Transport for NSW

Quantum Technology

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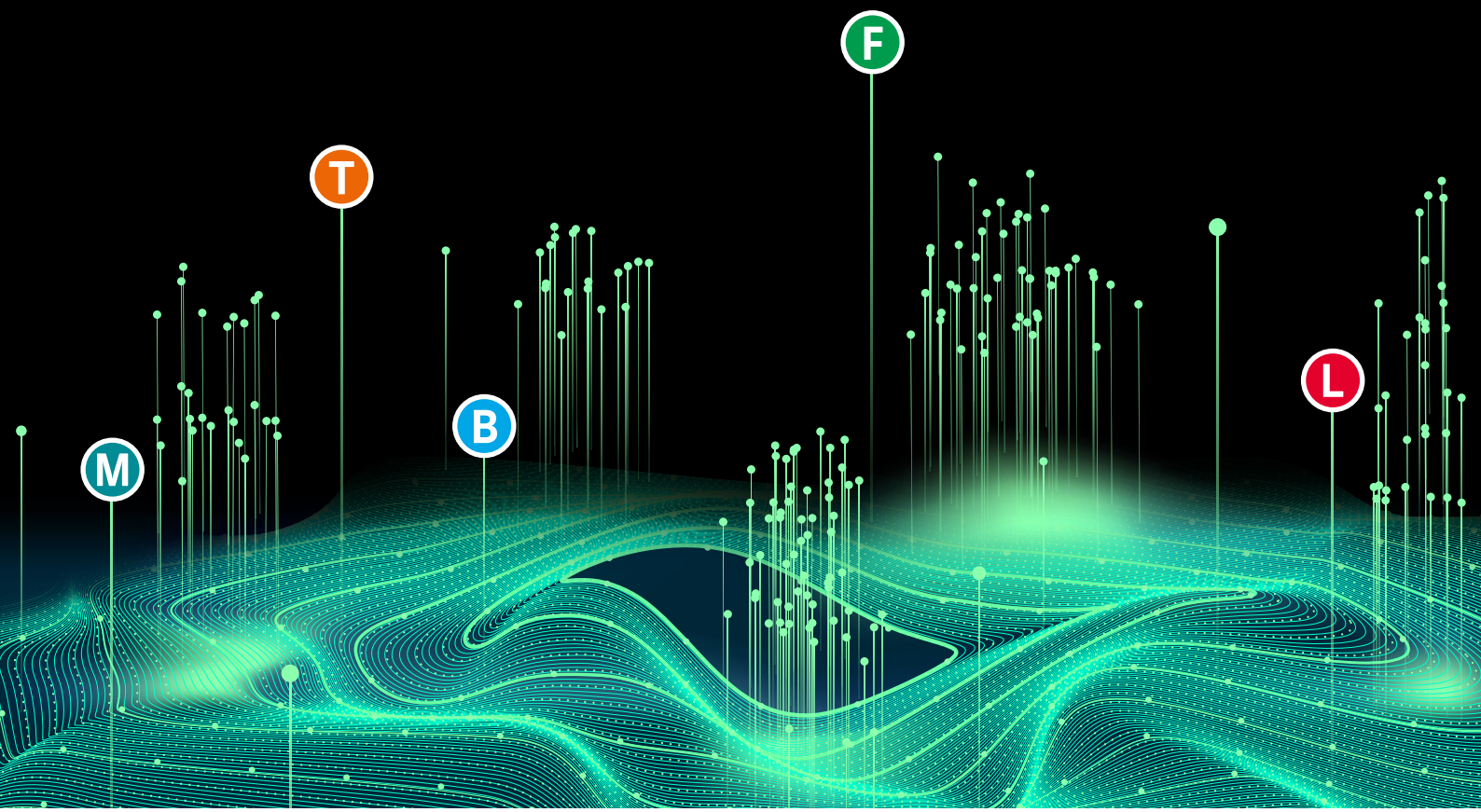
NSW GOVERNMENT

future transport technology



Transport for NSW plans its first journey into the quantum realm

In a world first for any transport organisation, the NSW Government and Transport for NSW are exploring the revolutionary new field of quantum technology.

Transport has a proud tradition of adopting innovative technology to connect customers and create successful, vibrant communities. We continue that commitment by investing in quantum technology.

This transformative technology will enable us to deliver cutting edge customer experiences through real time, personalised information and has the potential to unlock new ways to solve some of the most complex challenges faced by transport networks, ensuring the smooth delivery of our services in the years to come.

Quantum technology uses the unusual physics of subatomic particles to perform calculations that were never before possible, boosting the computing power available to manage, run and optimise the NSW transport system.

Bringing together world-leading experts based here in NSW and global partners, Transport for NSW will build the foundations of an ecosystem of innovation.

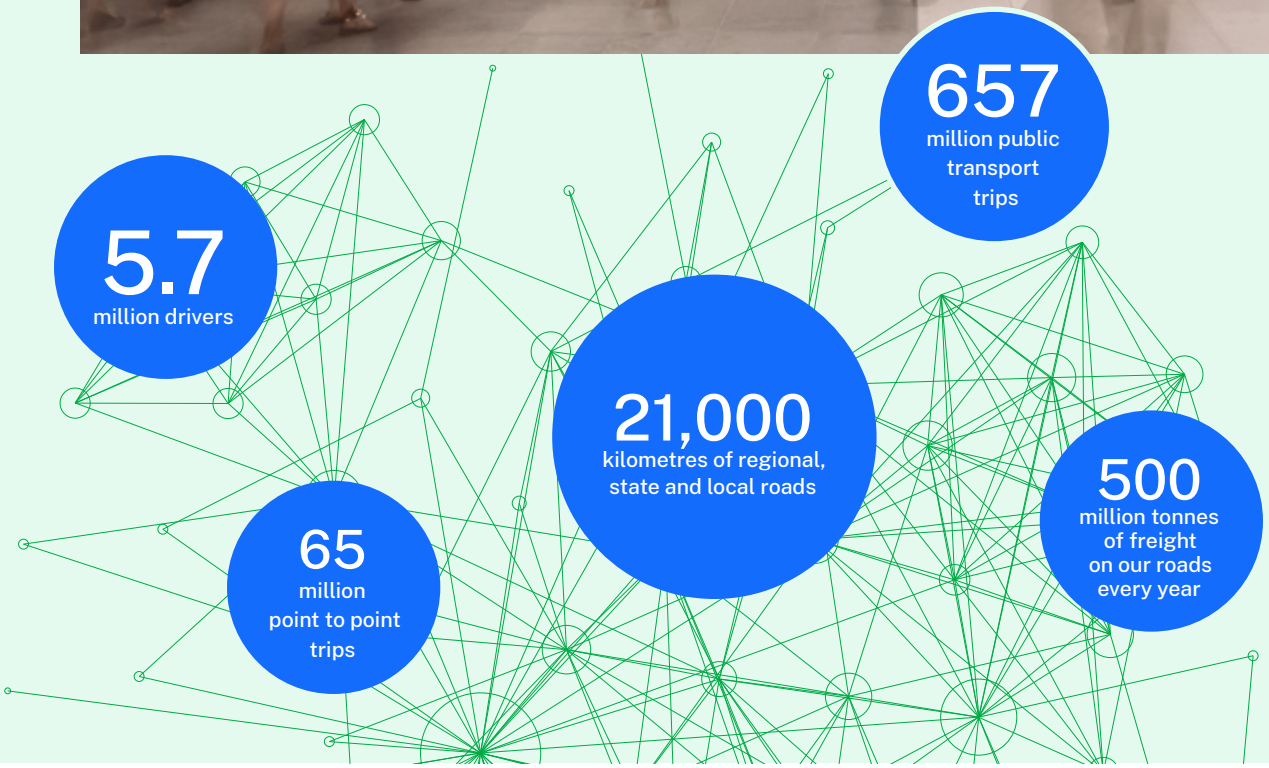
By investing in quantum technology today, we will be at the forefront of the next revolution in computing technology, create meaningful improvements to transport networks, and build stronger research capability in NSW.

Rob Sharp
Secretary
Transport for NSW

Introduction

Annually Transport passengers take more than 657 million trips on public transport across trains, metros, buses, ferries and light rail services in NSW and 65 million point to point trips in taxis, car share and hire cars. Our 5.7 million licensed drivers travel across 21,000 kilometres of regional, state and local roads.

Each of these trips generates data, which can be analysed to better manage networks today and improve planning for the future. Our networks also generate data from many other sources, including ticketing, logistics, traffic systems, infrastructure sensors, and CCTV. When added together, the volume of data quickly becomes enormous, meaning that finding valuable insights requires computing power that pushes the limits of today's supercomputers. This challenge will become greater still as the network expands, usage grows, and more and more sensors are deployed. New technologies are needed to deliver valuable insights from vast quantities of data in a timely fashion. That is the promise of quantum technology.



Transforming a data-driven industry

Transport has always been a data-driven industry. Even from the earliest days of handwritten spreadsheets and printed timetables, the ability to record and manage network data has been critical to ensuring its smooth, safe, and efficient operation.

Over time those handwritten processes have been improved by successive generations of computing technology, all the way through to the advanced artificial intelligence and machine learning technologies housed in classical supercomputers and cloud computing environments of today.

That computing power is used to manage the incredibly complex systems that are essential for keeping the people and goods of NSW moving, from the safe operation of the road and rail networks through to the intricate scheduling of services and management of traffic flow. Computing power is essential for developing maintenance schedules that allow vehicles and infrastructure to be used efficiently and safely, and for ensuring we have the staff available to operate them.

All these calculations are needed to create a transport system that meets the needs of millions of users who each have very different requirements.

In a network where operations are managed down to the second, this creates massive computational challenges.

But as we look to the future, we see challenges that today's technology cannot solve. For example, scenarios such as service disruptions push the limits of what's possible in terms of planning and management and we see limits in our ability to respond and recover from interruptions in a timely manner.

We know that the people of NSW are expecting more from the transport system. New concepts such as turn-up-and-go services and driverless vehicles need even greater levels of computing capability to operate smoothly, including the ability for network controllers to make decisions based on data that is being collected in real time. The ability to analyse data instantaneously promises to enable better prediction, and avoidance, of disruptions and the ability to dynamically alter schedules and services should problems occur. The volumes and complexity of data involved make such outcomes difficult to achieve today.

As our population and transport system grows, we need to find new and better ways to maintain and optimise the operation of NSW transport networks in real time to deliver the best possible experience for our customers. Quantum technology will allow us to process complex calculations using enormous data sets faster while continuing to responsibly protect customer data.

By creating this capability within Transport we can not only improve current and future transport services across the State but also build capabilities and awareness that will benefit other government agencies and private sector organisations in the mobility space, and attract leading talent to NSW.

This is why the NSW Government is investigating the potential of quantum technology and helping build a quantum ecosystem that will thrive and flourish here in NSW.

Future Transport Technology Roadmap

The Transport for NSW *Future Transport Technology Roadmap 2021-2024* launched in March 2021, stated that investigating quantum technology was one of our key goals. That goal is now being brought to life through our quantum technology vision and roadmap, which extends over 5 years.

Our 5-year vision is to be regarded as a global leader in transport quantum technology by:

- Identifying where quantum technology can solve real-world transport problems.
- Operationalising business-orientated transport quantum technology use cases to deliver value for Transport for NSW and our customers.
- Curating access to physical quantum computing capabilities to support both research and operations.
- Learning and building transport quantum technology software capabilities and early integration of Transport for NSW technology landscape.
- Developing a critical mass of skills and capabilities in NSW.
- Being recognised as a global centre of research excellence.

This vision will see Transport partnering with experts and partner organisations to explore the application of technology across various aspects of the transport system.

Specific activities include:

Creation of the **Transport for NSW Centre of Quantum Technology** housed within the **Quantum Terminal** at **Tech Central** in Sydney – Transport for NSW will have a team dedicated to the research and application of quantum technology in transport.

Recruitment of two new **Quantum Technology Co-Directors** to enable and deliver the research and development program.

Establishment of a **Quantum Technology Expert Advisory Panel** to advise on the goals and activities of the Transport's quantum roadmap, and research program.

Seeking **Expressions of Interest** from partners and experts to conduct joint research and development programs and attract leading global thinkers in quantum technology to NSW.

Quantum Expert Advisory Panel

NSW has some of the world's brightest minds in the field and Transport's investment in quantum technology will help ensure their work can flourish and expand here. Transport has formed the Quantum Technology Expert Advisory Panel consisting of some of the world's greatest quantum technology experts.

Professor Stephen Bartlett
University of Sydney, Quantum Physicist

Associate Professor Dominic Berry
Macquarie University, Centre for Quantum Engineering

Professor Michael Bremner
University of Technology, Centre for Quantum Software and Information

Joost de Kock
Transport for NSW, Customer Strategy & Technology, Deputy Secretary

Dr Hugh Durrant- Whyte
NSW Chief Scientist

Professor Elanor Huntington
CSIRO

Dr Ian Oppermann
NSW Chief Data Scientist

Rob Sharp
Transport for NSW, Secretary

Professor Michelle Simmons AO
2018 Australian of the Year, University of NSW

Andrew Stevens
Chair, Innovation & Science Australia

Professor Peter Turner
Sydney Quantum Academy CEO

Transport will recruit a **Director of Quantum Technology** and a **Fellow of Quantum Technology** who together will build and lead the Transport for NSW Centre of Quantum Technology's capabilities and skills and facilitate the application of knowledge into the transport network and its people, and more broadly across the NSW Government. They will bring the centre to life through research projects, pilot programs, and field trials. A global search is underway to recruit these specialists.

Leveraging global capabilities to deliver the world's best transport solutions locally

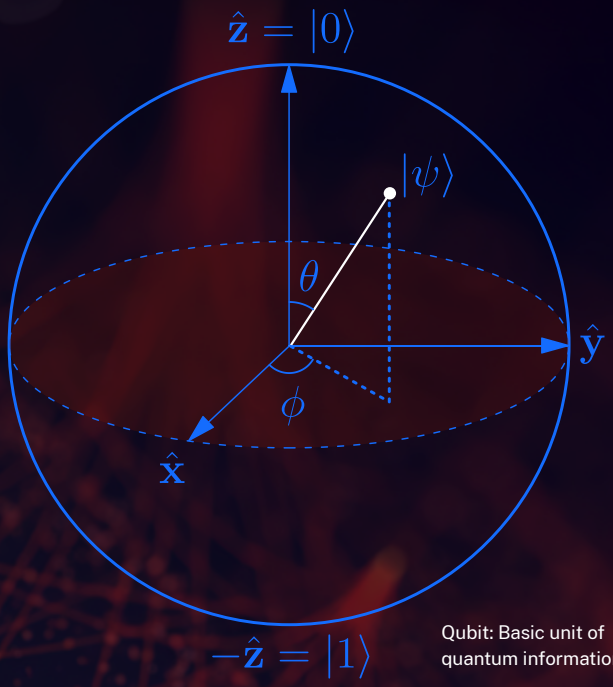
While Transport for NSW is driving the practical applications of quantum technology for transport across the State it will work globally to realise the benefits of this groundbreaking technology. Our approach will attract investment and talent to NSW.

Expressions of Interest from global industries, start-ups, academia and individuals will help us research, develop, and implement quantum technology across the transport system. From algorithm and software development and access to leading hardware to the creation of a quantum technology ecosystem, we want to partner with technology and service providers, industry and academia. We welcome co-investment to scale-up opportunities.

Benefits for NSW transport users

While the full benefits of quantum technology may be some years away, by investigating their potential now we will gain clearer insights into how they might solve some of our most significant challenges and help us improve future service delivery. Our goal is to build a strong understanding of quantum technology and its uses so we can realise those benefits as quickly as possible.

Potential applications of quantum technology in transport	
 Intelligent traffic control	New capabilities to optimise transport networks based on the real-time detection of subtle changes in network usage, enabling vehicles to avoid traffic jams and disruptions before they happen. This includes having buses, trucks, ferries, trains, and light rail vehicles communicate with our intelligent network management systems, including SCATS to determine where users are and deploy resources where needed while dynamically updating schedule information.
 Dynamic scheduling	Using a quantum computer to calculate the fastest route for buses in near real time to reduce passengers' travel time and enable more efficient use of network resources. The quantum computer assigns each bus to an individual route, meaning each bus can navigate around traffic bottlenecks.
 Real-time response	Using a quantum computer to analyse data and create algorithms that deliver the ability to respond to network disruptions in real time, including rerouting services and enabling faster deployment of replacement services, possibly before they are needed. This would enable dynamic traffic management in the event of major disruptions or during major events, with changes determined and communicated instantly based on the assessment of real-time data.
 Mobility as a service	The creation of on demand transport services that deliver turn-up-and-go transport networks that meet the needs of all customers. This allows travellers to seamlessly plan, book and pay for, and access multiple modes of transport through a single app or website. Quantum technology would be used to both predict service demand and dynamically schedule vehicles and staff.
 Predictive maintenance scheduling	Using real-world data to ensure assets and vehicles are maintained on a schedule relating to their actual performance and usage, enabling them to safely spend more time in service.
 Disaster response	Allowing for the creation of dynamic disaster management and evacuation plans that can immediately account for changes in the on-the-ground situation and communicate this information instantly to people in affected areas to save lives.



Qubit: Basic unit of quantum information

How quantum technology works

Quantum technology works by utilising the unusual properties of particles at the subatomic scale to perform incredibly complex calculations.

In today's computers (also called classical computers) calculations are made using transistors, which are microscopic 'switches'. When power is applied to a switch it can be placed in either an 'on' or 'off' state. These 2 states represent the digits 1 and 0, which comprise a 'bit' of information. When millions of bits are strung together in a microprocessor, they can be used to perform algorithms, which are the basis of calculations and form the foundations of modern computing.

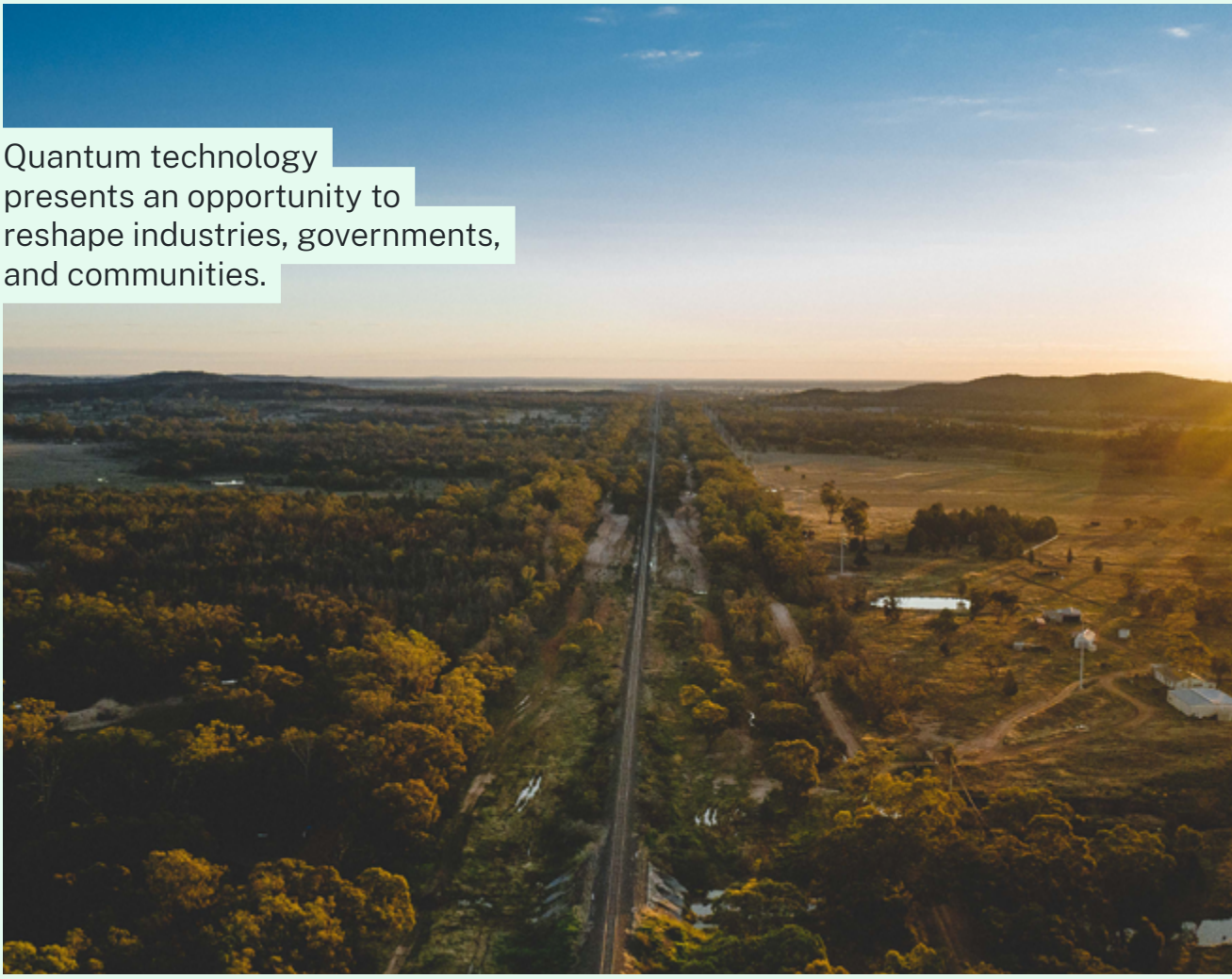
In a quantum computer, individual particles (photons, electrons, or atomic nuclei) are used instead of the transistors. Each of these particles has what is known as a 'spin state', which is a description of its movement. This state is either 'up' or 'down', and when described in computing terms, this represents the 1 or 0 of classical transistors, and in a quantum computer these are known as qubits.

Due to unusual quantum principles, a qubit can be said to be both in the 1 or 0 state at the same time. This enables algorithms to run multiple calculations simultaneously. Stringing together more qubits enables the calculating power of the quantum system to scale at an exponential rate.

The end result is that even a relatively simple quantum computer could solve in minutes problems that would take a classical computer thousands of years to calculate.

However, quantum computers have typically been highly unstable and error-prone, which has meant that until recently it has been difficult to create one that was sufficiently stable to perform meaningful computing tasks. But recent breakthroughs in technologies such as superconducting circuits and the microwave pulses or laser beams that manipulate the quantum states are leading to the creation of the first practical quantum computers.

At the current rate of advancement, it is reasonable to expect that quantum technology will be a more common element of high-end computing systems within the next 5 years.



Quantum technology presents an opportunity to reshape industries, governments, and communities.

Transport's investment in quantum computing reflects our commitment to embracing the latest technologies to deliver improved outcomes across the NSW transport system and deliver benefits for all users.

This work sits alongside other investments in emerging technologies such as autonomous vehicles, AI, advanced sensors, account-based ticketing systems, intelligent decision engines, road safety cameras and drones, all of which promise to improve the operation of the networks today and into the future.

By investing in quantum technology today, we plan to be at the forefront of the next revolution in computing technology, create meaningful improvements to the transport system and build stronger research capabilities in NSW.

When quantum technology fulfills its promise of enabling immense volumes of data and complex calculations to be performed in a timely manner, it will unlock numerous possibilities for more efficient and safer services, and deliver better experiences for the people of NSW.

Through partnering with local and global quantum technology leaders, Transport for NSW customers can look forward to benefits such as personalised real-time information to help optimise their journeys, reduced disruptions, and improved reliability and safety.

Quantum technology presents an opportunity to reshape industries, governments, and communities. Our goal is that 5 years from now NSW will be home to a thriving quantum technology ecosystem that is solving real-world transport problems for our customers, while supporting the world's brightest minds to work and research in quantum right here creating a better future for all the people of NSW.

For further information, please contact quantum@transport.nsw.gov.au

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