maturing regional opportunity.

What is clear is that success requires a concerted system-wide focus, to ensure skills development and workforce inclusivity, access to infrastructure, and the right regulation. This is a shared mission whose goal is to improve our lives, to solve global environmental, medical and energy challenges, and understand more about our place in the cosmos as we chart humanity's future.

It was such an honour to lead the development of Australia's National Quantum Strategy. With the support of a dedicated taskforce in the Department of Industry, Science and Resources, we have engaged with industry leaders, academics, investors, and government officials. We visited many companies, start-ups and labs across Australia and overseas, including in the United Kingdom, the United States, Japan and the Republic of Korea. There have been numerous roundtables and town hall meetings and two public consultation papers. A National Quantum Advisory Committee was established and has provided excellent insights, feedback and advice. Engagement from the quantum community has been phenomenal and I thank all contributors.

This process has strengthened my confidence that, with clear-eyed determination, investment and a collaborative approach across government, research and industry, the transformative capabilities of quantum technologies are ours to realise.

Dr Cathy Foley AO PSM

Strategy at a glance

Australia is on the cusp of a transformation driven by advances in technology. With the right policy, regulatory and economic framework, this transformation will modernise our economy, improve our society, support national interests, and create high-paying jobs for future generations. Quantum technologies are at the centre of this transformation. They present a unique and exciting opportunity to enhance Australia's productivity and drive our long-term prosperity by enabling modelling, improved data management and identifying new trends in data in ways not achievable with classical computers.

The National Quantum Strategy is based on extensive consultation with the quantum sector and wider community over 2022. Consultation was led by Australia's Chief Scientist, Dr Cathy Foley AO PSM, and included submissions, roundtables, working groups and town hall meetings. The level and quality of participation highlighted the sector's potential and appetite for action.

These consultations, combined with the guidance of our National Quantum Advisory Committee and contributions from state and territory governments, identified the key efforts and actions needed to realise Australia's quantum opportunity.

The National Quantum Strategy focuses on 5 central pillars of effort. Each pillar has a set of actions s47C(1) that will position Australia for success. The pillars are based on:

- creating a thriving environment for research, development, commercialisation and use of quantum technologies
- building a highly skilled quantum workforce
- generating and ensuring equitable access to critical infrastructure and materials
- ensuring our regulatory settings support industry development, sovereign capability, economic growth and Australians' human rights while protecting our national interests
- building trust and inclusion, ensuring responsible development and use.

The Strategy provides a plan for the Australian Government's consideration, including investment opportunities. Australia's quantum ambition will not be realised by working alone – every part of the quantum ecosystem needs to work towards the same goal, including through investments. The Australian government will drive the implementation of the strategy, but some actions and initiatives will fall to other partners to lead. We will work with and draw on the strengths of industry, businesses, universities, states and territories, and international partners as required to ensure Australia's quantum opportunity is realised.

National Quantum Strategy

Vision for Australia's quantum future

In 2030, Australia is recognised as a leader of the global quantum industry, and quantum technologies are integral to a fair, inclusive and prosperous Australia

5 Pillars

Thriving research, development, commercialisation and use of quantum technologies

Trust, ethics and inclusivity

A skilled quantum workforce

Regulation supporting all national interest

Access to key infrastructure and materials

s47C(1)

Key actions

Establish a **Quantum initiative** that provides a front door for quantum activities, boosts coordination and supports collaboration and commercialisation

Measures to attract and retain quantum research talent, leveraging the **Quantum PhD program** and **National Quantum Collaboration Initiative**

s47C(1)

Fit for purpose regulatory measures and frameworks to support commercialisation and growth while protecting Australia's national interest

s47C(1)

Measuring our success

GDP added to the Australian community

Revenue from quantum technologies

Jobs generated from quantum technologies

Increase in quantum and adjacent studies and skills development

Quantum technologies

Quantum science describes the behaviour of matter and energy by assuming the universe and all its properties (including space, matter, energy and time) are divided into discrete chunks. Quantum behaviours – particularly quantisation, superposition and entanglement – can be used to build advanced technologies that would otherwise seem impossible.

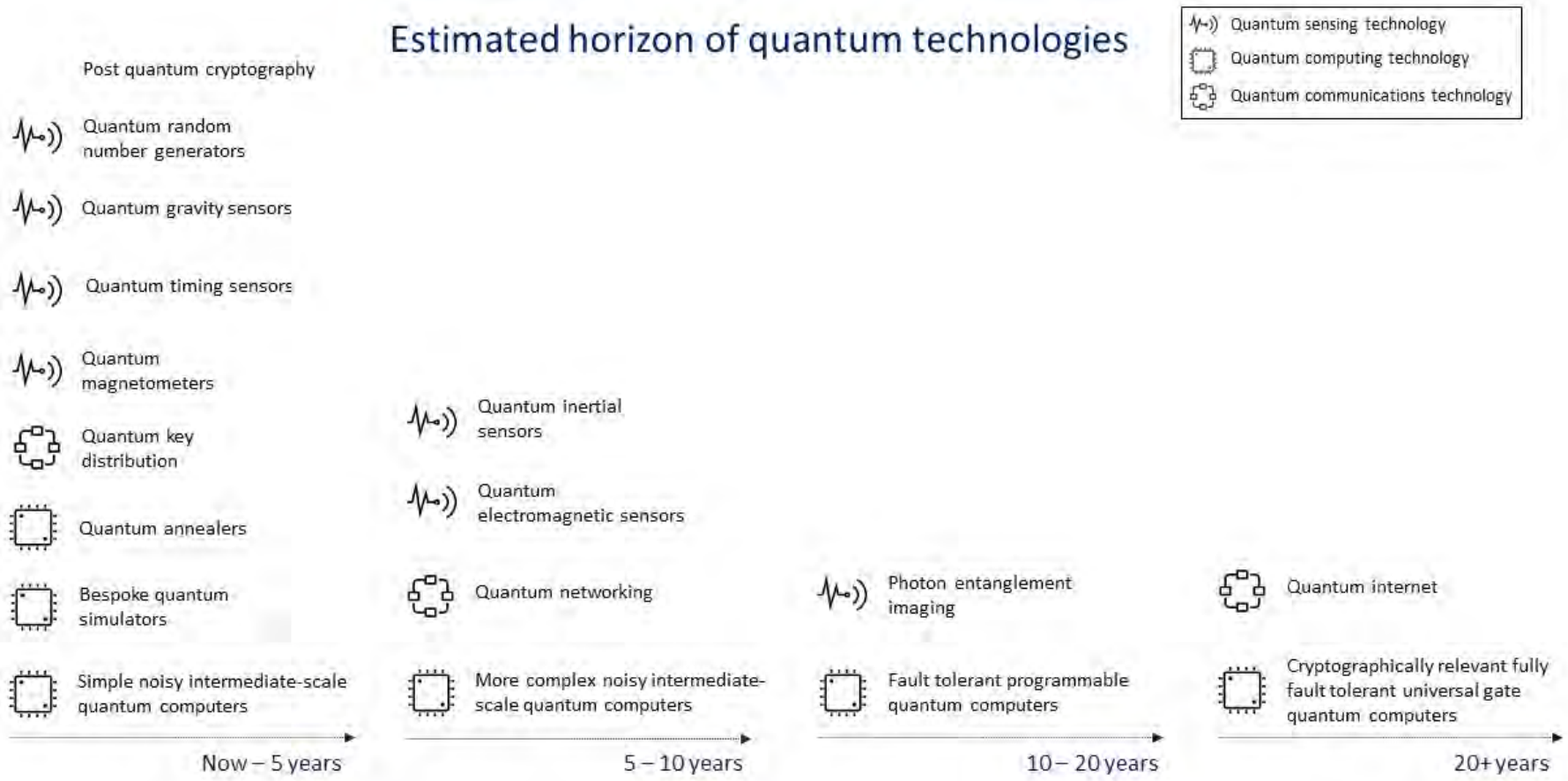
Quantum technologies are developing rapidly, and new applications being identified. While some quantum technologies like computing are still emerging, other quantum technologies are already in everyday use. Australia has already led breakthroughs in areas such as:

- quantum theory
- quantum optics
- semiconductor and superconducting devices
- atomic physics
- precision timing and sensing
- cybersecurity.

The National Quantum Strategy addresses the full spectrum of quantum technologies. It provides a pathway for growth of applications that are close to commercialisation, such as quantum sensors. It will also set Australia up for success in longer-term applications such as quantum computing.

Different technologies will mature and be ready for commercial applications at different times over the next 10 years, and beyond. Some technologies will not have a simple or quick path from research to commercialisation.

The strategy also recognises the importance of building foundational capabilities for quantum technologies, including software engineering, applications and algorithms (see Appendix A for a description of technologies).



Australia's quantum opportunity

Australia's quantum opportunity is immense. Australia is recognised as a global leader in quantum, with some of the best minds in quantum research and applied technology. The government is driving action to grow the tech sector – including quantum technologies – to improve our economy's long-term performance and the prosperity of all Australians.

The technology sector is already Australia's third-largest industry, employing 1 in 16 workers and contributing $167 billion to our economy every year, or 8.5% of GDP. The sector is growing rapidly and is forecast to contribute $244 billion a year by 2031. Quantum capabilities will amplify the growth of this sector in the near future and lead to entirely new kinds of technologies in the longer term. Australian quantum companies already attract significant venture capital investment compared to our international competitors, capturing a 3.6% share of global venture capital for quantum from 2017 to 2021.

Case Study 1: Quantum supporting other economic sectors

Quantum science can be applied to improve our understanding of industrial processes. An Australian start-up, Jovian Tech, is building process instrumentation to measure the spin-isomer ratio in hydrogen molecules. The thermophysical properties of molecular hydrogen depend critically on the spin state of the molecule. Chemical engineers can use information from Jovian Tech to optimise hydrogen production plant operations and lower costs in the hydrogen economy.

The importance of quantum technologies extends beyond economics, jobs, and applications for business and industry. In time, quantum technologies will be an important national capability supporting our security and our way of life. Ensuring Australia has a sovereign quantum capability will allow us keep pace with advances, and shape the evolving technology landscape in our national interest. Without a strong quantum sector, we risk outsourcing our sovereignty.

Realising the potential of quantum technologies will have risks and challenges. Core challenges impacting Australia's quantum sector have been identified and are addressed through this strategy, (see Table 1). Additional challenges that will require careful management include economic headwinds, a tightening global investment climate, uncertainty over development timelines and which technologies which bear fruit.

International competition will also create uncertainty and opportunities. Countries across the globe are investing billions into quantum technologies, and the Australian industry requires support to keep its leading position in the field. Australia has already invested hundreds of millions of dollars in establishing deep technical skills. It is now time to consolidate and accelerate these efforts. As we develop these efforts, Australia will also need to develop strong and robust supply chains to ensure our quantum industry is resilient to any global headwinds that present themselves.

The pathway set out by this strategy will position Australia to navigate these challenges and seize the opportunities that result.

Case study 2: Addressing transportation challenges

In 2020 Transport for NSW approached Q-CTRL with an interest in understanding how they – as an organization with heavy computational challenges – could put quantum computing to work for them. Many problems in managing transport services are computationally challenging - from timetabling of intersecting modes of transport to meet known patterns of demand through to dynamically routing vehicles to meet changing traffic patterns. These problems quickly grow intractable even for advanced computing tools as the number of "interacting" modes of transport, vehicles, connection points, and stops grows.

Q-CTRL took on the challenge and has focused on getting Transport for NSW quantum ready via a combination of quantum professional services and quantum control infrastructure software development. Q-CTRL worked with Transport for NSW to improve the performance of quantum algorithms relevant to transport optimisation problems and charted a path to quantum advantage. Q-CTRL identified a new hardware-efficient algorithmic implementation which enables modelling of transport networks on near term quantum computers using fewer computational resources than otherwise expected. The team built a custom circuit simulator to simulate multiqubit algorithms subject to the real noise endemic to near-term quantum computer hardware, and tested their prototype solutions on real cloud accessible machines. The results demonstrated that the target Mobility-as-a-Service problem could really be efficiently solved by a quantum computer, even in the presence of imperfections.

Having demonstrated a real quantum advantage in large-scale network optimization looks to be possible, Q-CTRL is currently building a custom software package for Transport for NSW. This will deliver the ability to optimize the execution of quantum algorithms for Mobility-as-a-Service problems to end users with expertise in transport analytics and data science.

Table 1: Quantum opportunities and challenges

Opportunities

Capitalise on expertise

- Our existing strength in quantum research, applied technology and promising start-up companies can be leveraged to grow a strong quantum industry across Australia.

Sovereign capability

- A strong quantum industry can provide Australia with sovereign capability and expertise in this enabling technology that will drive future advancement.
- It can provide Australia with access to, or control over the skills, technology, intellectual property and infrastructure that underpin future technological advancements.

Economic growth

- Quantum computing, communications and sensing could add at least $6.1 billion to Australia's GDP by 2045.

Productivity

- There could also be significant indirect economic benefits, helping to grow our tech sector and providing a cutting-edge to Australian businesses and industries across the economy.

Jobs

- Quantum could drive the growth of sustainable, inclusive and well-paid jobs. By 2030, the Australian quantum sector could generate around 8,700 jobs, rising to between 19,400 by 2045. The growth of the sector would also support employment across the wider economy, with a total investment impact of over 35,000 jobs by 2045.

International destination

- Australia can become a destination for international talent and promote the key capabilities that will let local industries succeed. A thriving and trusted domestic ecosystem will be essential for retaining Australia's talent.

Challenges

Investment capital

- Attracting early-stage patient capital is becoming more difficult in the current global investment climate.
- There is uncertainty over development timelines and which technologies to support.

Collaboration

- Stronger coordination and collaboration is needed to connect ideas and solutions to businesses and investors.
- Strong connections between research and industry are critical to uncover the use cases that are essential to increasing industry uptake and investment.

International competition

- Countries across the globe are investing billions into quantum technologies and competing for quantum talent.
- Australia could be locked out of access to cutting edge technology if it does not invest in its own capabilities, or develop capabilities needed by the world.

Business capability

- To harness the opportunities, businesses and their workers will need to be Quantum-ready and Quantum-literate.

Skills and talent

- Growth of the quantum sector depends on a skilled, diverse and inclusive workforce and an effective talent pipeline.
- Australian research institutes and quantum companies have to compete with other countries for the best and brightest minds.

Infrastructure and supply chain

- Growth is constrained by limited access to advanced infrastructure, materials and tools.

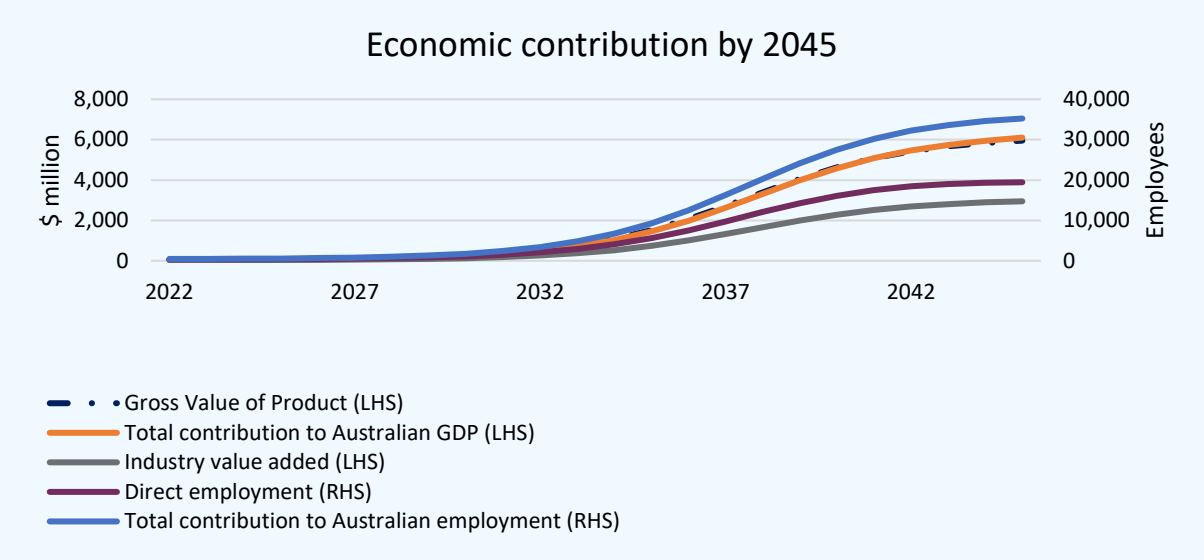
Regulatory settings

- Regulatory frameworks need to remain fit for purpose and responsive to technological developments, to protect national interest and ensure ongoing trust and confidence.

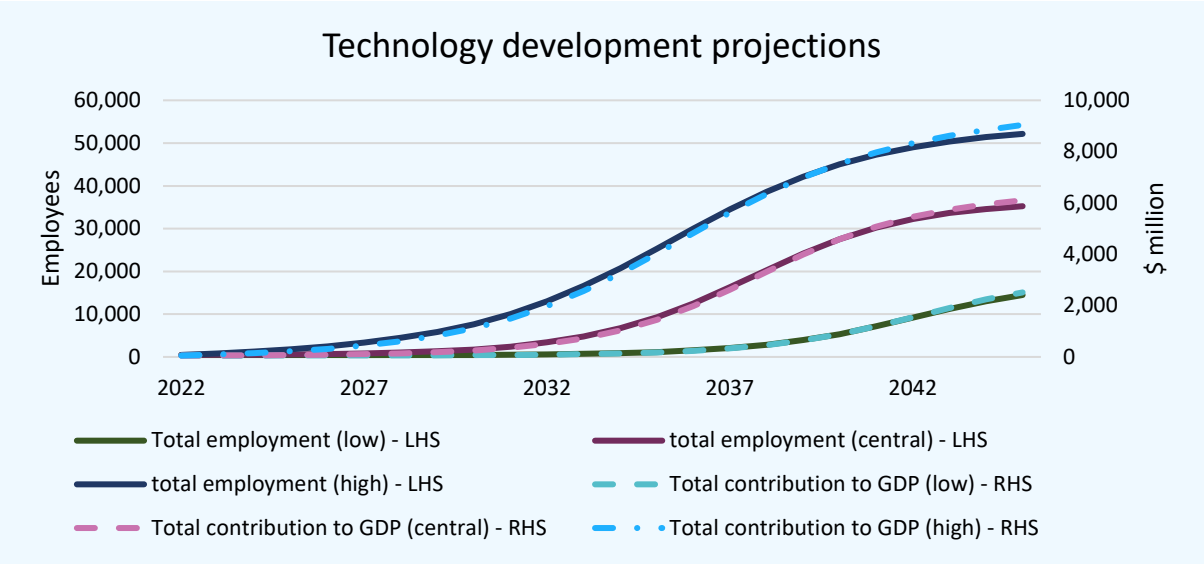
s47C(1)

Quantum boosting the economy

Globally, the quantum computing market is estimated to grow at a compound annual rate of over 30% over the next 5 years. In Australia, conservative estimates forecast revenue from quantum computing, communications and sensing could be worth $5.9 billion, and quantum technology development could contribute $6.1 billion to GDP by 2045. This includes $2.4 billion in indirect benefits due to productivity gains from quantum computing, sensing and communication. The quantum technology industry could directly employ 19,400 people, and by 2045 adoption of quantum technology could create more than 35,000 jobs across the economy (CSIRO, 2022; Centre for International Economics, 2022).



Importantly, the size of Australia's quantum opportunity depends on the pace of development and adoption of quantum technologies. If development can be accelerated, and we have wide adoption by industry and business, the economic opportunity could grow further than baseline estimates. In a rapid development and high-uptake scenario, quantum technologies could add as much as $9 billion to the economy and generate over 50,000 jobs by 2045 (Centre for International Economics, 2022).[1]



[1] High, Central and Low projections reflect a range of published estimates of how quickly quantum technologies may develop and be adopted by industry end users. The Central projection aligns with CSIRO's 2045 growth forecast.

A growing quantum sector would have significant direct economic benefits. But the greater opportunity for the Australian economy is the impact of quantum technologies across other sectors, providing a cutting-edge to Australian industries. Quantum sensors are already transforming industries, including mining, where quantum sensors are used detect minerals. Quantum could have a greater impact on technology than the transition from vacuum tubes to semiconductors had on conventional computing.

Case study 3: Using quantum sensors to find minerals

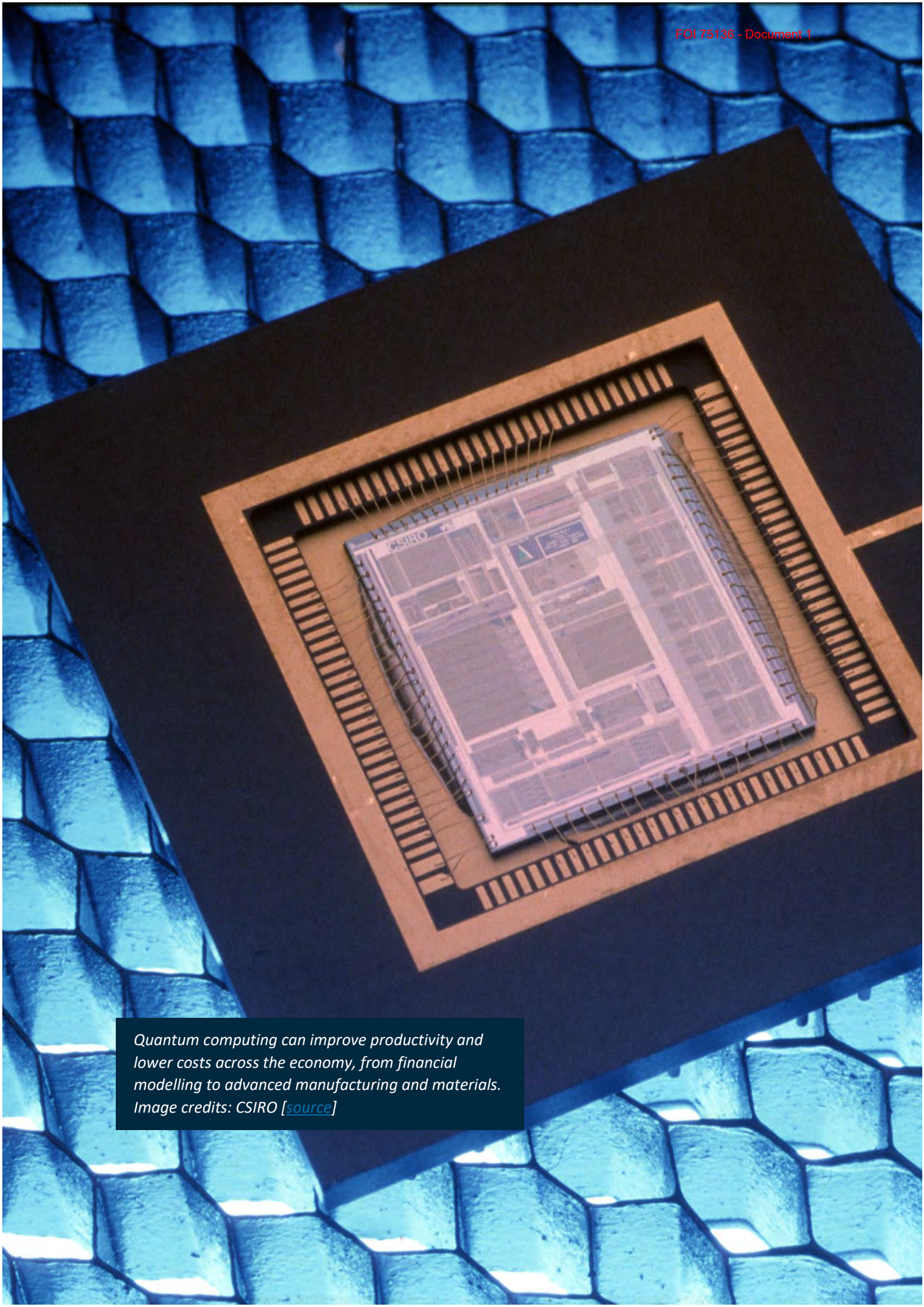
LANDTEM is an Australian technology developed by CSIRO that uses quantum sensors to detect magnetic fields that are 100 millionth of the size of earth's magnetic fields. This makes LANDTEM ideal for finding deep bodies of highly conducting ores, including nickel sulphide, copper and silver. It differentiates the target ore from other material, even when buried deep underground.

LANDTEM improves mineral exploration outcomes. It has helped discover more than $10 billion of ore deposits around the world with $4 billion of these discoveries located in Australia. LANDTEM has been used by Glencore, Legend Mining, Mincor Resources, Western Areas, Aeris Resources and companies in Canada. Legend Mining, for example, has most recently announced detection of new prospective nickel copper deposits in September 2022. Clients have seen LANDTEM reduce their operational costs of exploration by up to 30%.

New quantum applications could increase productivity and provide new ways of doing business in sectors including finance, energy, resources, agriculture, defence, meteorology and healthcare. Our economy's performance could improve through quantum computing's ability to rapidly process data that would otherwise take decades. This could increase efficiency, save energy, optimise logistics and manufacturing, and present new opportunities. Faster processing and simulation capabilities could lead to quicker and cheaper drug development by accurately modelling compounds and materials that we can't with current technology. Modelling can help us create new materials, and quantum sensors can provide improved diagnosis tools.

Case study 4: Improved efficiency in global banking

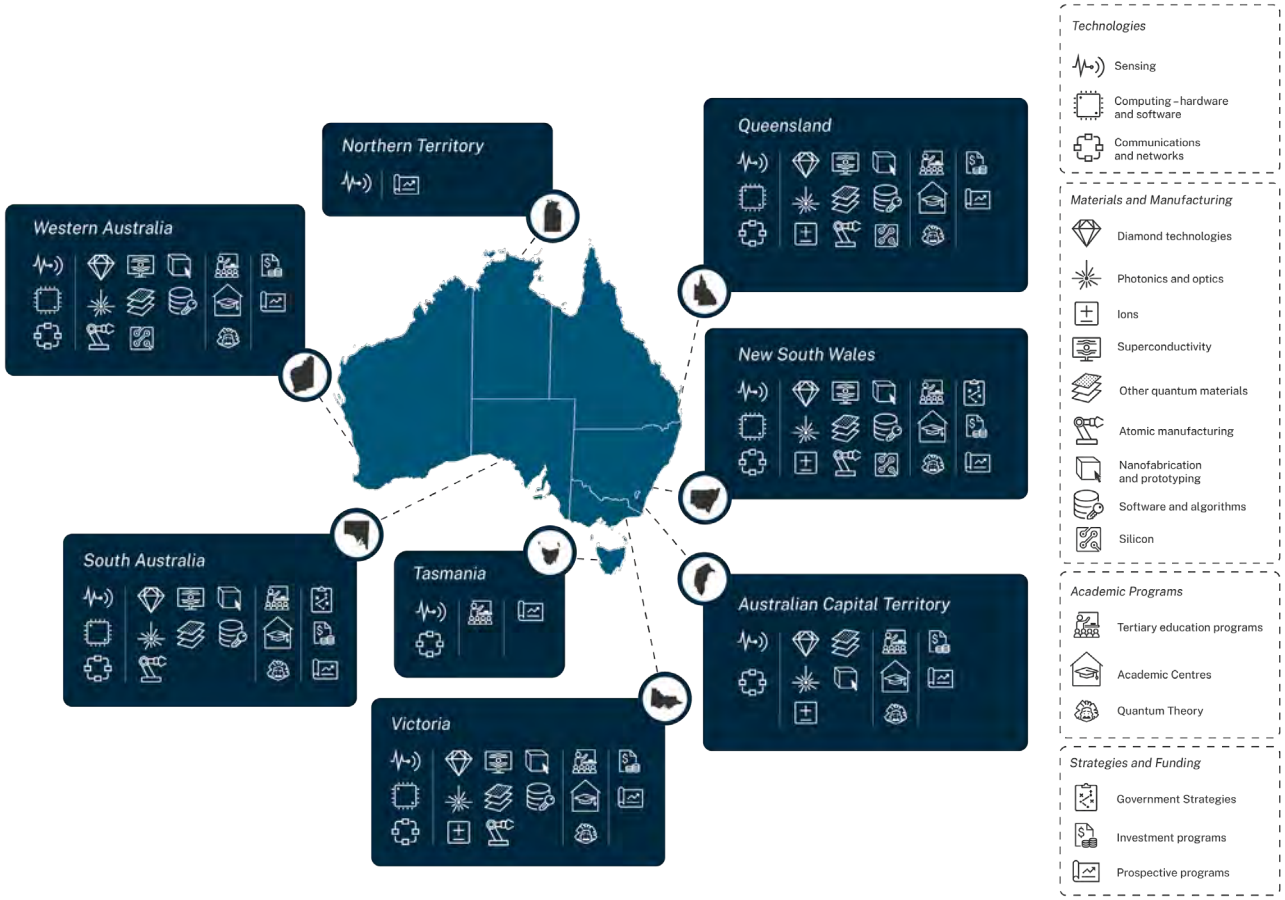
A major global bank, with an extensive virtual machine deployment hosting a range of banking services, was experiencing delays and the potential for duplicate keys used by the cryptographic processes for securing data and communication. Working with Quintessence Labs, a quantum random number generation (QRNG) solution was explored to ensure the timely delivery of high-quality randomness consumed by the cryptographic processes running in the virtual machines. The QRNG network appliances were deployed in all of the bank's data centres around the world, delivering entropy-as-a-service. Previously, during busy periods, login and cryptographically intensive operations had response delays of several tens of seconds. After the QRNG solution, response times improved by up to one hundred times. QRNG lowered the virtual machine instances experienced duplicate keys from 2.5% to none. The solution gave the bank, clear visibility of demand for randomness across the whole organisation.



Quantum computing can improve productivity and lower costs across the economy, from financial modelling to advanced manufacturing and materials. Image credits: CSIRO [source]

A national and international approach

Australia's strong quantum foundations include established strengths and capabilities across all states and territories. State and territory governments recognise the benefits of quantum technologies and are driving efforts to grow research, grow businesses, and attract international investment. Through a national approach, we will ensure these efforts are harmonised and complimentary.



International opportunities

Growing a thriving domestic ecosystem requires active international collaboration. Australia's close partnerships with many major economies and strong relationships in our region provide a solid platform to grow our quantum industry. The government will keep working with existing partners, and identify new ones, to:

- boost opportunities for quantum businesses
- establish norms and standards
- build research partnerships
- strengthen supply chains
- explore quantum solutions to global problems.

Strengthening Australia's international role will accelerate the development of quantum technologies, attract international talent and ensure we remain an influential voice in the international quantum community. We will ensure Australia remains a country that other nations want to work with and invest in. We will pursue international opportunities that align with our national interest and protect our national security.

Australia's quantum leadership in our region will open new opportunities for collaboration and diplomacy, including with ASEAN and Indo-Pacific nations, the United Kingdom, the EU, North America and our Pacific neighbours.

s47C(1)

Leveraging existing partnerships

Australia and the US have signed a joint statement of cooperation on quantum technologies. This will enhance both countries' quantum industries by improving market access and knowledge sharing. We are also exploring similar partnerships with other nations.

Quad

The Quad – Australia, India, Japan and the United States – works to uphold a stable, peaceful and prosperous Indo-Pacific region. The Quad's positive, practical agenda benefits the region by using its combined strengths and capabilities to respond to the region's key challenges.

The Quad is harnessing critical and emerging technologies to enhance the prosperity and security of the region. This work is organised into 4 areas:

- technology standards
- 5G deployment and diversification
- technology supply chains
- horizon scanning.

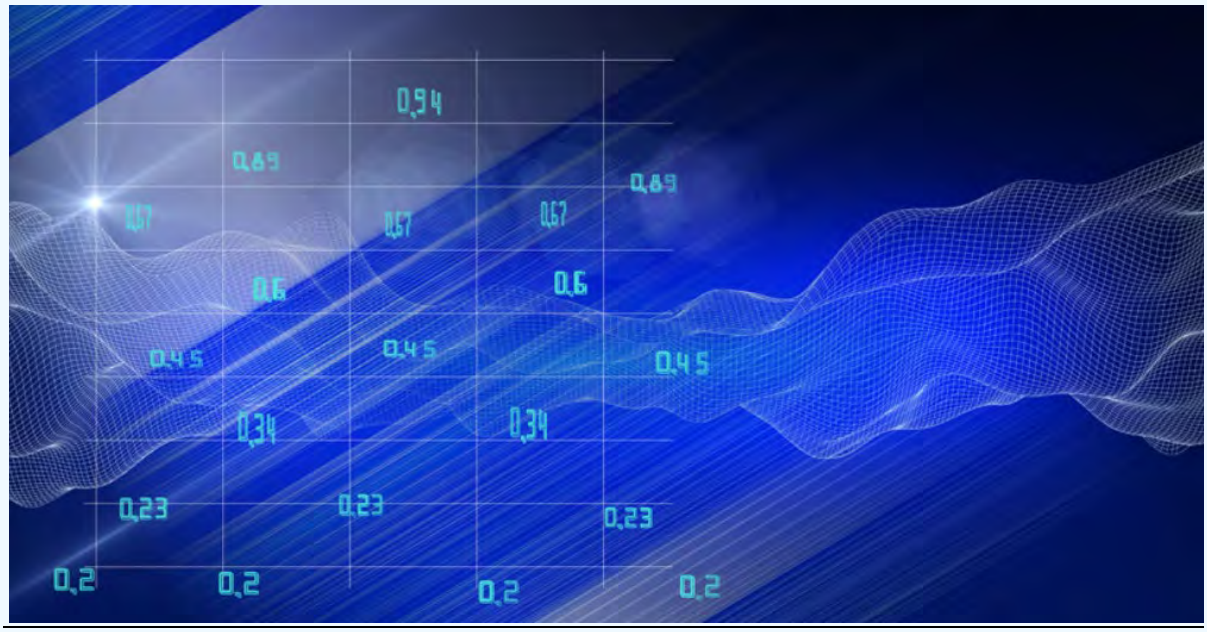
The Quad will continue to strengthen its horizon scanning cooperation with a future focus on quantum technologies, and through convening the Quad Technology Business and Investment Forum for networking with industry partners to expand capital for critical and emerging technologies.

AUKUS

The Australia, the United Kingdom and the United States' enhanced trilateral partnership (AUKUS) has 2 key areas of focus – nuclear-powered submarines and advanced capabilities. The partnership is committed to developing joint advanced military capabilities to promote security and stability in the Indo-Pacific region.

The AUKUS Quantum Arrangement (AQuA) is a core component of this work. AQuA will work to accelerate investments to deliver generation-after-next quantum military capabilities. There will be an initial focus on quantum technologies for positioning, navigation and timing. It is intended that the AQuA work will integrate emerging quantum technologies in trials and experimentation over the next 3 years.

While AUKUS's primary focus is on enhancing defence capabilities, going forward there will potentially be opportunities for Australia's broader quantum ecosystem to contribute to and support Defence's research efforts occurring through AUKUS.



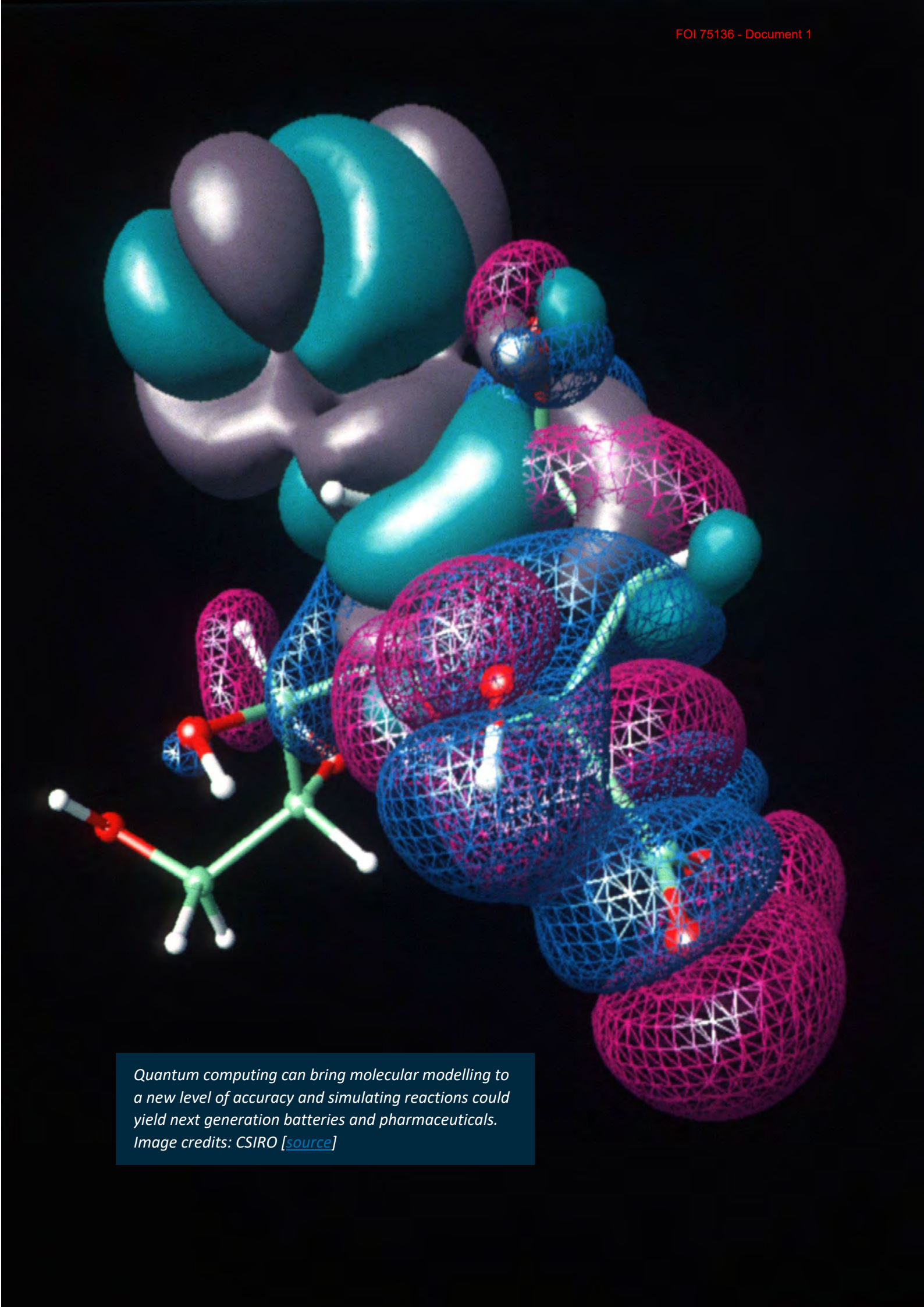
Case study 5: Collaborating for commercial quantum computers

The University of Technology Sydney's Centre for Quantum Software and Information (QSI) is participating in the US Defense Advanced Research Projects Agency's (DARPA) quantum benchmarking program. The program quantitatively assesses the performance of quantum computing algorithms and applications at scale. These multi-million dollar projects will be creating new tools and techniques for these assessments and involves global companies including HRL Laboratories, Boeing and General Motors and quantum technology companies including Zapata Computing, Rigetti Computing, and IonQ.

The quantum benchmarking program is estimating the long-term utility of quantum computers by creating benchmarks that quantitatively measure progress towards transformational computational challenges. The program will also estimate the hardware resources needed to achieve different levels of benchmark performance.

Quantum algorithms are currently benchmarked manually by a few experts, which typically takes several months per application. This practice can be sped up significantly by using software to model error correction, represent modern algorithmic techniques, and compile into low-level instruction sets. QSI researchers are developing the Bench-Q software suite for this purpose with the University of Southern California, University of Texas at Dallas, Aalto University in Finland, and Zapata Computing.

The Quantum Benchmarking program is using this software to estimate and optimise the cost of quantum algorithms in the processor platforms of Rigetti Computing and IonQ.



Quantum computing can bring molecular modelling to a new level of accuracy and simulating reactions could yield next generation batteries and pharmaceuticals. Image credits: CSIRO [source]

Pillars of the National Quantum Strategy

The National Quantum Strategy outlines 5 strong pillars that will support the realisation of our ambition. Each pillar has a set of actions to be completed over s47C . Together these actions address the opportunities and challenges facing Australia's quantum industry, and provide the signals to garner investments from individuals, industry, academia and government.

In many cases, the pillars focus on initial actions government can undertake to create the conditions for a thriving quantum industry. However, activities under each pillar will require coordinated and collaborative effort across the nation, with states and territories, our businesses and researchers, along with close engagement with the community for the quantum industry to be sustainable in the longer term.

Pillar 1: Thriving research, development, commercialisation and use of quantum technologies

Australia has a wealth of talent and ideas, as well as quantum technology solutions that are already commercial and almost ready to be commercialised. This is backed up by a government focused on long-term benefits. Our entrepreneurs and researchers are investing their time and talent into the next wave of quantum technologies and applications. As quantum research and technologies are maturing, the commercial and industrial opportunities are becoming more prominent. There is a growing body of tangible, scalable applications across a range of industries, with more emerging. Examples include:

- Quantum sensors being used to detect underground water leaks without digging, which could be used to lower costs and proactively monitor for leaks.
- Quantum sensors enabling fast accurate measurements in civil engineering.
- Quantum computing leading towards enabling optimisation for optimisation of supply chains and public transport, reducing waste and emissions.
- Quantum computing enabling increased energy density of batteries, supporting the transition to renewable energy.

The sector needs to attract more early-stage patient capital, as well as stronger coordination to connect ideas and solutions to businesses and investors. By demonstrating how quantum technologies can improve commercial outcomes and address key challenges, quantum researchers and businesses can demonstrate their strengths and attract investment. This includes near-term demonstration of market-ready products and solutions, and long-term applications for key industries and national capabilities. By building stronger connections between academia, business and industry, and translating research into industrial and commercial applications, we will deliver on Australia's quantum potential.

Australia's small domestic market and smaller pool of venture and non-dilutive capital means quantum companies need to access overseas markets and investment. The sector's growth will depend on stronger international connections and lower barriers to doing business overseas.

The quantum sector could also leverage a range of existing programs to accelerate research and grow, including:

- The University Research Commercialisation Action Plan, a $2.2 billion investment to strengthen university innovation and industry collaboration.
- the Higher Education Research Commercialisation Intellectual Property Framework, which helps businesses and industry work with universities on research and commercial projects
- the Australian Research Council's Centres of Excellence and National Competitive Grants Program (NCGP), including its Linkage and Discovery programs
- Cooperative Research Centres, which provide long- and short-term project funding for industry-led research collaborations.

Pillar 1 Actions

s47C(1)

Pillar 1: Thriving research, development, commercialisation and use of quantum technologies

s47C(1)

National Reconstruction Fund

The Australian Government is establishing the $15 billion National Reconstruction Fund (NRF) to support, diversify and transform Australia's industry. This will secure our future prosperity and drive sustainable economic growth.

The NRF will target projects and investments that help Australia capture new, high-value market opportunities. This will help our businesses grow and succeed in the economy of tomorrow. The NRF will provide finance (including loans, guarantees and equity) to drive investments that add value and develop capability in 7 priority areas. The NRF will partner with industry to unlock private sector investment to create sustainable industries and secure, well-paid jobs.

The NRF will be an independent financier that operates commercially to deliver a positive rate of return. It will be governed by a board who will make independent investment decisions guided by an investment mandate.

One of the NRF's priority areas is enabling capabilities. It includes $1 billion of finance to grow advanced manufacturing and support businesses to innovate and move up the technological ladder. A further $1 billion will be used to grow critical technologies. This will support home-grown innovation and build industry capability in areas like artificial intelligence, quantum computing, robotics, and software development.

The NRF is expected to start operation in mid-2023.

Case Study 6: Quantum supporting medical testing

Quantum scientists at the University of Melbourne, in collaboration with the Florey Institute of Neuroscience and Mental Health, are developing FeBI (Ferritin Bound Iron) diagnostic technology using a patented quantum sensing technology to detect iron loading within serum ferritin. This new technology contrasts with current tests which are confounded by inflammation due to their reliance on the ferritin protein levels rather than iron. A working prototype has been demonstrated to be functional on laboratory ferritin samples and the team is currently applying for funding and investment for clinical validation and commercial development.

Case study 7: Exploring quantum possibilities with edge devices

Autonomous vehicles, robotics, smartphones are just three examples of edge computing devices that have become mainstream technologies. However, edge technology does not yet have the computational ability necessary to handle complex algorithms, limiting the application of mainstream edge computing devices for heavy-duty computing.

Quantum computing could change that. As part of the Quantum Pioneers Program, the Pawsey Supercomputing Research Centre partnered with Quantum Brilliance to enable industry and research teams to explore the possibilities of edge quantum computing. One example of this is accelerating speech transcription at the edge.

Quantum Brilliance worked with an industry partner Trellis to develop the Quantum Decoder – a hybrid quantum–classical application that seeks to improve speech transcription algorithms. The Quantum Decoder will replace the 'beam search' decoder algorithms that are deployed in many everyday applications like vehicles and smartphones. Classical decoder algorithms truncate input data to provide results quickly, but some input information is lost, reducing accuracy.

The Quantum Decoder promises to be both fast and accurate. It uses a quantum computer to decode the input signal in a reasonable timeframe with no loss of information. This provides better accuracy at the same computational speed as similar-sized classical systems. The Quantum Decoder could be generalised to any signal processing problem, not just speech transcription. This means it has the potential to impact many industries, autonomous vehicles, robotics, smartphones, satellite image processing and manufacturing optimisation.

The recently announced ARC Centre of Excellence in Quantum Biotechnology will help Australia stay at the forefront of developing quantum technologies to transform our understanding of life.
[Getty image credit]

Pillar 2: A skilled quantum workforce

The growth of Australia's quantum sector depends on a skilled, diverse workforce. This requires an effective pipeline of talent – from schools, through universities and vocational training, and into industry.

We need to develop and promote quantum career paths that make entrants aware of the diverse opportunities in the industry: from machining and electrical engineering, to software development and quantum algorithm research, to teaching and science communication, to management and cross-sectoral applications.

Our researchers are the foundation of our strength in quantum technologies and the cornerstone of our future. Australia's quantum research excellence in universities and industry has established us as an international quantum leader. We have a long history of linking research with social and economic priorities through Centres of Excellence, which boost collaboration on innovative research. Our research strength is in part due to decades of government funding in fundamental and applied quantum science.

Our quantum sector is forecast to generate between 16,000 and 21,000 jobs by 2040, this number would grow with additional investments. The Australian Government plans to reach 1.2 million technology jobs by 2030, which will support and complement the quantum industry's requirements. But we need more than quantum experts – we need quantum-literate businesses and workers across sectors including manufacturing and engineering, as well as businesses that can identify and use new quantum applications.

Building a quantum talent pipeline is a long-term effort. We first need to assess our current, emerging and future quantum skills needs and consider how we can meet our short-, medium- and long-term skills gaps. In the short- to medium-term, we need to build greater quantum literacy in schools, and highlight quantum career opportunities to secondary students and other workers. In the long term we must inspire more children to choose STEM and quantum education and careers.

Australian research institutes and quantum companies have to compete with other countries for the best and brightest minds. Creating a thriving and trusted domestic ecosystem is essential for retaining Australia's talent. We need to promote Australia as a destination for international talent and promote the key capabilities that will let local industries succeed. To generate key expertise, we may need to build internal pathways and target key international talent.

Jobs and Skills Summit

At the 2022 Jobs and Skills Summit, the Australian Government committed to implementing a Digital and Tech Skills Compact. The compact will see the government work with industry, training and education providers, unions and others on practical measures meet Australia's digital and tech skills shortage.

A focus of the compact is developing an 'earn while you learn' scheme, or 'digital apprenticeship'. This will bring new entrants into tech-related roles and enhance the diversity of the tech workforce.

Pillar 2 Actions

s47C(1)

Case study 8: Inspiring students

As part of the STEM 2022 on demand series, Sydney Quantum Academy (SQA) and the NSW Department of Education created a video showing teachers how to light a path to a quantum career for their students. The video explains that the era of quantum computing is fast approaching and covers some of the potential applications for emerging quantum technology.

By clearly explaining our quantum future and the sector's growing need for diverse skills, the video can help teachers inspire a new generation of students. The video is part of a wider campaign and activities SQA runs in partnership with several organisations including a summer school, open days and a careers fair. All are designed to demonstrate the study pathways and exciting careers available.

Pillar 2: A skilled quantum workforce

s47C(1)

Case Study 9: Building a quantum career

The past seven years have seen a flurry of challenges for 22 year-old Ritika Bazzad. Despite this, she's overcome obstacles – including a global pandemic – and is now deep into a PhD on quantum materials. Her first obstacle was integrating into a new country halfway through a school year; when she arrived in Australia from her native India in 2014 and, due to the different start dates for academic years, she had to repeat Year 10.

After graduating high school, her father suggested Ritika consider science, leading to an applied physics degree at the University of Technology Sydney (UTS). Then she heard about Sydney Quantum Academy (SQA), a partnership between four universities – Macquarie University, University of Sydney, UNSW and UTS – backed by the NSW Government. SQA provides scholarships, career development and a thriving local community of young researchers. She qualified for a PhD Experience Scholarship, with access to career development and entry to the SQA PhD Experience program. This program allows students to pick up technical expertise, leadership, and other transferable skills by taking part in the same seminars, workshops, and coursework as those on scholarships with a stipend. And they get to experience the cutting edge of quantum science and technology from both a theory as well as a practical perspective.

Ritika's research – in the Quantum Materials and Photonics Team at UTS – is focused on nanomaterials, artificial structures just billionths of a metre in size; at that scale, matter displays quantum effects that can be manipulated. She is experimenting with hexagonal boron nitride (or hBN) crystals so they can better emit single photons (or particles of light). If it can be perfected, it could lead to semiconductor chips just one atom thick, opening the door to advanced 2D quantum state engineering.

Case Study 10: Value chain for domestic supply and manufacturing

Silicon Quantum Computing (SQC) has worked with Australian industry to help build an end-to-end quantum value chain.

To feed the manufacturing underway, SQC secures raw materials from a local provider Silex Systems. With the support of the Department of Industry's CRC program, Silex expanded its operations to include the production of isotopically pure silicon at its facilities in Lucas Heights, NSW.

Down-stream of the hardware, SQC procures services from quantum software company Aqacia, which helps develop machine learning tools focused on accelerating quantum computing chip development and insights. While SQC is one of their local "anchors", the digital nature of the company means that Aqacia is able to provide services to, and earn revenue from, all over the world.

At the other end of the local value chain, SQC has had a long-standing relationship with the Commonwealth Bank and Telstra, its co-development partners who recognised early the transformational nature of quantum computing to their business. As the technology continues to mature these essential partnerships have informed the company of the valuable use cases and accelerated the development of the full quantum computing stack in SQC to meet these requirements.

Pillar 3: Access to key infrastructure and materials

Australian researchers, start-ups and quantum businesses need improved access to advanced infrastructure, materials and tools to build a thriving quantum ecosystem. In considering infrastructure needs, s47C(1)

s47C(1)

Research infrastructure

The Australian Government has invested in a range of research infrastructure, some of which could be leveraged for improving access for quantum researchers and businesses. The National Collaborative Research Infrastructure Strategy (NCRIS) focuses on maintaining Australia's position as a global leader in research by ensuring researchers have access to cutting edge infrastructure. Some current NCRIS projects that could be leveraged to enable better access for quantum researchers include:

- Australian National Fabrication Facility – provides micro and nanofabrication for Australian researchers
- Pawsey Supercomputing Research Centre – is a Tier-1 High Performing Computing facility dedicated to accelerating scientific research, including the recently installed room-temperature diamond-based quantum accelerator
- National Imaging Facility – provides flagship imaging equipment, expertise, tools data and analysis, including quantum instruments available at their Western Sydney University node

Pillar 3 Actions

s47C(1)

Pillar 3: Access to key infrastructure and materials

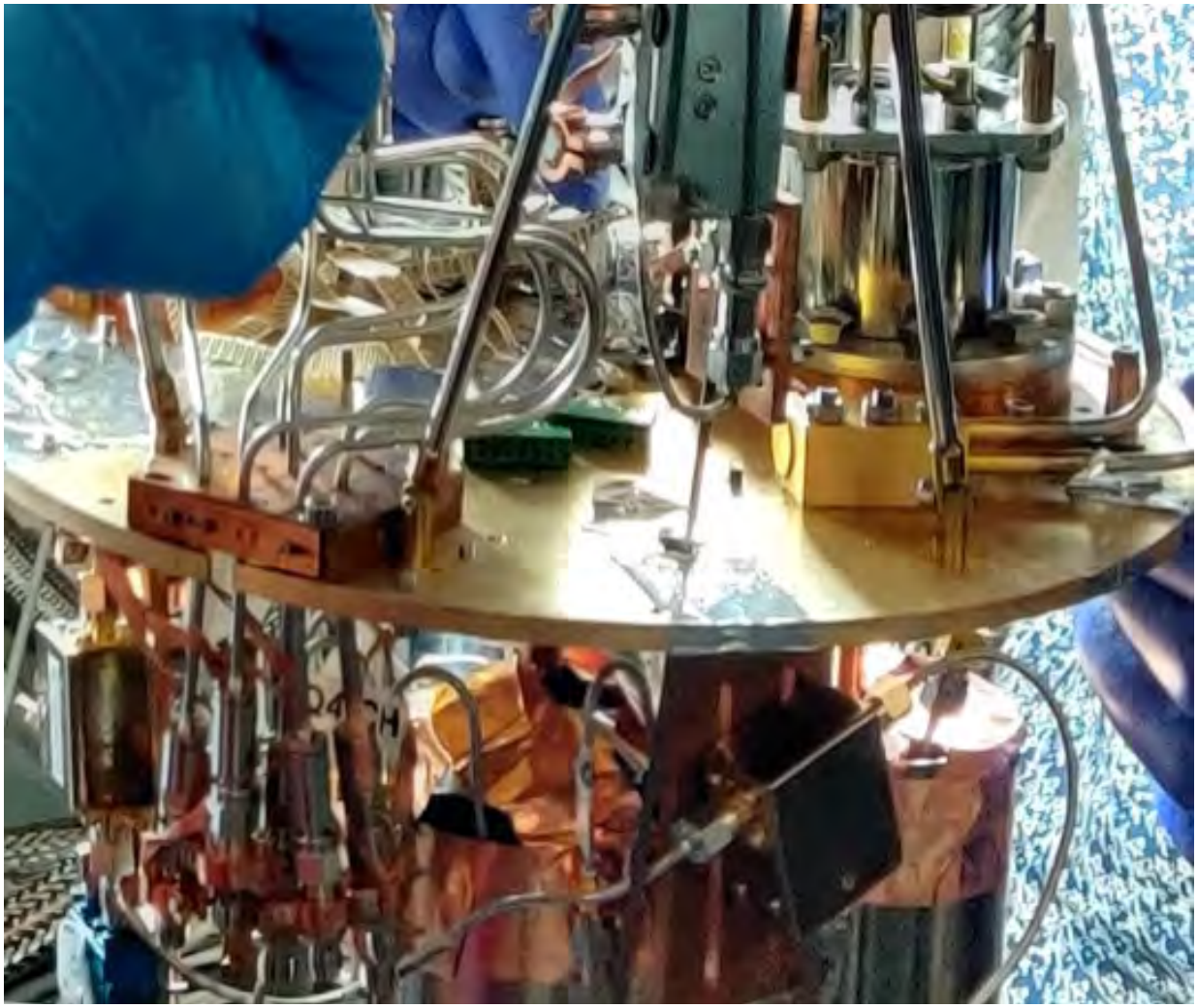
s47C(1)

Case Study 11: Access to infrastructure enables quantum start-ups

Analog Quantum Circuits (AQC) is an Australian quantum start-up focussed on superconducting quantum hardware. AQC is based on research in superconducting microwave devices, which was supported by the Australian Research Council through Future Fellowships and the ARC Centre of Excellence in Engineered Quantum Systems (EQUS).

AQC's establishment faced two major challenges commonly experienced by other start-ups seeking to commercialise university research. AQC experienced difficulties in securing access to university-held intellectual property that underpins their research and development. They also experienced challenges accessing the necessary facilities for fabrication, process control, and cryogenic measurement to undertake development of advanced hardware.

Gaps in the research and development pipeline create challenges for AQC and other start-ups seeking to become operational. For example there are currently no openly-accessible industry cryogenic measurement facilities in Australia available for use by quantum technology companies. Where advanced facilities do exist, access can be costly and have long lead times. While universities host some equipment that is industry accessible, this does not cover the full range of requirements for a vibrant quantum technology industry.



Case Study 12: Transitioning from the lab to future applications

Phasor Innovation is an Australian quantum business specialising in radio frequency and microwave engineering, electromagnetics, system integration and quantum technologies. Phasor Innovation is collaborating with the University of Melbourne and RMIT University on researching and developing the next generation of diamond-based quantum sensors. There are a range of new and emerging applications for this technology in many areas including the defence, mining, space and medical sectors.

The collaborative university and industry team successfully competed in the inaugural Army Quantum Technology Challenge in 2021 and are currently working together on a subsequent project to design, construct, test and evaluate a quantum diamond-based vector magnetometer that will provide improved surveillance and detection of subterranean targets. The team has also received funding from Defence to further develop the technology for precision magnetic navigation in GNSS-denied environments.

Caption: Testing the performance of a nitrogen-vacancy diamond-based vector magnetometer at the University of Melbourne Quantum Magnetometer Test and Measurement Facility. Credit: Lew C 2022, Quantum Magnetometer Test and Measurement Facility, digital photograph by Chris Lew, University of Melbourne.

Pillar 4: Regulation supporting national interests

Quantum technologies present Australia with enormous commercial potential and advantages in sovereign capability. We must protect Australia's national interests while ensuring we can take full advantage of the opportunities for Australia's quantum researchers and industry. s47C(1)

Australia's regulatory environment provides strong protections, ensures fair competition, supports national interests, and promotes integrity in the market. This effective regulatory environment is an asset that provides certainty to businesses, investors and international partners looking to work with Australia. Regulations ensure our approach to technologies aligns with our values. These regulatory frameworks need to remain fit for purpose and responsive to technological developments, to ensure ongoing trust and confidence.

The development and application of quantum technologies could have significant implications for our national security. Quantum technologies have the potential to impact some of the most important national security functions including defence, intelligence, encryption, sensing and detection, computer processing, and communications. s47C(1)

There are significant opportunities for Australian academia and industry to contribute to defence and national security requirements through discovering and building new quantum capabilities.

To fully realise those opportunities, we need strong and trusted Australian quantum companies. Navigating the regulatory environment can be a challenge for advanced and emergent technology industries, including quantum, where the necessary focus on mitigation of risks and protection of knowledge and capabilities can inhibit growth and commercial opportunities. Australian technology companies do not have a large domestic market, which makes access to international markets critical for their survival and growth.

s47C(1)

t is also important for researchers and industry to be aware of the opportunities and risks so they can make informed decisions, and Australia's quantum infrastructure, institutions and individuals are not exposed to unreasonable risk.

Case Study 13: Quantum clocks and sensors supporting our defence force

Building on their strong relationship with the Institute for Photonics and Advanced Sensing (IPAS) at the University of Adelaide, QuantX Labs is developing ground-breaking quantum sensors and clocks. These critical capabilities will:

- enhance Australia's security through better undersea and underground surveillance as well as opening the door to next-generation Over-The-Horizon radar technologies
- support deployments of the Australian Defence Forces through enhanced navigation and surveillance capabilities,
- allow civilian and defence operations in regions in which satellite-navigation systems are unavailable,
- and provide support for critical civilian and defence infrastructure

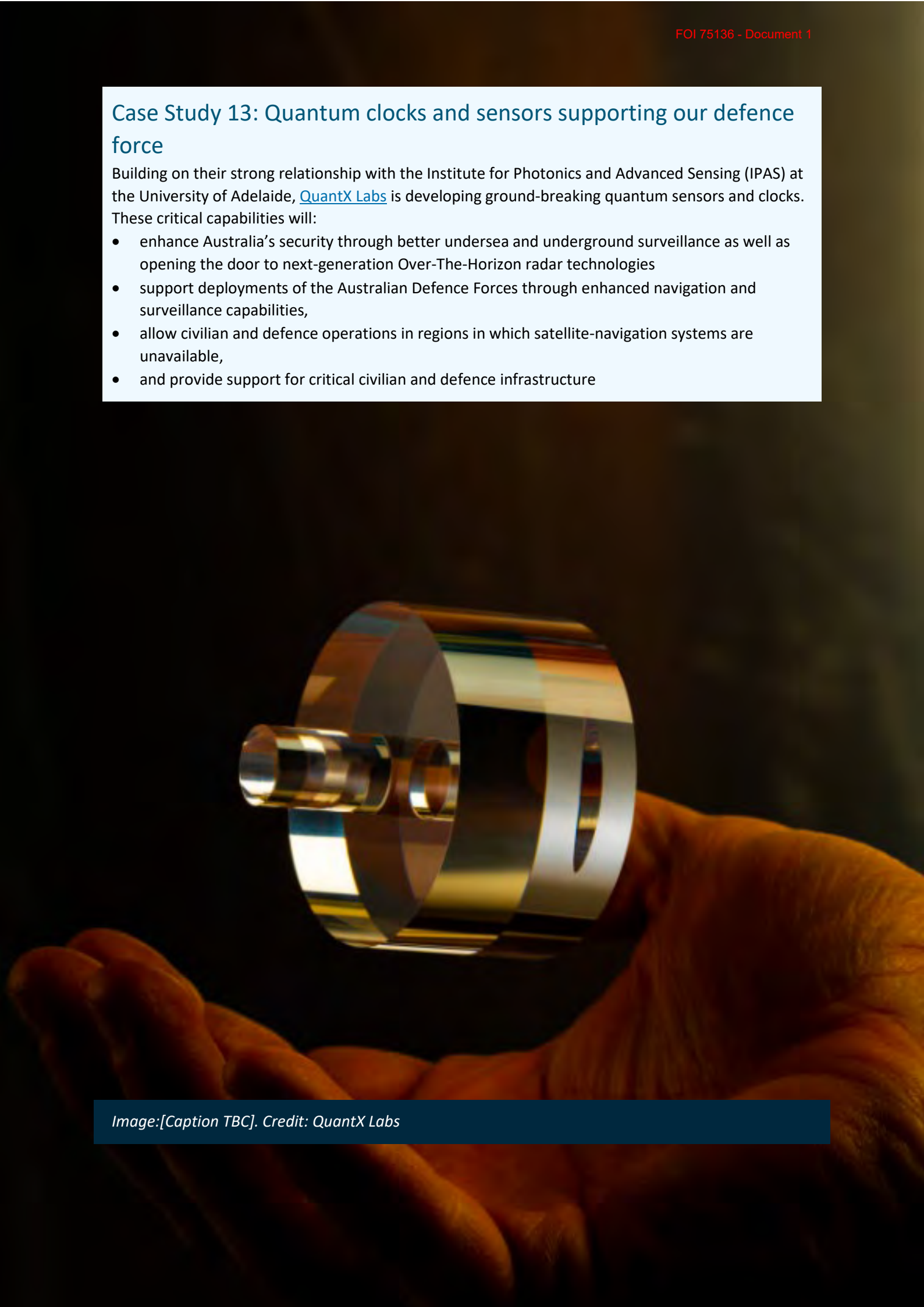


Image:[Caption TBC]. Credit: QuantX Labs

Pillar 4 Actions

s47C(1)

Pillar 4: Balanced regulatory settings and national interests

s47C(1)

Case Study 14: Army Quantum Technology Challenge

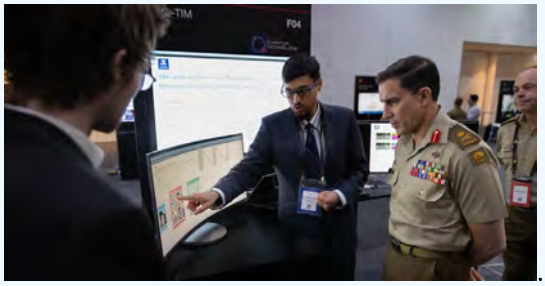
The Army Quantum Technology Challenge (AQTC) is an annual technology challenge, with the first two hosted in Adelaide in 2021 and 2022, and the flagship initiative of Army's Quantum Technology Roadmap. The AQTC is designed to leverage Australia's national strategic strength in quantum technology to rapidly identify the most disruptive and advantageous applications of quantum technologies for the land domain, whilst also stimulating the growth of the sovereign quantum industry that will deliver those capabilities to Army.

Each year, the AQTC challenges teams to demonstrate solutions to one of three challenge themes, which span quantum sensing, computing and communications. The themes are derived from current Army problems, Army's hypotheses about transformative effects that quantum technologies may have on land warfare, and input from the quantum technology community. Past themes have included: subterranean imaging and locating electromagnetic emitters using quantum sensors, optimising last-mile resupply logistics and enhancing image processing using quantum computers, and the disruption of satellite-mediated quantum communications and the implementation of post-quantum cryptography to harden Army's communications against attack from quantum computers.

To participate, teams propose a solution concept and undergo a selection process. Selected teams then receive seed funding to develop their solution over ~5 months before demonstrating it at the AQTC Demonstration Day. Since quantum technologies are diverse in technology readiness, demonstrations range from simulations to deployable prototypes.

Demonstration Day is a major event that is held in conjunction with the Chief of Army Symposium and the Army Robotics Expo. It provides the teams with the opportunity to interact with the full spectrum of junior soldiers to senior Defence leaders, and for those members to gain a tangible understanding of quantum technologies and their defence implications. At Demonstration Day, the teams are assessed by an evaluation panel drawn from across the Services and Groups and Army's strategic partners. The top-ranked teams are offered the opportunity to further develop their solution under significant Army Quantum Technology Exploit Projects. Being awarded an Exploit Project contract is the principal incentive for the teams. The projects are designed to bridge the gap from technology demonstrator to a field-deployable prototype that is ready for adoption by a land capability program.

Since commencing in 2021, the AQTC has achieved significant outcomes, including: the identification of the profound and near-term advantages offered by quantum sensors in subterranean imaging, the innovation of countermeasures to these sensors by Army soldiers, an appreciation of the vulnerabilities of quantum communications that has shaped Army's assessment of the technology and its employment, unexpected benefits from quantum computers such as increase resilience to adversarial attack in machine learning, Army's strategic partners identifying immediate opportunities to pursue with Australian industry, and a rapidly growing awareness of quantum technology across Army and wider that has stimulated an imperative to understand and act.



Quantum computing can improve fertiliser production and enable more accurate modelling and forecasting to help our agriculture sector manage climate change and weather events. [Getty image credit]

Pillar 5: Trust, ethics and inclusivity

Quantum technologies present near-boundless opportunities, but these opportunities must serve the interests of Australian society and contribute to our national wellbeing. Technologies that promise great opportunity and change also bring risks. Through building frameworks for responsible development and use, quantum researchers and developers will have a sound basis to develop technologies that align to Australian values and protect human rights. The public is increasingly aware of the ethical and societal implications of technological advances and we should not presume an enthusiastic embrace of quantum technologies. Quantum technologies will align with our values and expectations, our commitment to human rights and the rule of law. In adopting this approach, Australia can cement itself as a responsible technology developer, creating a strong brand which is expected to attract international companies and investors.

Standards for quantum technologies will be important for providing Australians with confidence they are being developed and deployed in a way that is trusted, secure and to their benefit. Technology standards, underpinned by trusted measurement, will foster the growth of this sector by creating a competitive supplier market, giving industry the confidence to adopt new technologies and ensuring global interoperability. This will provide consistency and opportunities to Australian companies seeking to develop or to reap the benefits of this technology. With industry leading, Australia can play an active role in the global bodies that develop technology standards, and help to ensure that standards for quantum technologies support the growth of a vibrant and competitive marketplace by fostering values of interoperability, innovation, transparency, and security. We will also work to ensure the development and adoption of standards doesn't unnecessarily inhibit research, development and commercialisation of quantum technologies.

Building greater community awareness and acceptance of quantum technologies will be a cornerstone of a thriving and sustainable Australian quantum ecosystem. Sparking interest in quantum technologies will inspire adults and children to pursue careers in the quantum and wider technology sector. This will just address key skills shortages and ensure a sustainable talent pipeline. Driving diversity in quantum will also unlock new and unique use cases.

To maximise the opportunities from quantum, we must also push for greater inclusion and diversity, and pursue measures to lift the participation of women, Aboriginal and Torres Strait Islander people and other underrepresented groups. The community must engage with rural and regional Australia and connect with families, teachers and children so the whole of Australia understands and can benefit from quantum technologies.

Pillar 5 Actions

s47C(1)

Pillar 5: Trust, ethics and inclusivity

s47C(1)

Case Study 15: Contributing to global quantum governance

Growing Australia's place in and contribution to the international quantum ecosystem has been enabled through our participation in the development of world first governance guidelines for quantum computing. In 2021, the World Economic Forum established a multi-stakeholder network centred on the acceleration of responsible quantum computing. This took place as the ethical, legal and social implications of quantum computing were just beginning to be discussed globally. But there was wide recognition there were no established governance guidelines available that would guide the development and use of the technology for broader social good.

Over the course of a year, the Forum coordinated a comprehensive multi-stage co-design process involving quantum science and technology experts, business leaders, social scientists, policy makers and authorities on emerging technology ethics and law drawn from around the world. Australian expertise was broadly represented and participants in the development of these guidelines came from CSIRO, the Sydney Quantum Academy, the Australian National University, the University of Western Australia, The University of Queensland, Monash University, and Quintessence Labs.

The Australian participants worked alongside other key quantum experts and stakeholders across R&D, government and industry sectors across the globe to tackle early-stage questions about how to not only assess and manage the opportunities of quantum but also the potential risks so that they might be mitigated. The process set the course for looking at the long-term futures that we most wanted to create with quantum computing and created a set of actionable principles that can be debated, refined and used to collaboratively shape how the technology will be used. It demonstrates that the Australian quantum ecosystem plays a critical role in both thought and practice leadership in the field of responsible quantum governance that will generate broader benefits to humanity.

Strategic approach

The National Quantum Strategy is integral to the government's agenda to build a stronger economy and create sustainable, well-paid jobs. The strategy is part of the overall approach to critical technologies: technologies that will be central to Australia's prosperity, social cohesion and national security. These technologies cut across many government portfolios and industry sectors, requiring a coordinated and consistent approach.

The strategy reflects the role of government in leading investment and policies that help businesses harness emerging technologies. This includes:

- Providing the enabling environment for businesses to harness emerging technologies
- Creating a regulatory environment that builds trust and confidence and supports growth
- Providing national leadership and policy coordination
- Investing and using financial incentives where appropriate, including as an early adopter

To guide the Australian Government's investments in the quantum sector, the following principles will maximise the benefit to industry and minimise market distortions. Investments should:

- Have the potential for significant impact in Australia's quantum sector or the broader economy
- Align with government policy priorities, and Australia's economic and national interest
- Counter market failures, address financing impediments and support the commercialisation of the sector, including enabling infrastructure that will bring industry to scale
- Leverage contributions from other sources, for example from private sector financing, academia or research organisations, industry, state and territory governments, and international counterparts and existing programs such as grant programs and Specialist Investment Vehicles.

Working together to deliver

To achieve this vision, we need a truly national effort from Australia's entire quantum ecosystem – all states and territories, the education sector, the technology and manufacturing industry, businesses and investors, and the wider community.

The Australian Government and research sector have led the way. The government has been investing in quantum for over 20 years, helping to build a strong foundation in quantum information, science and technology. We can build on these foundations by coordinating our efforts and investing further to grow Australia's skilled workforce, businesses, infrastructure, partnerships and capabilities.

The Department of Industry, Science and Resources leads the development and implementation of the strategy. We will work with partners across government, including the:

- Department of Education
- Department of Foreign Affairs and Trade
- Department of Home Affairs
- Department of Defence
- Department of Employment and Workplace Relations
- Treasury.

Quantum computing and simulation can unlock new advanced materials to deliver cleaner and more efficient energy generation and storage.
[Getty image credit]

Measuring our success

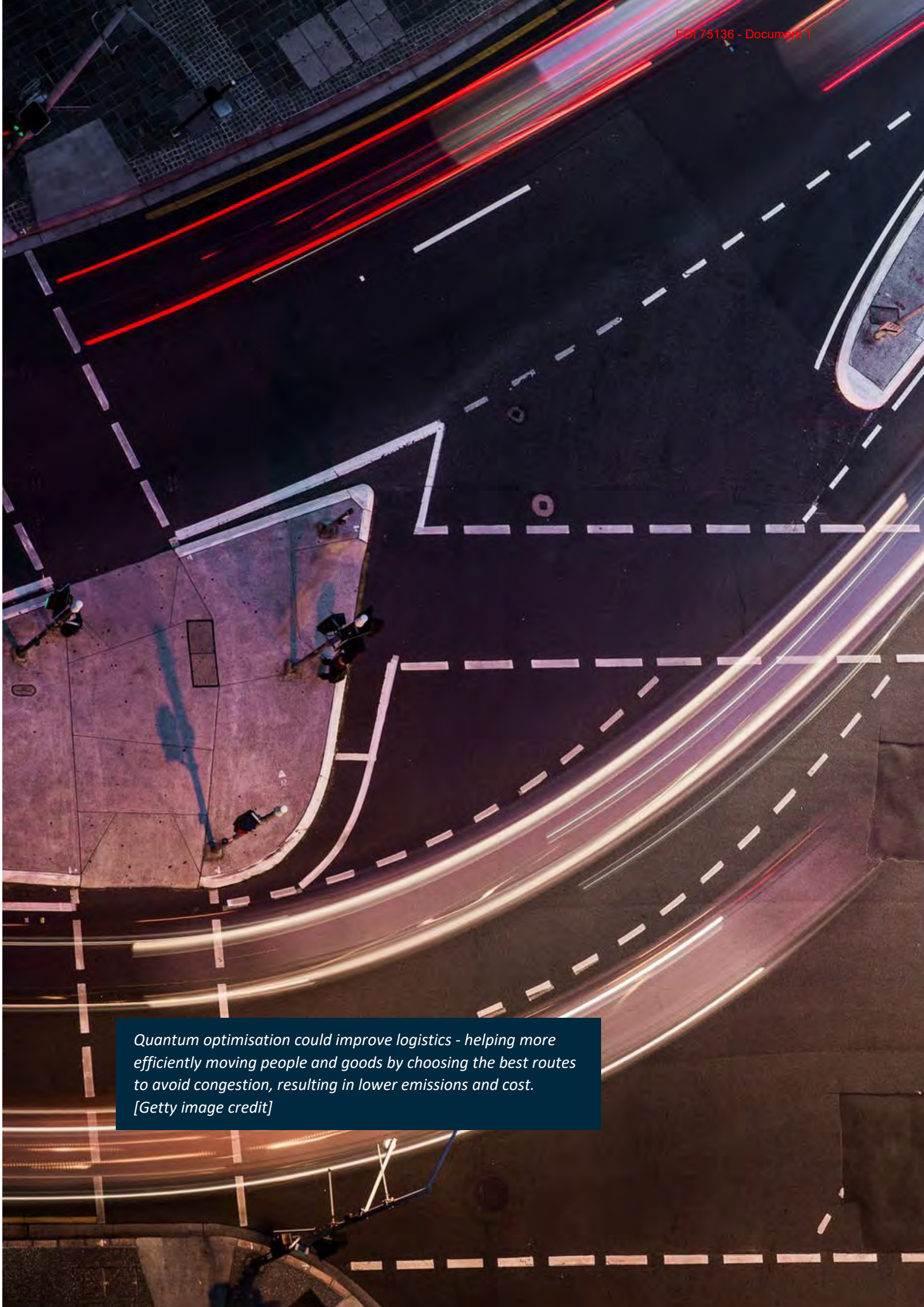
To ensure we deliver on the ambition presented in this Strategy, the Australian Government will carry out regular reviews of the Strategy's progress against a number of quantitative and qualitative measures of the state of the sector. Starting in 2023, benchmarking reviews at the commencement and end of each implementation phase will track Australia's performance against key indicators of achievement, such as:

Indicator of success	What will we measure?	Related actions
Australia is actively realising the transformational impacts of quantum technologies across finance, healthcare, agriculture, environment, energy, defence, transport, resources and other sectors	• Market research: uptake of quantum across the Australian economy • Wider industry economic benefit arising out of application of quantum technologies	1.1, 1.2, 1.3, 1.4, 4.1
Australia has a strong quantum technology industry	• Number of companies • Number of start-ups being generated • Valuation of Australian quantum companies • Investment leveraged by industry	1.1, 1.2, 3.1, 4.1
Australia remains a leader in quantum research, and has established strong pathways for the commercialisation and industrialisation of that knowledge	• International rankings in research publications and impact for quantum • Number of patents and trademarks of Australian quantum technologies • Australian quantum R&D expenditure • Licensing and sale of intellectual property by Australian quantum companies	1.1, 1.2, 1.3, 2.1, 2.4, 3.1
Australia has high quantum-literacy, leading businesses to identify and generate wide use cases, and attracting talent into career paths at early stages.	• Market research: public awareness of quantum opportunity	2.1, 2.2, 2.3, 5.1
The quantum industry is supported by mature talent pipelines through the secondary, VET and tertiary sectors, from adjacent industries and from overseas, where Australia is a destination of choice	• Number of employees in Australian quantum companies • Job vacancy rate for Australian quantum companies • Number of applications and visas granted for eligible skilled migration candidates • STEM education enrolment and performance metrics	2.1, 2.2, 2.3, 2.4

Indicator of success	What will we measure?	Related actions
Australian quantum researchers and businesses have access to the infrastructure, manufacturing and materials to advance and grow their field	• Market research: perceptions of barriers to growth	3.1, 3.2, 3.3
Australia is recognised as an international leader in quantum technologies, and has deep relationships with key partners, enabling the transfer of knowledge, capital and business	• Number of international agreements • Number of international collaborative research projects • Value of quantum technology exports • Value of Australian contribution to global value chains for quantum technology • Business-research collaboration	1.5, 2.4, 3.2, 3.3, 4.3
Australia's approach to quantum technologies is balanced, supports national interests, is inclusive and aligns to Australian values	• Market research: perceptions of barriers to growth	2.3, 4.1, 4.2, 4.3, 5.2

Appropriate targets for these measurements will be established as part of the first benchmarking review in 2023.

In addition, the Australian Government will track progress against key economic indicators of sector growth as the sector grows towards $5.9 billion in industry revenue, $6.1 billion contributed to GDP, 19,400 direct jobs and over 35,000 jobs supported across the Australian economy by 2045.



Quantum optimisation could improve logistics - helping more efficiently moving people and goods by choosing the best routes to avoid congestion, resulting in lower emissions and cost. [Getty image credit]

Appendix A - Quantum technologies

Quantum technologies and materials are a cross-sectoral enabler that will shape many areas of our economy. They have the potential to bring significant economic and productivity gains as well as social and environmental benefits. There are three main categories of quantum technologies:

Quantum sensing allows us to detect and map through barriers, in unique ways and at distances with extreme precision. Applications for quantum sensors include enhanced imaging, passive navigation, precise timing, and remote sensing. This may help us to:

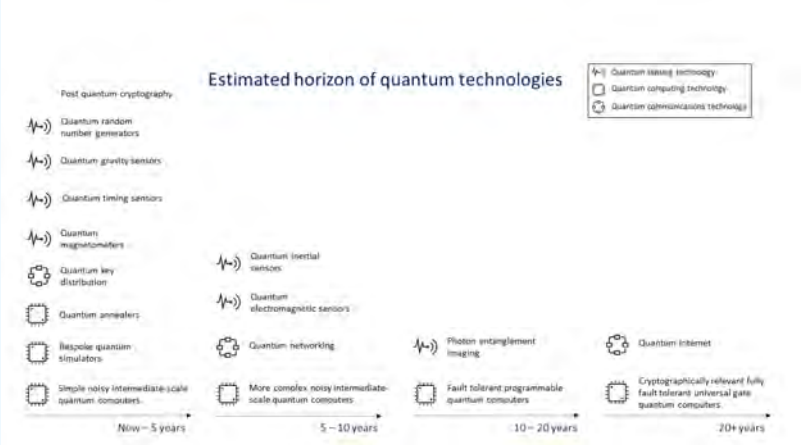
- map and understand the brain, the heart and other organs and transform the way we detect and diagnose disease at extremely small scales
- detect mineral deposits deeper underground without needing to dig
- find leaks or issues in underground pipes and cables
- navigate with greater accuracy. More accurate position, navigation and timing systems are important for emerging technologies such as self-driving cars and military capabilities.

Quantum computers use quantum mechanics to perform certain complex calculations in a smaller number of steps than an ordinary computer. Quantum computers work by first creating a superposition of lots of different possible solutions to a problem – encoded in qubits – and then manipulating that superposition so that wrong solutions cancel out and right ones are strengthened. By harnessing these capabilities, there are opportunities to:

- optimise logistics to deliver our parcels faster and more accurately
- improve the efficiency of our public transport networks
- model probabilities of extreme weather events, and complex health challenges like pandemics
- model optimal responses to emergencies like fires and floods
- simulate complex molecules which have applications in advanced materials (such as the best structure and material composition for aeroplanes) and clean technologies like batteries
- model chemical and drug reactions, which can drastically speed up medical research for new medicines and vaccines

Quantum communications may enable faster and more secure communications networks. Applications for quantum communications include transferring information between quantum computers and sharing cryptographic keys between distant people in a way that means it is impossible for anyone else to copy. Through quantum communications we can:

- drive the next generation of cyber security and secure communications
- create high-speed networks, including a future quantum internet, that will deliver a host of new applications.



Quantum imaging and computing could lead to better outcomes through faster and more accurate diagnoses and treatment.
[Getty image credit]

industry.gov.au/quantum